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MEETING REPORT

Wesley T. Huntress, Chair

T. Jens Feeley, Executive Secretary

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Welcome and Introduction

Dr. Wesley T Huntress, Chair of the NASA Advisory Council (NAC) Science Committee, opened the proceedings, thanking committee members for agreeing to help advise NASA, which is currently undergoing change. Dr. T. Jens Feeley, Executive Secretary of the Science Committee, made some administrative announcements, reminding members that the meeting would adhere to Federal Advisory Committee Act (FACA) rules, and invited that public comments be submitted via email or telephone.

Dr. Huntress identified committee member Dr. Byron Tapley as Vice Chair of the Science Committee, which would meet four times per year. As Chair, Dr. Huntress would bring forth items of note to the full NAC. Dr. Huntress reviewed the role of the generally reactive Science Committee, including the provision of observations, findings and recommendations that constitute clear advice to NASA.

FACA Briefing

Dr. Feeley provided particulars on the FACA process and mode of operation. FACA is a mechanism that enables federal agencies to receive independent advice from the outside to improve the workings of the federal government. NASA policy directs that subcommittees or assessment groups of NASA advisory committees that may not be subject to the FACA will be established and managed under procedures that ensure the same spirit of openness and public accountability that is embodied in the FACA.

NASA's Advisory Committee Management Officer (CMO) was identified as Ms. Diane Rausch. Ms. Rausch provides management oversight for all committees and subcommittees, as well as for the final report submitted each year to GSA. New committees are also chartered through the CMO, which works closely with the agency's Ethics Office and General Counsel, and the Executive Secretaries of each committee and subcommittee. Any questions should be directed to Ms. Rausch, whose email address and phone number was provided to members.

Ethics Briefing

Mr. Michael Monahan provided the annual ethics briefing for Science Committee members, addressing the various ramifications of duties incurred by SGEs, and emphasizing the mechanics of financial disclosure. Mr. Monahan took a question from Dr. Charles F. Kennel on total days in combined service for a more detailed follow-up, and encouraged members to contact Dr. Feeley for further questions, to be forwarded to the Ethics Office.

Discussion of 2010 Work Plan

The Science Committee's portion of the NAC Work Plan for 2010 was reviewed briefly, contents of which include to review and advise on the Science Mission Directorate (SMD) Science Plan. For this purpose, each discipline subcommittee would be weighing in on the substance of the Plan, while the Science Committee was to evaluate the Introduction, sending comments to Dr. Feeley in advance of the April 2010 meeting. Dr. Huntress noted that the committee must further define work requirements pending the full-up NAC meeting; connections with the Education and Public Outreach (E/PO), and Exploration, and Space Operations Committee have yet to be made. Dr. Jack Burns requested a briefing from NASA's new Chief Technologist, Dr. Robert Braun, to be undertaken at the next meeting. Dr. Huntress concurred. Dr. Burns also noted being pleased that the International Space Station (ISS) was now on the Science Committee agenda. Dr. Huntress added in this context that SMD provides flight opportunities to ISS through the Explorers program, missions of opportunity (MoOs), and possibly through the Earth Science Division (ESD) Venture-class series of mission. Each subcommittee should consider what earth and space science or related technology demonstrations could make use of the International Space Station (ISS) as a platform.

Dr. Edward Weiler, Associate Administrator of SMD, added that the Administrator fully supports ISS science opportunities based on National Academies of Science (NAS) recommendations and category 1 proposals, recognizing that low-Earth orbit (LEO) will not suit all subdiscipline goals, and while acknowledging the imminent retirement of the Space Shuttle. Dr. Burns commented that it was difficult to identify what sort of peer-reviewed science could be performed on ISS. Dr. Weiler pointed out that SMD Announcements of Opportunity (AOs) and NASA Research Announcements (NRAs) currently permit proposals that would use ISS, but few proposal had been received and ranked high enough in peer-review to be funded, indicating that there is little interest from the Earth and space science community so far. Dr. Burns commented that as the Agency is getting ready to spend $30B over the next decade, he was interested in hearing what these science goals should be. Dr. Charles Kennel remarked that the low-gravity community no longer exists, which has led to the opinion that ISS is dispensable. He added that Europe feels differently about the ISS, thus there is a need to reconstruct the community, and expressed the hope that the new Decadal Survey for the biological and physical sciences would support community building. Dr. Weiler agreed strongly that ISS clearly represented an opportunity for life and microgravity sciences, and that this prospect should be evaluated by the NAC Space Operations Committee.

Dr. Kennel, enlarging upon the topic of ISS, called for the need to seriously consider the 2015-2020 timeframe, which opens up opportunities for proposals and flight time; the task for the next 5 years is to rebuild the ISS science community and develop strong science objectives. While Dr. Kennel did not feel that ISS would provoke a revolution, he asserted that Europe regards ISS as a facility (akin to the role of CERN) for doing microgravity research. Germany, e.g., has organized consortia of universities to examine areas of interest in zero/low gravity science. This type of peer group does not yet exist in the U.S. Drs. Kennel and Burns expressed interest in having a representative from the European Space Agency pay a visit to a future Science Committee meeting to discuss their approach to ISS utilization.

Dr. Burns, citing the future placement of the $1B Alpha Magnetic Spectrometer (AMS) on ISS, felt it would be helpful to know more about this “mysterious” ISS potential and supporting community. Dr. Kennel added that $400M a year could potentially go to waste without clarification of scientific standards and peer review for ISS. Dr. Eugene Levy questioned whether ISS was the best place, or the most opportune place, to carry out science, and whether such science could be achievable in other ways. Dr. Huntress commented that while the Science Committee addresses Earth and Space science, ISS must wrestle with being more inclusive in order to use the budget more wisely. Dr. Feeley commented that, as proposed by the Presidential budget, the $400M is to be used for science and technology on ISS, although particulars are not laid out yet. Dr. Judith Lean expressed confusion about boundaries, and whether there is other, high priority science that could be carried out with this allocated $400M. Dr. Michael Turner commented, in the context of ISS’s purported facility function, that the CERN model also has a fixed, robust budget upon which the community depends.

<u>Science Mission Directorate Update with Associate Administrator</u>

Dr. Weiler presented a status of the SMD. He reported on a busy year across the disciplines. Over the past year, Kepler has launched, a successful repair mission was carried out on the Hubble Space Telescope (HST), the Herschel and Planck missions have been operating well, and the launch of WISE has led to the discovery of some new Near Earth Objects (NEOs). The launch of the Orbiting Carbon Observatory (OCO) failed due to a fairing malfunction, the NOAA N’ and GOES-O satellites were launched, and Cassini fly-bys continued during this same period. SMD will inherit the operations of the Lunar Reconnaissance Orbiter (LRO) later this year. The MESSENGER mission to Mercury had its last flyby in September 2009, and is now preparing for Mercury orbit insertion in March 2011. The GOES-P launch is scheduled for March 2010, and the Stratospheric Observatory for Infrared Astronomy (SOFIA) had an open door flight, which was a major milestone. SOFIA also had a 40% open door landing, an unplanned event that was nonetheless successful. The Solar Dynamic Orbiter (SDO) launched after a 14-month

delay which was caused by launch vehicle availability issues, and is expected to be in final orbit in about 3 weeks; everything aboard the spacecraft is working well. The EPOXI spacecraft will perform flyby of comet Tempel 1 (the comet that was studied by NASA's Deep Impact mission) in November 2010.

The new NASA FY11 budget provides approximately $5B for science; the big benefactor is the Earth Sciences Division (ESD), which is up 61% through the 2015 runout. The overall science budget has increased by 29%. The Planetary Science Division (PSD) is up 23% over 5 years, and the Astrophysics and Heliophysics Divisions (APD and HPD) are more or less up 10% through runout. Dr. Weiler reminded committee members that ESD's increase was in fact a correction of past budget inequities. The good news is that SMD managed to receive a stable budget in a bad economy. The FY11 budget represents an initiative backed by real money. Some details of the SMD's Earth science budget request are currently under review by the Office of Management and Budget (OMB), but it is known that the funds have been directed to support an immediate re-flight of the OCO mission in FY12 or early FY13, a climate initiative, NEO observations. Dr. Weiler reviewed some reductions that will have to be absorbed for Agency issues such as center overhead and Information Technology (IT) infrastructure.

The funding for ESD will enable significant mission acceleration, particularly the Venture-class Principal Investigator (PI)-led program, a climate continuity mission line, the establishment of long-term carbon measurements, and the enabling of key non-flight activities (i.e. science). HPD is now funded for 17 missions, including SDO, a new Explorer mission, the Radiation Belt Storm Probe (RBSP) and Magnetospheric Multiscale (MMS) missions, and an initiation of phase A studies for Solar Probe, the highest priority Decadal Survey mission for HPD. The budget also supports a formal collaboration with ESA on Solar Orbiter (a $1B-class mission for ESA). Dr. Lean expressed concern regarding the lack of ionosphere/thermosphere/ mesosphere (ITM) representation in the HPD mission line.

Funding for PSD will allow for a fully funded launch of the Mars Science Laboratory (MSL) in 2011. The MSL mission is in the final phase of actuator life testing, which is now at 1X lifetime levels. While the mission is striving for a 2X lifetime, 1X can still accomplish all mission goals. The MSL mission is still within budget presented to Congress after the replan. The Program's also budget includes support for early Mars architecture development that underpins future ESA/NASA missions beyond MSL. There is now a signed letter of intent to form an international Mars Architecture Science Group, representing a real success story and a model for future missions. PSD continues to operate 11 Planetary missions, and will be launching the Juno mission to Jupiter and the lunar mission Gravity Recovery and Interior Laboratory (GRAIL) in late FY11. Funding has been included to further study a Europa/Jupiter Mission concept, a mission that could be jointly carried out with ESA; PSD is supporting an instrument AO in mid-FY11 for this purpose. The division will also be increasing funding for NEO detection and related studies, in addition to restarting Pu-238 production and Advanced Stirling Radioisotope Generator (ASRG) flight development. In response to a question, Dr. Weiler assured the Science Committee that SMD is negotiating with ESA for an open data policy on joint missions. Dr. Huntress observed that true joint mission implementation will have a critical dependency on an international partner in both an engineering and budget sense. Dr. Weiler recognized the inefficiencies and psychological barriers to true partnership, and the need for clean interfaces between NASA and ESA. He cited the Herschel and Planck program as a successful interface model. Dr. Weiler added that NASA will need a true prioritization from the Decadal Survey to address the resource constraints that plague planetary missions.

The budget for the Astrophysics Division (APD) fully funds the James Webb Space Telescope (JWST) for launch in 2014, operates HST, and provides funds for the NuSTAR, ASTRO-H, and Gravity Extreme Magnetism Small Explorer (GEMS) missions. In the meantime, the division awaits the Astro2010 Decadal Survey in the hope that it can be used to inform the NASA budget request submittal to OMB in early September 2010. Asked how Flagship missions will fit into the new budget, Dr. Morse explained

that APD has given a consistent message to the Decadal Survey committee that no significant Flagship planning can occur until JWST is launched. Dr. Weiler added that international participation would be necessary to support any new SMD Flagship missions, and reiterated that the Decadal Survey must take these constraints into account. Dr. Burns commented that it would be challenging to address new Decadal Survey priorities in Astrophysics. Dr. Weiler pointed out that SMD cannot carry out a Europa mission without cancelling Planetary missions. Dr. Morse added that the main message about the Astrophysics budget is that prior Decadal Survey expectations are holding. Questioned as to why APD had received a comparatively small increase, Dr. Weiler reminded the committee that the SMD budget has the consensus of OMB, NASA Headquarters, and extensive input from the science community, while also acknowledging that Astrophysics, Planetary, and Explorers are three areas which could use augmentation.

Dr. Huntress asked whether other agencies besides ESA and JAXA were interested in collaborating with NASA. Dr. Weiler expressed interest in formulating a ESA/NASA architecture and inviting more countries to contribute. He added that the Mars Exploration Program Analysis Group (MEPAG) has estimated that a Mars Sample Return (MSR) mission will cost $8-10B, and it is obvious that NASA and ESA can't fund this amount by themselves. In reply to a question from Dr. Lean, Dr. Weiler observed that the Explorers program was part of a more general $3B reduction in the previous administration. Dr. Noel Hinners queried the state of technology funding, to which Dr. Weiler responded that it will be better than ever if the budget is approved as written. The new Chief Technologist, Robert Braun, has an interest in developing cross-directorate technologies such as entry/descent/landing (EDL), gyroscopes, next generation charge-coupled devices (CCDs), etc., all of which are relevant to SMD. A technology roadmap will be developed in the near future. Dr. Levy recommended that the Science Committee establish a regular information exchange on technology development. In response to a question, Dr. Weiler explained that the Data Analysis (DA), Research and Analysis (R&A), and Guest Investigator (GI) programs are now stable.

Dr. Weiler invited the committee to consider Explorer options, and to weigh in on the value of 2 "full-up" Explorers versus one Explorer opportunity and several missions of opportunity (MoOs). MoOs would be the way to utilize ISS, and offer endless possibilities here that should be considered. Dr. Weiler noted that he did not want to generate a lot of excitement and risk subsequent disappointment, and would prefer the Science Committee's approval of one approach versus another. Dr. Hinners felt that MoOs had not ranked high in aggregate, historically. Dr. Hogan felt that the science per dollar obtained through MoOs tends to be very high. Dr. Weiler wished to emphasize the importance of choosing the best science over most science. In addition, Explorers could offer the opportunity for commercial participation, given realistic proposals and peer reviews. In addition, affordable launch vehicles (LVs) would benefit from competition that will eventually drive down price. The Falcon IX's expected performance is similar to a low-end Delta II, and would cover a lot of "sweet spots." However, it must be noted that SMD is a customer and does not choose launch vehicles preferentially. In the next 5 years, SMD hoped to see Taurus and Falcon vehicles become available, recognizing a certain number of flights will be needed to demonstrate reliability. Minotaurs are also a possibility as a stop-gap measure, but this is an issue for the Space Operations Mission Directorate (SMD).

Dr. Tapley addressed technology development and the balance between developing capabilities and requirements; he suspected the program will respond to Agency requirements. Dr. Weiler replied that SMD will be working to present these requirements, while personally acknowledging that he would like to see something like the New Millennium Program (NMP) once more. Dr. Burns asked how the 2016 Mars mission fit into the PSD budget. Dr. Weiler responded that the 2016 opportunity is currently being studied as a NASA/ESA mission, and is ultimately a Decadal Survey decision. Dr. James Green, PSD Director, interjected that the 2016 instruments are being selected for phase A studies, but that no flight selections will be made until after the Decadal Survey has been published. The community has given PSD

its approval on the phase A/B strategy so that PSD/MEP can proceed.

Dr. Torbert noted that the Heliophysics community is concerned about reductions in the Guest Investigator (GI) program. Dr. Richard Fisher, HPD Director, explained that the division had been given a directed rescission by Congress to reduce R&A, and thus a decision had been made to defer selection of GIs for a year, to allow budget recovery to take place. Dr. Fisher felt the rescission was a message to reduce carryover. Dr. Weiler added that the Agency is also implementing a FY10 budget that contained some directed funding which necessitated a $58M cut across SMD.

Asked again why APD seemed to have suffered a reduction in growth, Dr. Weiler reiterated that he was not the prime mover in this action and urged the Science Committee to ask how any directorate obtains true growth. In the past, SMD has grown at the expense of Earth Sciences, which is now finally starting to get its deserved growth. He argued that one must look at entire context. Dr. Hogan commented that a reporter has insinuated that the Astrophysics community had not been doing a good enough job advocating its science. Dr. Weiler countered that the fact was that this community currently has about $10B of instruments and spacecraft carrying out a tremendous amount of science. Dr. Kennel observed that the real issue is to determine what one could do with present funding, with input from Astro2010. Dr. Hinners felt that the insidious problem with Decadal Survey was its penchant for supporting mega-missions, squeezing out the Explorer program and other smaller missions. Dr. Kennel noted that the Decadal Survey would be costing the missions realistically, including historical patterns of overrun; it is possible that Explorers and MoOs will be considered in this context. Dr. Weiler remarked that in the 1990 Astrophysics Decadal Survey, the highest single priority was an augmentation to the Explorer programs, which in turn enabled a doubling of funding in the 1990s. He reiterated that he was awaiting the Survey's determinations of the best science for the money, adding that HST turned out to be $18B, but was worth it. However, he conceded that there is more latitude in smaller missions with competition and peer review. Dr. Huntress added that competition and peer review are the primary reasons that U.S. science is regarded as the best in the world.

Asked about relative agency responsibilities for climate services, Dr. Weiler briefly noted that the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program is being restructured, whereby the National Oceanic and Atmospheric Administration (NOAA) would have program control, and NASA Goddard Space Flight Center (GSFC) would be involved in instrument development. Dr. Hogan asked about the phasing issues between ESA and NASA that could affect international collaboration schedules. Dr. Weiler, using the Mars program as an example, noted that ESA had found a way to deal with important issues. Dr. Tapley commented on the lack of international collaboration at a grass-roots level for Earth Sciences. Dr. Weiler reported that ESD Director Michael Freilich has been working this issue diligently, with positive results.

Dr. Greeley noted that the National Research Council (NRC) had released a study on NASA international collaborations and recalled an attempt between NASA and the French space agency (CNES) for Mars Sample ReturnMSR, which fell apart. Dr. Huntress commented that CNES had lost its funding. Dr. Weiler added that that attempt also took place under a much different Mars architecture, in which sample return had been budgeted at a very unrealistic $500M. Dr. Levy cited by contrast the very successful Cassini-Huygens mission to Saturn. Dr. Burns asked how SMD would use its Science Plan. Dr. Marc Allen took up the question, stating that the Science Plan would be used to reset documentation for the budget, stressing that this would be a short updated version to reflect the current budget. The next Science Plan (2013) will reflect all the new Decadal Survey outcomes. Dr. Paul Hertz added that the Science Plan is used to lay out priorities and expectations such that the community can propose to them. Dr. Weiler observed that the Science Plan is critical to division Directors as they set out their R&A programs. Dr. Burns requested presentations, a day in advance of future meetings. Dr. Feeley agreed to expedite the

request.

Dr. Lean was concerned that the Science Plan appeared to be cut and pasted, with a lot of motherhood and vision and lacking specific data. Dr. Hertz explained that its function could be viewed as more of an implementation plan. Dr. Feeley noted that the NRC provides feedback to the Science Plan through its mid-term reviews that advise NASA on its progress. The Government Performance and Results Act (GPRA) grades assigned to SMD subdisciplines also play a role in this feedback, as well as NASA's required performance report to that is submitted to OMB and Congress on an annual basis. Mr. Greg Williams, SMD lead for the NASA Science Plan, added that there are two types of changes that would be especially welcomed as feedback- NASA accomplishments, and how NASA responds to new direction.

Crafting the 2010 SMD Science Plan

Mr. Williams provided the latest details on the evolving SMD Science Plan, described as essentially an update of the 2007 Science Plan. The Plan is being updated due to Agency requirements, recognizing the imminent nature of the next Decadal Surveys in the relevant subdisciplines, and reacting to the change in Administration and anticipated new directions. He reviewed the Science Plan schedule, which was aligned with the meetings of the NAC SC and discipline subcommittees. Dr. Lean asked if any attempts were being made to integrate the boundaries between subdisciplines. Mr. Williams pointed out that this was being done for Astrobiology, in one instance, but welcomed more feedback on including scientific synergies. Relevant information is also being extracted from the various SMD Roadmaps.

The Science Plan includes statements about national direction, Agency-level goals, recommendations from the science community, a plan for science (principles, strategies and challenges), and detailed plans by science area, including cross-cutting subjects, followed by a description of Education and Public Outreach E/PO activities. The Plan also includes how NASA reflects the national agenda for science, leadership in fundamental research, environmental stewardship, educating the next generation, technological innovation, and international and domestic partnerships. In response to several comments, Dr. Huntress directed members to give written edits to Mr. Williams.

Mr. Williams reported that current efforts focused on working to improve statements on strategy, and to enlarge on the set of challenges facing NASA, such as access to space, production of Pu-238, mission cost estimates, unrealized expectations, and impediments to international collaborations in space such as the International Trafficking in Arms Regulation (ITAR) laws. Asked how the Agency planned to cope with Flagship costs, Mr. Williams requested feedback from the Science Committee. Dr. Kennel suggested being honest about the historical context of cost overruns and taking into account the possible reasons.

Mr. Williams reviewed the common contents of science chapters, and looked to the Science Committee for feedback on the balance and purpose of information. Committee members commented on some omissions, such as a statement about "how the universe works (physics of the cosmos)", and mention of shared stewardships and complementarities between DOE, NOAA, NSF, etc. Committee members were instructed to send their edits to Dr. Feeley.

Planetary Science Division (PSD) Update

Dr. Ronald Greeley, Chair of the Planetary Science Subcommittee (PSS), introduced the presentation with selected science results. New views of Enceladus from Cassini were displayed with more highly resolved images of plume sources, as well as a Lunar Reconnaissance Orbiter (LRO) view of the "Cobra Head" in the Aristarchus Plateau, revealing an exposure of whitish rocks, showing that magma flow has gone beyond the basaltic stage and that the magma chamber has evolved chemically (cooked) over time. The crater-bound Mars rover Spirit is still capable of doing useful science. Thus far the rover's cameras have recorded 750 dust devils over 3 complete seasons; such data is providing links between surface and

atmosphere phenomena. Dust devils are now associated with power surges in the rover, which in turn are associated with dust being removed from the solar panels by wind activity. Data suggest that dust devils on Mars tend to occur during time of temperature gradients, much like terrestrial dust devils. The maximum number of dust devils tends to occur just before the maximum amount of dust in atmosphere is observed. Spirit has also been monitoring dust devil tracks, which get covered up in a year or so.
Dr. Greeley reviewed PSS recommendations to PSD regarding the need for Pu238 production for both outer and inner Solar System missions; encouragement of international ties, particularly for the Mars program; encouraging full participation of the Planetary community; the benefits of the Arecibo radar facility beyond NEOs; the role of Planetary science in the evolving lunar program; monitoring of MSL and the future Mars program; evaluating Supporting Research and Technology (SR&T) programs; the need for standard simulants of lunar/asteroid/Mars soils for sample acquisition and trafficability; and long-duration missions to the Outer Solar Systems and the evolution of flight teams over time.

Dr. James Green, PSD Director, continued the presentation, beginning with highlights of the FY11 budget, reporting that PSD received an increase of $145M from FY10-11. He noted that as PSD will obtain its Decadal Survey in 2012, the report can be used to plan FY13 and beyond. An extended mission for Cassini (XXM), beginning in September 2010 through 2017, has been approved, for the purpose of studying seasonal changes at Titan and Saturn. At the end of Cassini XMM, the spacecraft will be ditched in a trajectory through the rings, during which time the spacecraft will analyze the planet's interior with a magnetometer. The NEO program has been increased by $16M. Funds have also been dedicated to restart Pu-238 production, and to fully support operating missions and the upcoming Juno, GRAIL, MSL, LADEE and MAVEN missions. ASRGs are also being developed for a 2014/15 launch. The Europa Jupiter System Mission is in pre-phase A. Congressional action is under way to determine NASA's role, if any, in NEO avoidance.

In response to PSS recommendations, Dr. Green said his division would be seeking a solution to the Pu-238 shortfall and the development of advanced radioisotope power systems (RPSs). While the budget had been zeroed out for actual production, FY10 Appropriations stated that a start-up plan should be put in place. NASA has worked with DOE to deliver such a plan and the two agencies continue to work well together, maintaining testing of RPSs. Dr. Green was not at liberty to provide specifics on funding sources, but allowed that PSD may not be the only source for contributions for funding the re-start. Fundamentally, however, the NASA role is understood to be as a provider of funding. Mr. James Adams, Deputy Director of PSD, stated that the NASA is working with DOE to determine the production rate of Pu-238, and allocation once it is stockpiled.

An ESA partnership is still developing for a 2016 Mars opportunity, which is currently conceived as an ESA Trace Gas Orbiter with an EDL package from ESA. In response to keeping PSS apprised of the costs of MSL, Dr. Green reported that the division has made significant progress with the mission, meeting critical milestones while holding regular meetings and teleconferences with PSS. The titanium issue has nearly been resolved, and is not expected to negatively impact the mission. Three remaining issues are the SAM wide-range pump problem, a radar transmit/receive unit, and the multi-mission radioisotope thermoelectric generator (MMRTG), which has a shortfall in power. There are no backup units for the MMRTG, but there are backup modules that can be put in test if necessary. In its present state, the MMRTG will still operate for several decades. In the worst case scenario, the mission would have to perform more power management activities in the winter season, thus the MMRTG is not a showstopper. Mr. Doug McCuistion added that the function of the RTG is to "trickle charge" the batteries, amounting to a minor operational issue during the cold months.

Dr. Green reported that earlier in the year, MSL had requested funding within altered guidelines, and since that time no further impact has been anticipated for PSD as a whole. PSS recommendations on the

2018 Mars opportunity have also been considered. PSD is now contemplating a NASA/ESA rover mission for an Astrobiology sample return technology activity, which could provide the framework for potential sample return in the 2020's. There is a Mars subpanel on the Planetary Decadal Survey, including international representation, which is currently turning over the question of future Mars opportunities. In response to a question, Mr. McCuistion remarked that the ESA Mars program is not science-driven, and is meant to provide technology development for European states.

PSD has responded to several other PSS recommendations. PSD is creating an SR&T Working Group (WG), and efforts are also under way to develop co-Investigator, IDS and Principal Investigator mechanisms for personnel additions to flight programs. The division is also forming panel to assess technology development projects, which had its first meeting in January. Dr. Weiler questioned the timing of review of R&A. Dr. Green replied that the effort has just started and expects to respond to marching orders from the Decadal Survey. Dr. Adams added that the panel is looking more at improving processes for the time being. Regarding directed funding for the Arecibo facility, PSD will both accommodate the shortfall and increase science usage of the facility. The division has also responded to the recommendation on developing simulants. Finally, as the Exploration Systems Mission Directorate (ESMD) transitions to new activities, the Optimizing Science and Exploration Working Group (OSEWG) will also evolve to reflect these new areas.

Recent accomplishments

Selections for the New Frontiers program have been announced: these are MoonRise, OSIRIS-REX and SAGE (Venus Lander). A Stand-Alone Mission of Opportunity (SALMON) has also been released for ESA's Trace Gas Orbiter. A Planetary Technology Review has begun. The Discovery bidder conference and comment period has taken place and results are in evaluation. An Agency Program Management Council (APMC: a high-level internal agency review for major programs) for MSL and the Lunar Quest Program had been completed, and NRC has released its new NEO Survey and Mitigation Report.

Upcoming milestones

The Venus Climate Orbiter (JAXA) arrives at Venus in late 2010, GRAIL will launch to the Moon in 2011, and MSL is due to land on Mars in 2012. NEO activities will begin in a more sustained fashion; the objective of these activities is to detect and track at least 90% of any 140-meter-plus size NEOs that have the potential to impact the Earth. Current systems for tracking include various ground-based assets, the U.S. Air Force's (USAF) Linear and the Catalina Sky Survey. The WISE mission has also been employed for this purpose, and has detected one 300-meter and one 600-meter NEOs, as well as new asteroids. With the additional funding, PSD will extend collection and archive of WISE data and also work with the U.S. Air Force's Pan-STARRS program, and investigate use of additional USAF surveillance assets. PSD will also support Arecibo and the Goldstone Deep Space Network (DSN) facilities, determining parameters that define an object with impact potential. Dr. Green noted that NASA NEO detection software is being adapted for the Pan-STARRS system, thus PSD will have dedicated and directed observations on USAF assets. Citing NRC findings that NASA cannot meet its goal of cataloguing 90% of NEOs by 2020, Dr. Green reported that a space mission in concert with ground-based operations could meet this goal by 2022. If cost is the issue, then an entirely ground-based option is best, bringing NASA to its goal by 2030. Dr. Weiler noted that it would take $1B. Dr. Burns remarked that the risk of "planet killers" is minor and did not see a need for urgency. Dr. Green believed that NASA has retired much of the risk of the 6000 known NEOs, but is still evaluating their parameters. That said, the risk is still believed to be small. By continuing its current approach, NASA could obtain 50% of its goal by 2020. The 2030 date assumes that NSF's Large Synoptic Survey Telescope (LSST) will be in operation.

Taking heed of studies showing that 30- to 50-meter NEOs can cause Tunguska-class impacts, NASA

will continue to survey for smaller objects. Believing that the U.S. should take the lead in organizing and empowering a suitable international entity to deal with NEO hazards, NASA is continuing to engage other agencies. Data from airbursts from the Department of Defense should be made available openly. Dr. Hinners asked if a human NEO mission could be considered. Dr. Green felt that two per decade would be in the realm of possibility, but noted they would be highly constrained by short windows, complicated orbits, etc. The Scouts Program is not viable for this purpose. Dr. Green added that it was important to note that the last Planetary Decadal Survey had as its highest priority the New Frontiers program. The Science Committee expressed overall satisfaction with the PSD response. Dr. Huntress agreed to take the Pu-238 issue to the NAC and requested Dr. Green's chart delineating the effects of the Pu-238 shortfall on space missions.

Heliophysics Division (HPD) Update

Dr. Roy Torbert, Chair of the Heliophysics Subcommittee (HPS) led with a report from the HPS. He noted that the terms of six subcommittee members would be ending in March and that the subcommittee was invited to suggest replacements. He reviewed the top-level objectives in Heliophysics, remarking that HPS remains concerned about mission costs. The 2009 Heliophysics Roadmap has just been completed and contains a new planning paradigm. Dr. Torbert displayed a graphic on strategic planning illustrating how NRC studies and the Decadal Survey feed into the Science Plan, Roadmap and Strategic Plan. Dr. Burns suggested that Mr. Williams include a similar graphic in the Science Plan presentation.

The HPS Roadmap strategy was described by Dr. Torbert as a science queue with a flexible mission implementation approach. Dr. Huntress commented that a "queue" implies nonflexible approach. Dr. Torbert explained that the Roadmap attempts to allocate cost categories rather than missions, working through several sample missions as illustrations to set cost boundaries. It is the mission science goals and recommended cost parameters, instead, that are strictly queued. Dr. Lean felt that the Roadmap did not describe a plan for adequately understanding systematic (i.e. ionosphere, thermosphere and mesosphere: ITM) interactions. Dr. Torbert felt that the Roadmap had accomplished much given the budget constraints. Dr. Lean commented that the ITM community is dissatisfied with its representation, and that NASA continues to be lost in the quest for understanding of space weather. Dr. Barbara Giles, Executive Secretary of the Heliophysics Subcommittee, noted that the Roadmap team had examined issues carefully and had made compromises, recognizing that in order to address the breadth of the Heliophysics system with multiple missions, HPD would have to limit the cost of individual missions so as to remain within the available budget. The Roadmap strategy is to accomplish as much as possible within each mission, competing the design within cost caps.., so as to be able to deploy a system of six missions.. This compromise is meant to address the system science as well as serve the individual needs of specific scientific disciplines. Dr. Torbert noted in this context that there are two missions in the queue that address ionospheric science, and urged Dr. Lean to read the particulars. Asked how missions were costed, Dr. Giles explained that the Roadmap developers used 2-3 design reference missions, some large and some small, and performed cost studies done on the Design Reference Missions (DRMs). The six missions in the science queue were spaced out over time and given cost caps based on results of the DRM cost studies.

Dr. Torbert reported further on the progress of the Heliophysics System Observatory, noting that missions in the Great Observatory (GO), a widely deployed fleet of instruments, are well supported within the new Roadmap view. He also reported on the progress of new missions in development. The Radiation Belt Storm Probe (RBSP) mission is in phase C, and MMS is also in phase C for a 2014 launch. The new SMEX, IRIS, will study solar chromospheres. Other Missions in development include Solar Orbiter, Solar Probe Plus, Space Experimental Testbeds (SETs), and the suborbital BARREL program. Supporting elements are an active Theory and Modeling program, international and inter-agency partnerships, GI and SR&T programs, low-cost access to space (LCAS), Virtual Observatories, DA programs, and data

centers.

Recent HPS findings concern the upcoming Heliophysics Decadal Survey, which the subcommittee would like to see concentrate on identifying objectives and avoiding specific implementation advice. The HPS concurs that the Decadal Survey should provide an overarching strategy for carrying out these objectives, naming ranked science objectives for missions as opposed to ranked mission designs.Dr. Giles added that the objectives could be considered in a similar fashion as the New Frontiers missions, in terms of science targets to which the community can propose, thus leaving the AO to define implementation. In response to a question, Dr. Giles explained that in the roadmap exercise, Flagships were not recommended for the 20-year time frame, giventhe funding available and the community's desire to deploy several missions rather than one.Dr. Kennel felt that the HPD Roadmap was a good-faith planning tool, and should be considered by the Decadal Survey as valuable input.

HPS suggested through a finding that a sub-goal for Heliophysics research should more accurately reflect the interaction between Sun and Earth. An HPS finding to SMD applauded efforts to procure low-cost access to space (LCAS) but was concerned by excessive mishap reviews of small failures, and has since been encouraged by mission assurance efforts to facilitate small, moderate-risk flights. A finding on solar wind monitoring expressed concern about data handling; HPS found that the while the Mission Operations and Data Analysis (MO&DA) program is being managed appropriately, it is underfunded.

Dr. Torbert briefly reviewed science highlights, noting that data accumulated during the continuing and peculiar solar minimum, characterized by weak magnetic fields at the Sun coupled with Earth's cold and sparse ionosphere, has demonstrated a direct influence on Earth. The effects of the minimum are persisting, and galactic cosmic rays are at record highs. The solar wind speed is still dropping, and Earth's radiation belts are at record low measurements. Dr. Kennel observed that galactic hard cosmic rays are the ultimate limit to dwell time in space, and are most relevant for humans in space; for soft particle events (from coronal mass ejections: CMEs), astronauts could use temporary shelter for protection.

The Interstellar Boundary Explorer (IBEX) has detected an unexplained ribbon of emission of energetic neutral atoms. WIND has observed expansion and heating of solar winds. The CRaTER instrument on LRO has detected unexplained ionizing radiation emanating from the lunar surface, possibly arising from the Moon's interior, implying therefore that a lunar astronaut could not burrow into regolith for the purpose of shielding from a CME event.

HPD Director Dr. Richard Fisher provided a status on HPD, beginning with a review of operating missions and upcoming MoOs. The Solar Dynamic Observatory (SDO) was successfully launched on 11 February 2010. The suborbital program goal is about 20 launches per year; 16 launches are planned for this year, with 2 recent successful launches. The Solar Probe-Plus AO is out, which will be followed later this year by the Explorer AO. Dr. Fisher noted that the Explorer flight programs serve both HPD and APD. RBSP has completed its critical design review (CDR) with no issues. The BARREL program recently had four payloads successfully launched in an Antarctic test campaign, but is currently investigating a power system anomaly. The ESA/NASA mission, Solar Orbiter, has officially extended phase A through 2010, for which NASA will provide a few instruments and/or instrument components, plus a launcher; ESA will provide the remainder. Dr. Lean remarked that there were no cutting-edge missions in ITM. Dr. Fisher replied that HPD is indeed investing $1.6B into the study of Earth's magnetosphere, which is linked to the ionosphere, and added that ITM proposals must be considered in the context of science merit. Furthermore, concern about the ITM has been written into the HPD Roadmap. Dr. Huntress noted further that the ITM issue will also be taken up by the Decadal Survey. Dr. Fisher felt that a robust, noble goal, resource and political would be required to carry out an ITM mission, and that the Roadmap examines this issue in all three respects.

The MMS mission is now in phase C/D, and a letter of agreement for their contribution of a scientific instrument has been signed with JAXA, MMS for launch in 2015. Hinode's end of prime mission review has been conducted. The Explorers IRIS mission underwent a major review in January and is on a very fast track. The ESA LISA Pathfinder schedule has slipped, and additional funding must be found to keep it going. Work is under way at NOAA to refurbish two NASA instruments for the DSCOVR mission. NASA will provide the spacecraft for DSCOVR, and NOAA will secure the launch vehicle.

Dr. Fisher reported that Space Weather is now a section of the American Meteorological Society, and noted that there has been great interest in this area. HPD has initiated Heliophysics Decadal Survey talks with the NRC. Heliophysics missions in development are mostly green on the stoplight charts. Recent end-of-prime-mission reviews include: Aeronomy of Ice in the Mesosphere (AIM), the first comprehensive global-scale view of noctilucent clouds; THEMIS, which has discovered new links between the ionosphere, mesosphere and the propagation of aurora; STEREO and SOHO, which detected the first M-class flares of the new solar cycle; and Hinode, which yielded new insights about the origin of solar wind, determining that it is driven by powerful magnetic fields at the outer edges of active solar regions.

Dr. Fisher reviewed particulars of the recently launched SDO mission. Full mission success is defined as the completion of 22 72-day intervals. SDO includes the EVE instrument, which measures the distribution of ultraviolet radiation emitted from the Sun; AIA telescopes with high data cadences that will be used to study recombination of magnetic fields; and the HMI instrument, which will perform helioseismological measurements from the photosphere to one-third the distance into the interior of Sun. Dr. Fisher noted minimal cost growth with this mission, even with the launch delay.

HPD's budget strategy has enabled a robust schedule of small, medium and flagship missions to achieve the majority of the 2003 NRC Decadal Survey missions. The division's 2010 Senior Review will determine the tenor of the operating fleet to achieve maximum science return. HPD continues to cope with some challenges: Solar Orbiter will now launch in 2017, and Congressionally-directed reductions to R&A and GI program will have to be absorbed. The Solar Probe Plus budget has been increased, but program content overall will stay the same. At present, HPD has 20 operating missions, and 30 spacecraft. The division will be supporting new fellowships, and will also be releasing new textbooks in graduate-level Heliophysics. In response to HPD recommendations and findings, Dr. Fisher reported managing to the Roadmap as suggested, and an agreement to rewrite mishap procedures. HPD remains concerned with MO&DA funding levels. Dr. Huntress applauded the new start for Solar Probe.

February 17, 2010

Future meeting dates

The Committee discussed future meeting dates and agreed on the following: April 20-21, 2010, at GSFC; July 13-14, 2010, in DC area, and September 28-29, 2010, as a virtual meeting (WebEx and telecom only).

Astrophysics Division (APD) Update

Dr. Craig Hogan, Chair of the Astrophysics Subcommittee (APS) presented an update of recent APS and APD activities, beginning with science results. He reported an incredible year for 2009, representing a peak in Astrophysics science. The SM4 repair mission provided a thorough update of HST, which is working beautifully, and has experienced an order of magnitude in its ultraviolet spectroscopic capabilities. WISE has launched, providing another significant technical improvement in near-infrared

imaging. WISE will function as a critical finder scope for the future JWST. Kepler has launched and has started to return excellent science. Kepler is expected to be in the news frequently, detecting exoplanets in the habitable zones of stars. SOFIA, an airborne infrared telescope and successor to the Kuiper airborne observatory will soon transition to early science operations. Herschel Planck has launched successfully. Herschel is an infrared mission that is complementary with SOFIA; and Planck will map the radiation of the early universe. Preliminary data from both missions is very promising. Dr. Hogan praised the success of the White House Star Party public outreach effort, which had been a highly anticipated event.

New millisecond pulsars have been found in unidentified sources using a variety of ground-based assets. WMAP and Fermi data have also shown what appears to be a protostellar bubble in the center of the galaxy, in both gamma and microwave energy bands. Most spectacular are the findings of Kepler: five exoplanets have been detected, some of which possess extremely low density (.017), comparable to Styrofoam. Kepler's precision photometry has also produced data of unprecedented quality on the stars themselves. It is estimated that three years of data collection will be required to detect the first Earth-like exoplanet. In response to a question, Dr. Morse noted that JWST would be the best candidate to look for biomarkers such as water in exoplanets detected by Kepler, and that there is in fact a JWST Working Group considering this problem. Targets are prohibitively dim stars (magnitude 9- 13). Dr. Morse discussed briefly the loss of two Kepler CCDs, representing a loss of 5% of the field of view. The net effect of the loss is that it will take a little longer to cover the sky in each cycle.

Dr. Morse continued with a review of APD activities. WISE began its 9-month survey in January 2010. The balloon program is being regarded with new enthusiasm, particularly missions such as CREAM V around the South Pole during the summer months, and Superpressure Balloon testing, including Ultra-Long Duration Balloon (ULDB) testing is being conducted; last year one ULDB flew for 42 days. The goal of the ULDB program is to fly 100 days at mid-latitude ranges, with night observations. A 25 million-cubic-foot balloon could carry about a one-ton payload. Another ULDB test will be conducted in September 2010, after a recent failure has been satisfactorily analyzed. Thus far, the failure seems to have been due to a manufacturing flaw. Once these issues have been resolved, APD plans to solicit proposals for balloon payloads. APD is trying to encourage the growth of the Suborbital Program in general, to offer better capabilities and to be more substantive in both science and technology. Balloon payloads are generally more science-driven than Sounding Rockets, the latter of which are better for testing technologies.

Upcoming milestones

Senior Reviews will determine the fates of several missions this year. Dr. Morse noted that while the Spitzer telescope is drifting away from Earth, it possesses at least several more years of science viability in its warm phase, and will be the subject of at least two more proposal cycles. The Astro2010 Decadal Survey is expected to be delivered in late summer 2010, weighing in on LISA and the Joint Dark Energy Mission (JDEM)- the hope is that at least one of these missions will fly in the next decade, but it is recognized such hopes are larger than available funding will permit. An NRC study of NASA's Suborbital Research Capabilities is due imminently, to which NASA will be responding over the next year. Asked about obtaining suborbital flights on commercial vehicles, Dr. Morse reported that a recent request for information (RFI) received only a lukewarm response, resulting in mostly fair and poor category proposals. Dr. Weiler added in this context that it was hard to justify rocket flights for astrophysical science, as rockets are regarded more as a means of testing instruments. SMD will release another ROSES announcement for attached payloads only. Dr. Burns hoped to see opportunities for inexpensive rocket flights that could carry student payloads. Dr. Weiler replied that those hopes would depend on progress in the commercial vehicle market.

Responding to APS recommendations, the division and the subcommittee are creating a new framework

for a new Technology Fellowship to support creative scientists who can interact with engineers and create new technologies. The new five-year fellowship is meant to nurture postdoctoral students and junior faculty and allow them to advance their careers, and is an addition to existing postdoctoral fellowships such as the Hubble and Sagan. The fellowships would make greater demands on the host institutions (including industry) and mentors. The cost is estimated at $1-2M per year, and will not be taken from the R&A program. Dr. Weiler pointed out that any "new" funds would come from future missions. Dr. Hogan remarked that he recognized the chicken-and-egg problem, and stated he would not be opposed to the use of R&A funds to support the fellowship, if necessary. Dr. Burns applauded the idea and suggesting that it might be broadened to include other science divisions, as well as the new Chief Technologist office.

APS is also in the process of standing up new Program Analysis Groups (PAGs), community-based groups that address subdisciplines within the sciences. APS currently has an Exoplanet PAG (ExoPAG) chaired by APS member Dr. James Kasting, and has recommended the establishment of a Physics of the Cosmos and Cosmic Origins PAGs (PhysPAG and CorPAG), both of which are now being developed. The Science Committee concurred on this decision and Dr. Huntress agreed to bring the issue to the NAC.

Dr. Hogan addressed the upcoming Explorer program opportunities, to emphasize strong support for a competitive process for giving both stand-alone missions and missions of opportunity (MoOs) a fair science hearing. Dr. Levy suggested leveraging such missions with the newly proposed technology fellowship.

Dr. Jon Morse reviewed aspects of the APD budget, noting that the FY10 enacted budget will suffer a Congressionally directed reduction, part of an SMD-wide $59.2M reduction, including a directed cut to R&A of about $1M. Planning for LISA, JDEM, IXO and SIM Lite remains unchanged, pending the new Decadal Survey. There are some new augmentations that will enhance SOFIA and JWST cost reserves. Gravity and Extreme Magnetism (GEMS) Small Explorer (SMEX) has been selected for a 2014 launch. Kepler has received funding augmentation to support a more robust ground-based follow-up. R&A and the Suborbital Program have been allocated steady funding at FY10 levels, while the division continues to work on unobligated funds. JWST requirements are stable, using its workforce efficiently and aiming to launch on schedule. Questioned about an increment of $85M on JWST, Dr. Weiler explained that SMD was following Headquarters direction to maintain reserve levels; this action does not reflect the existence of any technical problems. Dr. Burns noted that the media has misinterpreted this action as overruns. Dr. Morse observed that for a mission of JWST's complexity, a 2% correction represents incredible fidelity. Furthermore, he noted that APD is spending only 40% of its budget on Flagship missions, as opposed to 60-70% in the past. APD also paying the lowest fraction on the development of future technologies, but the new PAGs will help to fix that. APD's budget strategy is to be conservative in the outyears and asking has asked the Decadal Survey to follow this guideline. Dr. Burns expressed concern that the whole portfolio for SMD is falling off, and pondered how to stably manage NASA through budget fluctuations while training future talent. Dr. Huntress remarked that lower-cost mission lines and programs with healthy, realistic reserves will pave the way to the future, making planning more efficient.

In light of Dr. Hogan's end of term as APS Chair, the Science Committee gratefully acknowledged Dr. Hogan for his service to the subcommittee.

<u>Presentation of Exceptional Public Service Medal to Byron Tapley</u>
Administrator Charles Bolden briefly joined the proceedings to present Dr. Byron Tapley with NASA's Exceptional Public Service Medal and accompanying plaque. Mr. Bolden thanked Dr. Tapley for his service to NASA over the years and also thanked the NAC Science Committee for its efforts in guiding

the science policy of the Agency.

Earth Sciences Division (ESD) Update

Dr. Tapley, Chair of the Earth Sciences Subcommittee (ESS) presented recent results of ESS activities. The subcommittee issued no new recommendations, but Dr. Tapley noted that a number of concerns have arisen from the incompatibility between ESD requirements and the available budget, which may evolve into future recommendations.

A number of science results were reviewed, namely those in water mass movement, a key climate driver. The GRACE satellite has enabled some water mass estimates and thus has helped to elucidate the parameters that drive increases in sea level, which is influenced by temperature and increased water mass. GRACE provides altimetric data, and the Jason/Argo system provides buoys to measure salinity and temperature. Dr. Tapley acknowledged tectonic effects and their contribution to these measurements, and corrections made for other geophysical variables.

GRACE has also detected and documented unsustainable groundwater loss in the San Joaquin Valley, CA and NW India. The UAVSAR synthetic aperture radar instrument on GRACE also measured the deformation of Hispaniola faults following the Haiti earthquake, carried out extensive mapping in real time.

Remarking on the large number of satellite observations required for climate study, Dr. Tapley noted that Earth Science satellites and sensors are aging and plans for replacement are uncertain. In addition, the division has endured failures of QuikSCAT and IceSat. There is the strong application in each EDS theme for societal impact, as stated in the Decadal Survey. Overall, mission classes are regarded as foundational or Decadal Survey-based, fulfilling national needs, or climate/operational. The ESS has expressed concern about the adequacy of assumptions on foundational missions as expressed by the Decadal Survey. The ESS feels that simultaneity needs are not being satisfied by current missions, data continuity is not being addressed, international collaboration and data availability from international partners are not reliable, and the ongoing issue of NPOESS is distressing. Dr. Hinners asked if there were ESD assets for solar irradiance monitoring. Dr. Freilich replied that this is being fulfilled in the Glory mission. In addition, ESD has made a commitment to fund foundational missions within the FY10 budget, however Decadal Survey missions are only partially funded, and climate/operational missions are essentially unfunded.

ESD Status

Dr. Freilich, Director of ESD, presented a status of the division. He began by displaying a Terra image of heavy snow cover on the UK on January 7, 2010, showing the effects of an almost unprecedented, extreme negative phase of the Arctic Oscillation. ESD is currently flying 15 satellites, with 13 producing excellent science, QuickSat and IceSat have come to the end of their science missions, but he noted that both satellites were well beyond their intended lifetimes. Plans are under way to bridge the IceSat data gap with the airborne ICEBRIDGE program. Missions in formulation and development include Glory (aerosol and total solar irradiance) later this year. The AQUARIUS mission has slipped, but all of its instruments have been integrated. NPOESS Prime (NPP) has had a late delivery from partners, which necessitated a slip to September 2011. The LandSat Data Continuity Mission (LDCM) will be launched in 2012, and Global Precipitation Measurement (GPM) will be launched with JAXA in 2013 (the mission has been de-scoped due to accommodate required reserves). ICESat II and the Soil Moisture Active and Passive (SMAP) missions are in planning.

ESD has received a budgetary augmentation which includes a specific direction to re-fly OCO (OCO-2), both for scientific and national need. The division was also given a substantial climate initiative with a

few strings attached, such as data analysis. Data provided by NASA will be fed into some NOAA climate products and services, but there is no joint interagency plan governing this activity. Dr. Freilich noted that the NPOESS climate deficiency is not being adequately mitigated.

The budget augmentation is not being used for any previous foundational missions, and will build on an existing, balanced program. OCO-2 development and launch is scheduled to be accomplished by February 2013. The budget will allow acceleration of selected Decadal Survey missions- SMAP, ICESat II, DESDynI and CLARREO-1, or all four Tier-1 missions. The latter two will be flown as cost-constrained missions. Costs of the latter two missions were double what the Decadal Survey had estimated. The augmentation will also expand and accelerate Venture-class competitive, PI-led programs, allowing annual solicitations for major flight instruments plus biannual airborne and small-mission solicitations (about $90M per year). The goal is to develop common instrument interfaces by encouraging flights on ISS, international partnership missions, etc. Launch vehicles will be Pegasus, Falcon, and partner-provided launch vehicles-ESD will not choose the launch vehicle. Dr. Hinners remarked that ESD would be spending a large amount just to put something on the shelf. Dr. Freilich explained that ESD was trying to be prepared for short-window opportunities such that it might take advantage of partnerships as they arise, as well as take advantage of ongoing regular flights and international opportunities. Dr. Torbert suggested that ESD reserve some money for accommodation, and expressed skepticism on the subject of a common instrument interface. Dr. Freilich felt that the obvious pitfalls paled beside the more important need to move forward with a unique opportunity. Dr. Marc Allen noted that there is a continuous process of discussion going on in parallel to this activity, thus the "shelf" problem may never come up. Dr. Kennel supported the idea with some historical observations of successful partnerships with JAXA, wherein they offered berths for instruments on spacecraft.

ESD has also been directed to examine long-term measurements, provide affordable, programmatically realistic instruments that address pending gaps in long-term climate measurements, and to develop climate continuity missions. SAGE III has been tentatively identified as a mission, which can be flown on ISS by 2013, and GRACE-C, a follow-on mission to GRACE, will likely to be jointly developed with Germany. A wedge exists for potential additional measurements. ESD is also enabling key non-flight activities such as a multi-year carbon monitoring pilot program, and expansion and modernization of geodetic groundwork. The flight cadence allowed by the budget augmentation is dramatically improved, potentially allowing for 13 missions to fly out to 2017, based on a somewhat conservative cost estimate. Missions could be flown virtually every year, not counting Venture-class missions. As a scoping example, ESD could also allow planning and instrumentation for OCO-3. Dr. Kennel noted the significance of the current Administration's giving NASA leadership in climate continuity, remarking that it was a long overdue recognition of where the capability lies, refuting the view that such measurements are just a long-term time series. Science unfolds over decades, and the commitment to a sustained series stimulates research and applications in many, unexpected areas, fueling scientific interest. As an example, Dr. Tapley added that long-term time-series measurements allow the understanding of individual mass and temperature effects on sea level change. Dr. Levy commented that public and political discussion has also polluted the activity, and that the science is indisputable. He added that this endeavor is not just gathering evidence for already understood phenomena; there also are many unanswered science questions that require long-term terrestrial query. Dr. Lean observed that long-term measurements also applies to other divisions, such as in ITM, and that one cannot keep saying that NASA does not do monitoring. She suggested that HPD could take this same tack in arguing for a long-term L1 monitor. Dr. Tapley added that NASA should revisit the issue of long-term measurement across the Agency. Dr. Kennel recommended developing a framework for policy discussions on adaptation to climate change. Dr. Huntress suggested the Science Committee pose the issue as a finding, as it could represent a profound decision to support long-term planning of missions. Dr. Freilich expressed his support for the finding.

Unmet Expectations – The Tuning Fork Chart

Dr. Weiler briefly presented his renowned "tuning fork" chart, comparing the FY10 and FY11 budgets, illustrating the difference between FY04 in normalized dollars for science, showing that the FY04 budget is still substantially higher than FY11 in real dollars, representing at least a two billion dollar gap between 2004 and the present. He asked the Science Committee to consider this in light of public perception that overruns are the real problem. Dr. Burns noted that in a recent meeting with John Holdren, President Obama's Advisor on Science and Technology, Dr. Holdren expressed commitment to restore science funding, in part due to consideration of the real funding issues presented by Dr. Weiler.

Explorer AO Discussion

Dr. Weiler re-introduced the subject of two full Explorer missions versus one Explorer and MoOs. Dr. Huntress felt that to achieve maximum science return per dollar, one must maximize flexibility, as opposed to a pre-decision to do one or the other. Dr. Kennel agreed, but pointed out that in a discretionary program, it is hard to explain why the money is available in unspecified form- this approach must be accompanied by a clear explanation for the reason. Dr. Weiler noted that support for an Explorer mission is usually a given in the community, and proposals come with thorough cost and technical reviews; selection would be based on cost risk and technical risk. He emphasized to some anecdotal objection, that the proposal must be category 1 science in order to be selected. He stated that he would choose the clear winners, and if they were all good, he would select the low cost-risk, technology-ready proposal. Duplicative science does not get a category 1 assessment.

Dr. Hinners noted that it makes sense to have the option of MoOs, while ensuring that the community understands there is no hidden prejudice, and that science will dominate. Dr. Huntress remarked that there is a perception of bias against MoOs, which needs to be addressed adequately. Dr. Torbert felt that he could convey the dilemma to the Heliophysics community. Dr. Huntress agreed that the SMD AA must have maximum flexibility in order to make an objective decision. Dr. Morse added that the Explorer program might be useful for introducing game-changing technologies, and recommended Solar Orbiter as a means for getting technologies to appropriate TRLs. He added that the value of MoOs can be exemplified in the Astro-H mission. Dr. Weiler noted that another option in all AOs is a category 3 designation that is not often used. Category 3 is defined as good science with low TRL technology; this is how the Kepler mission was born. Dr. Levy argued that within universities, there seems to be an inadequate number of scientists writing category 3 proposals. Dr. Torbert felt that category 3 proposals were automatically eliminated because the level of effort is so high. Dr. Kennel remarked that a consistent policy for supporting category 3 proposals would help this cause. Dr. Hertz countered that the challenge is that a researcher must write an entire mission proposal when all he/she wants is technology development money; another path would be more useful. Dr. Weiler reiterated that technology proposals must have justifiable science. Dr. Huntress felt this dilemma constituted another argument to re-establish the New Millennium Program (NMP).

ISS utilization for science and technology

The Science Committee briefly discussed how to consider the ISS for science utility. Dr. Kennel suggested inviting the Director of ISS Utilization to the next NAC Science Committee meeting. Other suggestions were to direct the science subcommittees to consult with the Deputy Directors on the issue of how ISS can be useful, and then become informed about how NASA will go about ISS utilization. Dr. Weiler noted that ESD is already using Venture-class funds to develop an ISS instrument.

Dr. Huntress opened up the discussion for further issues. General approval existed for a re-start of Pu-238 production and approval of the new APS PAGs, and for supporting ESD toward long-term measurements,

in the context of a long-term climate research program characterized by quality and calibration from decade to decade. The committee called for stability in the commitment to quality in climate data, which was deemed to be better held in the research rather than the operational community. Mr. Dom Conte of General Dynamics commented on the Explorer issue, acknowledging that industry could not speak to science in each proposal, and requested better insight into the odds of being selected. Dr. Weiler recommended that industrial proposers hire science consultants for this purpose. Mr. Lamont DiBiasi commented that this approach does work if the AO is less specific, concentrating on output. Dr. Weiler commented that there was no easy answer, but acknowledged the issue. Dr. Burns wondered whether it was possible to leverage new technology to enhance the Explorer program, as it is important to fill future gaps with new Explorers. Dr. Huntress felt that science should not be performed with money tagged for technology development. Dr. Hinners remarked that before advocating a new NMP, NASA should evaluate the pros and cons. Dr. Fisher agreed to provide some additional material on lessons learned, in response to a final report cited by Dr. Weiler. Dr. Kennel advocated improved access to space to improve technology, including a discussion of NMP lessons learned, and concern for the education pipeline; Dr. Huntress agreed to write the relevant finding. No public comments were noted. Dr. Huntress adjourned the meeting.

Appendix A:

Meeting Attendees

NAC Science Committee members
Wesley Huntress, *Chair*
Byron Tapley, University of Texas, *Vice Chair* and Chair Earth Science Subcommittee
Jack Burns, University of Colorado
Ronald Greeley, Arizona State University
Noel Hinners, Self
*Craig Hogan, University of Chicago, Chair Astrophysics Subcommittee
†Charles Kennel, Scripps/University of California at San Diego
Judith Lean, Naval Research Laboratory
Eugene Levy, Rice University
Roy B. Torbert, University of New Hampshire, Chair Heliophysics Subcommittee
Michael Turner, University of Chicago

* = representing the Astrophysics Subcommittee for this meeting only
† = *ex officio* member

NASA Attendees
Jim Adams, NASA Headquarters
Randy Albertson, NASA Headquarters
John Allen, NASA Headquarters
Marc Allen, NASA Headquarters
Jay Al-Saadi, NASA Headquarters
Stephen Ballard, NASA Headquarters
Scott Barber, NASA Headquarters
Max Bernstein, NASA Headquarters
Robert Braun, NASA Headquarters
Marguerite Broadwell, NASA Headquarters
David Considine, NASA Headquarters
Craig Dobson, NASA Headquarters
Mitra Dutta, NASA Headquarters
Michael Freilich, NASA Headquarters
Michael Goodman, NASA Headquarters
Charles Goodrich, NASA Headquarters
David Halpern, NASA Headquarters
Hashima Hasan, NASA Headquarters
Jeff Hayes, NASA Headquarters
Paul Hertz, NASA Headquarters
Peter Hildebrand, NASA Goddard
Charles Ichoku, NASA Headquarters
Nancy Jenkins, NASA Headquarters
Ken Jucks, NASA Headquarters
Amy Kaminski, NASA Headquarters
Mona Kessel, NASA Headquarters

Anne Kinney, NASA Goddard
David Leisawitz, NASA Headquarters
Eric Lindstrom, NASA Headquarters
Roy Maizel, NASA Headquarters
Hal Maving, NASA Headquarters
Michael Meyer, NASA Headquarters
Jon Morse, NASA Headquarters
Ruth Netting, NASA Headquarters
Marian Norris, NASA Headquarters
Douglas McCuistion, NASA Headquarters
Michael Moore, NASA Headquarters
Michael New, NASA Headquarters
Curt Niebur, NASA Headquarters
Arik Posner, NASA Headquarters
Jennifer Rumburg, NASA Headquarters
Linda Sparke, NASA Headquarters
Stephanie Stockman, NASA Headquarters
Mary Voytek, NASA Headquarters
Azita Valinia, NASA Headquarters
Tom Wagner, NASA Headquarters
Amy Walton, NASA Headquarters
Greg Williams, NASA Headquarters
Diane Wickland, NASA Headquarters
Dan Woods, NASA Headquarters

Non-NASA Attendees
Linda Billings, George Washington University
Yudhijit Bhattacharjee, Science Magazine
Dom Conte, General Dynamics
Joe Criscione, Stellar Solutions
Barbara Cherry, SGT Inc.
John McCarthy, Orbital Sciences
Richard Rogers, Stellar Solutions
Mike Monahan, OGC
Ken Ford, IHMC
Jon Malay, Lockheed Martin
John Petheram, Lockheed Martin
Chuck Rudiger, Lockheed Martin
Cynthia Wallace, Harris Corporation
Ana Wilson, Harris Corporation
Joan Zimmermann, Harris Corporation

Appendix B:

Committee Membership

Wesley Huntress, *Chair*
Byron Tapley, University of Texas, *Vice Chair* and Chair Earth Science Subcommittee
Jack Burns, University of Colorado
Ronald Greeley, Arizona State University
Noel Hinners, Independent Consultant
*Craig Hogan, University of Chicago, Chair Astrophysics Subcommittee
†Charles Kennel, Scripps/University of California at San Diego, Chair Space Studies Board
Judith Lean, Naval Research Laboratory
Eugene Levy, Rice University
Roy B. Torbert, University of New Hampshire, Chair Heliophysics Subcommittee
Michael Turner, University of Chicago

* = representing the Astrophysics Subcommittee for this meeting only
† = *ex officio* member

Appendix C:

Meeting Agenda

NAC Science Committee
February 16-17, 2010
NASA Headquarters

Day 1 (Tuesday, Feb 16) in MIC-3/3H46

8:00-8:30am	Remarks, Announcements, Introductions	Huntress, Feeley
8:30-9:30am	Annual Ethics Briefing	Monahan
9:30-10:15am	FACA Briefing	Feeley
10:15-10:30am	**Break**	
10:30-11:45	SMD Overview & Implications of new direction for NASA	Weiler, Huntress
11:45-12:15	Discussion	
12:15-1:15pm	**Lunch on Own**	
1:15-1:45pm	NASA Science Plan for 2010	Williams
1:45-2:15pm	Discussion	
2:15-3:15pm	Heliophysics	Torbert, Fisher
3:15-3:45pm	Discussion	
3:45-4:00pm	**Break**	
4:00-5:00pm	Planetary Science	Greeley, Green
5:00-5:30pm	Discussion	
5:30pm	**Adjourn**	

NAC Science Committee
February 16-17, 2010
NASA Headquarters

Agenda

Day 2 (Wednesday, Feb 17) in MIC-5/5H45

8:00-8:30am	Announcements/Future meetings	Huntress, Feeley
8:15-9:15am	Astrophysics	Hogan, Morse
9:15-9:45am	Discussion	
9:45-10:00am	**Break**	
10:00-11:00am	Earth Science	Tapley, Freilich
11:00-11:30am	Discussion	
11:30 – 1:00pm	**Lunch on Own**	
1:00-2:00pm	Special Topics & Assignments • Explorer AO Approach • ISS Science & Technology	Huntress, Feeley
2:00-2:30pm	Discussion	
2:30-3:00pm	Public Comment	
3:00-5:00pm	Findings and Recommendations	
5pm	**Adjourn**	