

NASA ADVISORY COUNCIL

SCIENCE COMMITTEE

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NASA Headquarters  
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MEETING MINUTES



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Wesley T. Huntress, Chair



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Greg Williams, Executive Secretary (Acting)

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### Remarks and Announcements

Dr. Wesley Huntress, Chair of the NASA Advisory Council (NAC) Science Committee, welcomed new members David McComas, Eugenia Kalnay and Scott Hubbard to the Science Committee. Reviewing the agenda for the day, he highlighted the 2011 Work Plan for the committee, and the pending formation of the Task Group on Analysis Groups (TagAG), a task group designed to help to understand how the Science Committee's (SC) Analysis Groups can support NASA efforts in human and robotic space flight. This task group will be chaired by NASA's new Chief Scientist, Dr. Waleed Abdalati. A memo outlining Administration policy for scientific integrity, issued by John Holdren of the Office of Science and Technology Policy (OSTP), was also distributed to the committee. The memo features a recommendation for a wider search for SC member nominees. Mr. Greg Williams, sitting in for SC Executive Secretary, T. Jens Feeley, distributed a calendar of upcoming meetings.

The committee noted that the FY11 Continuing Resolution (CR) holds NASA to FY10 spending rates, thus preventing new starts and new programs. The new CR cuts \$0.5B for Science in NASA (\$536M), which represents a significant funding crunch. Furthermore, the proposed FY12 budget assumes funding at FY11 levels, and then flatlines agency spending in the outyears, cutting \$6B over 5 years. Dr. Huntress recalled that 1992 marked a precipitous drop in NASA funding in an era when space science was dominated by flagship missions. At that time, many missions were either eviscerated or cancelled, and \$1B was removed from the Cassini program. There are obvious implications for the ambitious Decadal Surveys for Planetary, Earth Science and Astrophysics, which will require a difficult adjustment. Nonetheless, it is the Science Mission Directorate's (SMD) job to carry out Agency policy within this fiscal crisis.

### Overview of FY12 Budget Request including JWST

Dr. Ed Weiler, Associate Administrator of SMD, presented an overview of NASA's current operating and budget status, reporting that within the past 12 months, the Stratospheric Observatory for Infrared Astronomy (SOFIA) reached its pointing and stability specifications on its first attempt, and has begun its science flights. The Geostationary Orbiting Environmental Satellite (GOES) was launched for the National Oceanic and Atmospheric Administration (NOAA) earlier this month. The Solar Dynamics Observatory (SDO) launched in February 2010 and has been a tremendous success. The Cassini and Rosetta missions continue to be active and productive, and successful flybys of comets Hartley 2 and Tempel 1 were also achieved. SMD will be launching \$4B of planetary missions over the next 9 months, with MESSENGER due to begin its orbit around Mercury on 17 March. Dawn will go into orbit around Vesta, and Juno (an Outer Planets solar-powered mission), GRAIL (two-satellite lunar mission) and the Mars Science Laboratory (MSL) will launch in August, September, and November. NuStar, an Astrophysics mission, is scheduled to launch in early 2012, and the Radiation Belts Storm Probe (RBSP, a Heliophysics mission), will launch in May 2012. MSL will arrive at Mars in August 2012.

Dr. Weiler reviewed the most recent budget figures. SMD was authorized to receive \$5B in 2011, and the President's budget has allotted roughly the same amount. The CR allocates about \$4.5B, thus the community must be prepared for the possibility that \$4.5B is the most SMD will get, or possibly less than that figure. FY13-16 estimates are notional and may necessitate draconian cuts in the worst-case scenario. The budget is essentially flat in the outyears, although the Earth Science Division (ESD) increases slightly; the primary impact for ESD is that the Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) and Climate Absolute Radiance and Refractivity Observatory (CLARREO) missions will be moved out at least years. The Planetary Science Division (PSD) decreases from \$1.4B/year to \$1.1B/year in the outyears. The Astrophysics Division (APD) appears to be increasing, but this reflects the transfer of Explorer program Future Missions funds previously held in the Heliophysics Division (HPD). HPD is actually flat with a bit of inflation.

In constant FY11 dollars, science has effectively decreased from nearly \$6B in the mid-90s to less than \$5B annually. SMD is currently supporting a total of 84 missions, and 97 spacecraft.

The SMD FY12 budget strategy is to be responsive to the science community by supporting priorities in the National Research Council (NRC) Decadal Surveys, and also to be responsive to national priorities, such as the re-launch of the Orbiting Carbon Observatory (OCO-2). Each science theme must manage within its budget. Projects in development are budgeted to a life cycle cost (LCC) reflecting a 70% confidence level (CL). GRAIL, Juno and RBSP were budgeted using this philosophy and are currently coming in under budget. SMD is actively refining cost ranges and improving budget estimates over time.

The SMD portfolio has been affected by rising launch costs (much faster than inflation). New prices for Atlas Vs have increased significantly, and launch vehicle costs may de-scope the planned Solar Orbiter (SO) collaboration with the European Space Agency (ESA). The biggest blow will be absorbed by PSD, as their launch vehicles tend to be larger than other divisions. HPD will be affected almost as much.

### ***NASA Science Budget Changes***

DESDynI and CLARREO have been moved out at least 3 years. A second instrument for Global Precipitation Measurement (GPM) has been cancelled. PSD will not be able to support all five Planetary programs; this will entail cancellations, delays and de-scoping. APD may be able to fund its highest Decadal Survey priorities but will have no new funding (except for technology development) for large missions beyond the James Webb Space Telescope (JWST). In the Exploration Systems Mission Directorate (ESMD), the precursor robotic program was zeroed out, but some money has since been added back. JWST has been reduced to \$375M per year.

### ***JWST***

Mr. Rick Howard presented a status on JWST. Mr. Howard accepted the JWST Program Director position in November 2010 in a move meant to elevate program visibility and improve communication. JWST now has its own separate program line, reporting directly to NASA Associate Administrator Chris Scolese, with meetings occurring at least twice per week. The program has accepted the 22 recommendations of the Independent Comprehensive Review Panel (ICRP) report. While the program had been working at a 70% joint cost and schedule confidence level (JCL), the decision was made to operate at 80% JCL because of the complexity of the mission. The President's budget request for the program is flat from FY12 onward. The program re-plan started with FY11/12 numbers to provide a realistic schedule and cost baseline for the earliest launch date possible, and will begin running a joint confidence level (JCL) tool over the next few months. The program is also making significant progress in instruments, sunshade, mirrors, optical elements, spacecraft, etc. JWST flight hardware is well along in development; all flight hardware for mirrors will be completed within a year, with final testing of primary mirror segments to begin in April. Scale-testing on membrane management and the sunshade is also under way. Asked about a recently identified "hot pixel" problem, Mr. Howard reported that during NIRCам team testing of its 0.6-5 micron detectors, a substantial increase in high dark current pixels was noticed (from ~1% of the pixels to more than 2%). It is not yet clear why this increase over 2 years' time took place; the concern is that this increase could continue indefinitely. The same HgCdTe detectors are used on the NIRSspec and fine guidance sensor (FGS) instruments. A Failure Review Board has been established to determine the root cause; a report is expected in April. The specification is for no more than 5% of the pixels to be inoperable at instrument end-of-life [hot pixels count as inoperable]. The worst-case scenario would require brand-new flight detectors, including backups, which would cost approximately \$30M for all the instruments, and a year of development time. The same type detectors are used on the Hubble Space Telescope (HST) but they are cut off at 1.7 microns; whether the problem is unique to the 5-micron detectors (which contain more mercury) remains to be seen.

All mirror elements for JWST are complete and will be finished polishing by the end of the Summer of 2011. European Space Agency (ESA) flight instruments will also be delivered at that time. Based on budget guidelines from FY11 and FY12 (constrained), and using a detailed proposal from Northrop-Grumman for a rebaselined project the program is planning to a 2018 launch-readiness-date schedule. Re-plan options will be complete in May 2011. The bottom line is to have a new plan for JWST in time to be proposed for the NASA FY13 budget, using FY11 and FY12 constraints to hit the JCL 80% confidence level, and to determine what offsets are required and where they would come from. Asked if the end of the HST mission were to be linked to the JWST launch, Dr. Weiler would not speculate whether HST would be operable in 2018.

Dr. Weiler returned to the SMD budget presentation; he felt it would be possible to carry out a good program with \$5B with the aid of the subcommittees and the community. SMD is looking forward to competition in the launch vehicle market and plans to select the most reliable, cost-efficient rocket and build a program around it. The Directorate is also planning around budgets of less than \$5B (\$4.1B, \$4.2B, etc.). The first budget casualties would be the original increases to Planetary and Earth Science. ESA and NASA have similar budget concerns, and these have been the subject of bilateral discussions. NASA has already established a significant collaboration on Mars with ESA; the Planetary Decadal Survey will provide further guidance on this issue, and a bilateral meeting will follow closely upon the survey release. ESA and NASA were driven together by cost issues, and this collaboration is expected to continue.

#### Ethics Briefing

Rebecca Gilchrist delivered the required annual ethics briefing to the Science Committee, and provided a contact email for consultation on ethics matters: [ethicsteam@hq.nasa.gov](mailto:ethicsteam@hq.nasa.gov).

#### NASA Launch Services – II (NLS II) Update

Ms. Lynn Cline, Space Operations Mission Directorate (SOMD), reviewed the terms of the NASA Launch Services-II (NLS II) contract. The previous launch service contract (NLS I) expired in June 2010, but inventory will cover some launches out to 2015. The new period of performance is through June 2020, on the same terms as the previous contract, (indefinite quantity, indefinite delivery; IDIQ) and was negotiated based on not-to-exceed prices. The contract was also negotiated on a firm fixed-price basis, incorporating best commercial practices to the maximum extent. The current contract does not preclude a discount associated with a block buy, but NASA generally will be responding to individual mission requirements. Delta II/IV and Taurus II vehicles are not included on NLS II. However, every August, an opportunity opens for new launch service providers to enter the contract. Falcon 1 and 1e vehicles have been put on hold, but technically they are still on contract under NLS II. Other vehicles covered are the Falcon 9, Atlas V-401 and V-551, Taurus XL, and Pegasus vehicles. Multiple opportunities in different classes may better promote competition. Launch service cost comparisons are as follows: NLS I; small \$30-\$75M, medium \$50-\$80M, and intermediate (ELV class) \$100-\$125M. NLS II costs; small \$32-\$111M, medium \$102-\$136M, and intermediate \$102-\$334M. This represents actual costs for NLS I and not-to-exceed prices for NLS II, and includes telemetry services, mission assurance etc. not just what is paid to the service provider. Dr. Huntress commented that increased costs may force the agency to forgo mission content for vehicle prices, and that it would be extremely hard for users to plan with these services. Ms. Cline acknowledged these concerns and indicated that SOMD is working closely with SMD on how best to plan under these circumstances, Ms. Cline took an action to provide the percentage of the mission cost that is typically spent on launch services and how much it would change with the new prices. Dr. Huntress suggested that multiple buys could drive prices down. Ms. Cline responded that this would be difficult to accomplish because of the state of the industrial base; the last multiple buy did not net much of a discount. In the intermediate class particularly, prices reflect the large increase by ULA. NLS II terms dictate that the order year price is based on the launch date-minus 30 months, at which time a cumulative down payment of 10% is due. Payment is now required at award a change that was made to

allow NASA to establish a firm launch date with the provider. Ms. Cline noted that the contract includes a standard work plan, with milestones leading to each launch.

Challenges associated with the Evolved Expendable Launch Vehicle (EELV) will require close work with the US Air Force (USAF) and the National Reconnaissance Organization (NRO) to mitigate. Performance ranges offered by Atlas V are also less than expected, while prices have increased. Re-establishing a competitive medium class (with retirement of Delta II) will be a challenge. The cost risk for EELV remains, as well as schedule/cost risk to secure manifest slots (for Atlas V). The USAF is in between contracts and will continue to pay infrastructure costs, but they do not have contracts yet for the outyears; this may contribute to possible increased costs in the future. A crowded manifest is also contributing to the problem: payloads that had been delayed for months or years are now finally being delivered. The USAF is in the final stage of its acquisition strategy, has a budget before Congress, and is negotiating for a block buy. The plan for new vehicle purchases is 5 USAF missions and 3 NRO missions per year, starting in FY13. The USAF has a set number of similar satellites, etc., and can plan for payload/vehicle combinations more easily- the USAF is not quite as customized or one-of-a-kind as NASA. Asked about DoD vs. NASA costing for a rocket, Ms. Cline took an action to provide these numbers to the committee.

Atlas V performance has declined, in part due to vehicle hardware configuration changes and modeling updates over the last decade. There are a few hundred kilograms difference from the previous contract in terms of mass-to-orbit capabilities. The erosion in the industrial base, and a 100-800% increase in parts/supplies have also contributed to the issue. The USAF has looked into the phenomenon and found it legitimate. Current prices are based on ULA assuming 5 EELV launches per year; if more launches actually take place, the prices may go lower. However, the production rate overall is lower than in the past and ULA is also anticipating manufacturing smaller lot sizes. There is no more excess inventory; it must be borne in mind as well that NLS I prices had been heavily discounted, as the expectation at that time was for a large commercial market and a large number of communication satellites that did not materialize. The government became the primary customer for EELV. NLS II terms can be renegotiated depending on number of vehicles actually needed, and there have been discussions to this effect already. NASA has been meeting regularly with the USAF and ULA on the issue.

Asked about the availability of the Delta IV, Ms. Cline noted that ULA may “on-ramp” it in August. It was not selected in NLS I. In response to a question, Ms. Cline reported that NASA has already purchased EELVs for confirmed missions at a rate of one to two per year: one in 2011, 3 in 2012, 2 in 2013, one in 2014, and one in 2015.

NLS II effects on the science community will vary. MAVEN (a Mars aeronomy mission) is the first Planetary mission under the new contract: a similarly sized vehicle at the currently scheduled launch date would now be 17% more expensive, and a 2018 launch date would be 34% more than MAVEN. The Science Committee concurred that there will be a huge impact on the total number of missions that can be carried out in SMD.

The Falcon 9, a new and emerging launch vehicle, has similar performance to the Delta II, and is less expensive than the Atlas V. However, it is not yet certified for a NASA science payload and work is being carried out to accomplish this for SMD. NASA is partnering with other government agencies to accelerate the certification schedule, and expects an “on-ramp” of Delta II and Taurus II fleets in August 2011. The Agency is also working with DoD to partner on developing a certification strategy for emerging providers in the EELV class. Within the Falcon 9 block 1, category 2, NASA is looking for 3 successful flights, with a minimum 2 consecutive flights, before it will be considered for use. The staff at Kennedy Space Center are monitoring these launches, serving on engineering review boards, etc. to track the progress of these flights. In response to a question about how much it would cost to re-start Delta II

production, Ms. Cline took an action to provide documentation of the NASA decision-making process regarding Delta II from several years ago when NASA decided not to pursue that path.

In the meantime, Ms. Cline related that cost impacts continue to be addressed; the USAF and NRO are seeking budgets for follow-on ELC contract cost risks. Mitigations for additional enhanced launch capability (additional workforce to reduce turnaround time, e.g.) continue to be worked. ELC cost risk is at least an additional \$102M. The best mitigation strategy would be for the USAF sign a new contract to continue to support infrastructure to support two types of vehicles, per their mission requirements.

NASA will need to work very closely with the USAF to resolve problems, and with SMD to give the best information to bound costs and timing of decisions. Ms. Cline professed SOMD's commitment to continue to work with customers and to ensure mission success.

#### NASA Chief Scientist Presentation

Dr. Waleed Abdalati, recently appointed NASA Chief Scientist, addressed the Science Committee and described his background in Earth Science, research on glaciers and ice sheets, remote sensing, and managing the cryospheric sciences branch at GSFC. Dr. Abdalati stressed that he accepted the position in the hopes of making a difference and being useful as an advisor to the Administrator. He noted that Mr. Bolden had also expressed an interest in employing a Chief Scientist to address the complex relationships among the agencies. The functions of the new office are meant to be free from the burdens of implementation in order to take a broad agency view, and to offer a different perspective across directorates and centers. The Chief Scientist will also identify where activities span directorates, and where these activities may be leveraged, and also "orphan science" such as life and microgravity sciences, which now resides within ESMD, to address the role of science in exploration. The Chief Scientist will provide advocacy on behalf of science in general, through a philosophical approach. The office should be perceived as an additional avenue for communication, not an opportunity for an end-run. The main goals are to maximize science return for investment of resources; the objective is to put NASA science at the forefront. As the space program is transitioning, there is an opportunity to highlight this.

Dr. Boss noted that the most recent Astrophysics Decadal Survey called for a Decadal Survey Implementation Advisory Committee (DSIAC)-based annual review, and asked how the NRC should coordinate with how the NAC advises SMD. Dr. Abdalati concurred with the idea that the assurance of NASA's compliance should probably reside with the advisory subcommittees. Dr. Abdalati's view was that Decadal Surveys are useful if properly executed, but thinks that the DSIAC would be valuable if it can appreciate other dimensions. Dr. Marc Allen commented that the 5-year cyclical contract with NRC is about to expire, presenting a good opportunity to re-vamp, and to improve the effectiveness of standing committees operated by the Space Studies Board (SSB), which also contains a degree of overlap with DSIAC objectives. NASA is already in discussion with Dr. Kennel to re-charter and restructure the advisory committees so that they will be able to carry out some DSIAC functions, with an eye to keeping the advice chain integrated. As of now, standing committees are not permitted to deliver advisory reports/products. Dr. Kalnay asked if it would be possible to reevaluate recommendations more frequently. Dr. Abdalati commented that the ESD has the added complexity of following policy and priorities set by the Administration, and felt that NASA would benefit from hearing from the chairs occasionally, but that the Decadal Survey must have a certain amount of staying power.

Dr. Huntress regarded SMD as already possessing its own strategic planning functions, and saw the Chief Scientist's position as contributing a broader agency perspective to strategic planning, and also taking that perspective from SMD and representing it to Administrator Bolden; he was pleased to hear that the Chief Scientist is not a figurehead role, and was instead a statement by the NASA Administrator that science is a priority. Dr. Torbert expressed concern about "evaluating ourselves to death," pointing out that the Heliophysics Division (HPD) carries out a roadmapping process every 3 years, which feeds constantly

into the Decadal Survey process. Dr. Abdalati noted that over-evaluation often results from community member complaints, which undermines original processes put in place; they go to the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP) to force new evaluations. As long as there is community buy-in, the HPD strategy is just right. Dr. McComas asked how the view of NASA can be shifted toward a more objective one. Dr. Abdalati suggested having a different kind of conversation; not just advertising NASA's great achievements, but focusing on concepts like looking at the edges of the universe, studying the evolution of the universe, and speaking to the core of the human spirit. Science should be connected to questions that persist in all humans- where are we going, where did we come from, and are we alone? NASA serves both science and society; it is important to understand that. There are emotional, pragmatic, cerebral reasons for exploration, as well as inspiration. Dr. Hubbard expressed hope that the Chief Scientist could be a voice for the life sciences and International Space Station (ISS) community. Dr. Abdalati hoped the Decadal Survey would support this notion or at least start a path forward through transparent processes, ensuring the community a voice. As it stands, it is vulnerable in the ESMD, and may benefit from its own subcommittee.

Dr. Huntress commented that the space science division conducts itself through peer review and competition, as well as external advice- all key to making it admirable; this philosophy hasn't infused into the rest of the agency. Dr. Abdalati believed that peer review and external advice would make the budget less vulnerable, and that the Agency needed to be vigilant about straying from that path. He felt there was room for a small amount of activity that is not peer-reviewed (i.e. high-risk, high-return projects), but that this type of activity also requires an adequate process for assessing its merits. Dr. Kalnay asked how one might handle Congressional members who do not accept beliefs on climate change. Dr. Abdalati felt it necessary to focus on the fact that no matter what one believes re: climate change, there are humanitarian, military, and other types of value in trying to understand forecasting. It's important to know what's coming. Asked how he might work with the OCT, Dr. Abdalati reported that he was already working closely with Dr. Bobby Braun, and expected this to continue. Dr. Torbert commented that science and technology can intersect in game-changing instrumentation research. Dr. Abdalati noted there were some resources for a small amount of this research. Dr. Tapley commented that he did not see an opportunity in OCT to engage in activities that have no defined outcome. Dr. Abdalati agreed, adding that these activities could be costly. Dr. Hinnert noted that in the ESD particularly, there is difficulty from going from the research to operations end when developing instrument sensitivity (that is geared toward scientific measurement). Dr. Abdalati responded that ESD Director Michael Freilich is involved in the US Global Research Change Program (USGCRP) effort in acquiring environmental data sets, and elevating instrumentation beyond weather specifications. OSTP seems to be paying attention to this effort. Dr. Boss recommended studying ways to achieve high-risk science associated with an innovative, 1980s-era research program (Rosendahl).

#### PSD Update

Dr. James Green presented an overview of the Planetary Science Division (PSD). Stardust is taking last set of images of comet Tempel 1, and Deep Impact has been turned off. Deep Impact still has some fuel for a third use, and PSD is analyzing inputs from the community for a potential call. Stardust is close to the end of its life. Juno, the lunar mission GRAIL, and the Mars Science Laboratory (MSL) are all poised to launch later this year. PSD has been working with ESA on the Jupiter Ganymede Orbiter for a mission of opportunity (MoO). Major accomplishments for PSD programs include preliminary design reviews (PDR) for both the lunar mission, LADEE, and the Mars aeronomy mission, MAVEN. Five instruments have been selected for the ExoMars Trace Gas Orbiter in 2016 (4 US instruments and 1 ESA instrument). Cassini has started its solstice mission (extended mission). The Spirit and Opportunity rovers celebrated their 7<sup>th</sup> anniversary on the Mars surface; Opportunity is still doing well. PSD has received 28 proposals for the Discovery program and is supporting JAXA's Hayabusa asteroid sample return; NASA will receive 10% of the sample mass for analysis.



The budget strategy in progress for PSD is to ensure successful launches of Juno, GRAIL and MSL, while recognizing that the Planetary portfolio will have to be restructured, budgeting for higher launch costs, covering 50% of the domestic Pu-238 production re-start, etc. It is important to note that FY12 begins a period of precipitous decline in budget dollars, amounting to about \$1B in reduction in the outyears, compared to the proposed FY11 budget. The Mars 2018 opportunity, Outer Planet (OP) Flagship missions, and the Mars Sample Return (MSR) mission are indefinitely delayed. There will also be a reduction in the Discovery flight rate due to launch vehicle costs. Operating missions and upcoming launches will remain the same.

Regarding the re-start of Pu-238, in June 2010, the Department of Energy (DOE) issued a joint NASA/DOE initiative to Congress. The initiative cannot be executed because Congress has not enacted a FY11 budget. The last purchase of Pu was made from Russia in December 2008. The Russians have renegotiated the contract with a preliminary estimate of a next delivery to be no earlier than (NET) calendar year 2013; quantities and pricing are procurement-sensitive. The Stirling generator is still in the technology line, and fully funded, and will be tested by 2014. The Stirling device may or may not be used by a Discovery mission. As to domestic Pu-238, the FY12 budget request supports the restart, which is also Decadal Survey-dependent. As a mission-enabling capability, it will be critical to infuse radioisotopic power regimes into smaller, low-cost missions to continue to explore low-light regions.

Dr. Ron Greeley, Chair of the Planetary Science Subcommittee (PSS), reported on subcommittee reaction to the budget climate. The subcommittee is deliberating on how to advise PSD, and is awaiting the release of the Planetary Decadal Survey on 7 March, which will help provide a strategy for making hard decisions. There are several new PSS members, many of whom were on the Decadal Survey panel. PSS currently has a request to NASA for extending some members for one month to deal with the Survey outcome.

PSS feels that the proposed post-FY12 budget is a disaster for PSD. There is no provision for strategic missions such as Mars and Outer Planets. The budget does not allow for new starts anticipated from the Decadal Survey. The budget places in jeopardy the talented work force and key centers for Planetary projects. The US could lose its preeminent place in Solar System exploration. It is clear that NASA must think more seriously about international partnerships.

PSS working groups have identified some cross-cutting issues, such as the need for planetary simulants in the Mars, lunar science, and sample curation milieus (a joint Working Group report is now available). There is also the potential for joint charters from SMD and ESMD. Prompted by recommendations from the NRC regarding mission-enabling technologies, PSS initiated a study in Spring 2010, and has produced a report draft, reiterating findings of the Fisk report, describing planetary science objectives and their linkages to mission enabling activities. Recent science highlights include intriguing data coming from the Opportunity rover, now at Santa Maria crater, which is providing fresh ejecta for analysis, in concert with remote sensing analysis that has indicated the presence of hydrated sulfates on the crater rim. The rover is also investigating the strata at the rim.

Dr. Green concluded the presentation by addressing science highlights for PSD. There have been a tremendous number of mission milestones, which will help to bring in data, and feed the community through R&A program. MSL will be the most capable analytical laboratory on Mars and will search for evidence of organic molecules, and isotopes of methane. MESSENGER will drop into its orbit of Mercury, to study a planet with a core that is larger than Earth's core, and which shows clear evidence of vulcanism. Dawn will orbit Vesta, a 500-km asteroid, and proceed a year later to Ceres, the largest asteroid in the asteroid belt. These missions will continue to feed the revolution in the field. A flyby of Pluto will occur in 2015, and Juno will reach Jupiter in 2015/16. PSD continues to plan for the future. The Discovery selection is on schedule, but could be derailed by a budget significantly below the 2010 level.

Asked if there were a possibility for a joint Bepi Colombo activity with MESSENGER, Dr. Green replied that the MESSENGER's life is too limited to permit a link.

#### Administrator Bolden Visit

Administrator Charles Bolden visited with the Science Committee, reporting that he had just returned from a House Appropriations Committee meeting, where he fielded several questions on SMD. Cong. Adam Schiff (D-CA) was curious about the Planetary budget, and Cong. John Culberson (R-TX) was heard to say that he wants a Europa mission "at any cost." Mr. Bolden also expressed great admiration for Dr. Abdalati as an incredible addition to the Agency, and hoped he would develop a good relationship with Dr. Ed Weiler, Associate Administrator of SMD. Mr. Bolden reported having met with the full House Science, Space, and Technology Committee the previous day, and described it as a very collegial meeting. The Congressional committees did report some concern over JWST and its impact on the NASA budget. However, Mr. Bolden expressed confidence that the JCL process would meet with success, but cautioned that operational and Data Analysis costs must be reliably estimated. He further remarked that Senator Culbertson had commented that he suspected the NASA reputation for starting and stopping projects was the result of inconsistent funding from Congress. It was refreshing to hear this. He also reported having had to explain the cooperative nature of NASA and National Oceanic and Atmospheric Administration (NOAA) yet again, in the context of Earth Science responsibilities.

Mr. Bolden offered his support for the Science Committee and asked how he could be more responsive and effective. Dr. Huntress encouraged more visits. Dr. Kalnay commented on the burden of increased launch costs. Mr. Bolden replied that the theoretical answer to the problem is commercial space; NASA is trying to devise more ways to get to low-Earth orbit. The Taurus II vehicle, for instance, is meant to serve the science community, as well as to deliver cargo to ISS. Dr. Boss thanked Mr. Bolden for writing a letter to ESA regarding Euclid and the Wide Field Infrared Survey Telescope (WFIRST) missions. Asked for his view on joint missions, Mr. Bolden believed international partnerships would be critical for Flagship missions. However, he wanted to do this for the best ideas, not simply to save money. International cooperation would aid in the sustainability of major missions, as well. Mr. Bolden also addressed the need to adjust the International Trafficking in Arms Regulations (ITAR) and other export/import regulations so that they don't cripple American industry and academia. He was encouraged that Secretaries Gates and Clinton are addressing the issue. Dr. Hubbard remarked that between the budget climate and the Planetary Decadal Survey, there would have to be a lot of re-planning; he asked that the Administrator help to elevate SMD visibility with OSTP and OMB, to clarify what it is that NASA is trying to accomplish. Mr. Bolden felt that Dr. John Holdren at OSTP was an incredible partner and a huge fan of NASA; NASA is currently considering the placement of NASA representatives at OSTP. He asked the Science Committee to help him understand how to tie the whole Exploration enterprise together; as an example, how cuts in HPD can reduce human exploration safety margins. He also needed to be able to put together a cohesive case for Mars, which could help support funding for in-space propulsion; there is currently no game-changing technology for leaving the planet.

#### Discussion

The committee discussed how various working groups can work with ESMD, in particular with the Lunar Exploration Analysis Group (LEAG). Dr. Greeley felt that LEAG could assist ESMD in its concerns with lunar science. However, the relationship with ESMD is to be determined. The Small Bodies Analysis Group (SBAG) could also be of use (e.g., human space flight to asteroids). Dr. Hinners cautioned that the lunar program could re-condense.

#### SMD Mission Cost Growth Analysis

Mr. Claude Frenner presented a response to a Science Committee request to perform a data analysis on mission cost growth. Mr. Frenner presented interim results from an Explanation of Change (EoC) study commissioned by NASA Associate Administrator Chris Scolese. The well-known Werner Gruhl Curve

shows that more money spent in phase A and B is correlated with less mission cost growth. However, preliminary results from the EoC study, with 30 missions in its data set, shows these conditions are not highly correlated; specifically finding that monies spent in phase B are not highly correlated to cost growth. Dr. Hinnners commented that content is important, as much as phasing. Mr. Freaner agreed. The current thinking is better effort should be expended in phase A/B with respect to planning and more risk reduction, as well as verification to the level of TRL 6. Mr. Freaner related anecdotally that prior to the preliminary design review (PDR) milestone, Werner Gruhl would meet with managers to determine whether a program was truly ready for PDR. PDR, unfortunately, has eroded into a less stringent milestone over time. Mr. Freaner reported that 50% of program managers could not demonstrate a stable baseline until after PDR; once baseline was reached, cost growth diminished. Dr. Hubbard commented that the Werner Gruhl curve is based on accurate PDRs.

Other EoC data indicate that the majority of life cycle cost (LCC) growth occurs after CDR. From PDR to CDR, the average mission cost increases 10%. From CDR to launch readiness date (LDR) a 41% cost growth is seen, excluding EO-1, without reserves. Dr. McComas commented that if one is excluding reserves from the statistics, it is not fair to call the results “growth.” In some cases, such as in the case of the New Horizons launch vehicle cost increase (\$175M to \$243M) was not growth, as the \$175M was only a placeholder because no EELV had been priced when New Horizons began development

#### Earth Science Update

Dr. Byron Tapley presented Earth Science Subcommittee (ESS) deliberations. As input to the FY2011 budget, The ESD developed an Integrated Climate Plan, which accelerated Decadal Survey Tier 1 missions, expanded the Venture Class program, among other things. Reacting to concern about the inability of NASA to implement long-term measurement sequences, ESD developed a set of Climate Continuity Missions, which ESS strongly supported as a significant and long-needed action. The Applied Science Program, a subgroup of ESD, has provided data that is important to hazard management. The ESS working group ASAG found that recognizing and strengthening NASA’s role in disaster response will benefit society, etc. ESS also considered the re-design of DESDynI, one of the Tier 1 Decadal Survey flagship missions originally comprised of two satellites with lidar, InSAR and L-band polarimetric SAR (synthetic aperture radar) capabilities to study the cryosphere, ecosystem structure and solid Earth. ESS reviewed the re-design and concurred that it was still scientifically viable.

Dr. Mike Freilich, Director of ESD, phoned in from off-site, where he was preparing to witness the imminent launch of the Glory mission at Vandenberg Air Force Base. He gave a brief overview of the effects of the FY12 budget on ESD. The FY12 removes \$1.2B from the \$2.1B, FY11-proposed Climate Initiative in the years FY12-15. There have also been explicit, Administration-directed cuts to important activities. ESD has cancelled a full Global Precipitation Mission (the core alone will provide a viable baseline mission). CLARREO will be held in pre-formulation phase through FY16, and the DESDynI lidar component was cancelled and its radar component deferred until affordable, planned augmentations to nonflight programs such as R&A. The budget does support a substantial amount of the Climate Initiative, however: Glory, Aquarius, and NPP launches are due to take place in CY11; support for Venture class solicitations and funding will go forward as planned; and preparations continue for the Orbiting Carbon Observatory (OCO-2). The LDCM launch is also a top priority for the end of 2012, to avoid a considerable increase in the cost of Atlas V vehicles. ESD has also received explicit direction to work with NOAA and OSTP to address approaches for providing sustained spaceborne climate measurements. Overall, the mission content that had been targeted for removal is commensurate with the directed resource reductions. The FY12 budget actually allows a \$234M increase over FY10 for non-flight activities (such as R&A) for FY12-15. There are still 14 named mission launches on the roster, plus a Venture-class mission for FY12. ESD remains a reasonably robust and broad program. At worst, in a final passed budget, there will be a one-year slip in the Soil Moisture Active and Passive (SMAP) and ICESat missions, and some impact in the non-flight arena.

The cost of CLARREO and DESDynI amounts to \$1.7B, including reserve held at Headquarters. Dr. Freilich felt that the rebalance was strictly a budgetary decision, not a performance-based decision, and that the rebalance itself is not disastrous. ESD devoted a third of its Climate Initiative plan (available on the Web) to show how the missions fit together and combined with R&A to address large Earth Science questions as well as applications. This effort provided useful guidance to OMB. There will be some scrambling to ensure data analysis can be matched up with measurements, etc. Dr. Kalnay commented that it was wonderful to see that ESD can move forward and asked if any thought had been given to future vertical-sounding measurements. Dr. Freilich reported that the Tier 3, 3-D WINDS mission is recognized as a science priority, but had been undercut by an unrealistic budget. ESD is currently able to invest only in key, Tier 3 technologies. Asked about the effect of launch vehicle prices, Dr. Freilich reported that the impact will rule out any use of an Atlas V vehicle for a single Earth Science mission. Missions will have to be designed for co-manifesting on a large mission, or planned around smaller vehicles. The loss of the Delta II is a big loss for ESD, which is now looking carefully at Falcon 9 and Taurus II vehicles. OMB pointed out that budget assumptions for the SMAP mission were predicated on the use of a Minotaur IV vehicle. ESD is also exploring various options for launches, including co-manifesting ICESat-2 on a DoD launch vehicle.

#### Discussion

The Science Committee considered launch vehicle costs as a possible finding or recommendation to take to the NAC, however stipulated that such a finding must be actionable to be useful. Dr. Huntress deferred a definitive statement to the April meeting of the Science Committee. Dr. McComas commented that NASA might obtain better leverage if its launch vehicle procurement group were located within SMD. Dr. Hinnners felt that it would not make much of a difference. Dr. Huntress noted that the real drivers are DoD and the NRO, but that he would broach the subject with SMD.

#### March 4, 2011

##### Morning Introduction

Dr. Huntress opened the meeting, and briefly turned the meeting over to SMD AA Ed Weiler, who noted the unfortunate failure of Glory to reach orbit on a Taurus XL, having experienced a failure similar to that of OCO-1, which was attributed to a faulty fairing. Glory would have provided the first polarimeter in orbit to help study aerosols in the atmosphere, as well as a solar irradiance monitor. ESD still has solar irradiance sensors on two satellites, however. Dr. Weiler would advise SOMD to recertify Orbital Sciences launch vehicles in general, as ESD has now lost approximately \$600M worth of missions, including the loss of OCO-1.

##### APD Update

Dr. Jon Morse, Director of the Astrophysics Division (APD) provided an update on division activities. Within the present portfolio, the Wilkinson Microwave Anisotropy Probe (WMAP) mission finished gathering data in Fall 2010 and has been passivated. The Wide-Field Infrared Survey Explorer (WISE) has completed its mission and is being decommissioned. APD has a smaller fleet but is still producing amazing scientific results, including a large data release from the Kepler mission that has added 1200 exoplanet candidates to a growing list. This release has tripled the number of known exoplanets in just two years. Missions in development and formulation include SOFIA, which is starting to carry out science flights interspersed with engineering hiatuses. NuSTAR, a hard x-ray mission, is due to launch in February 2012 on a Pegasus vehicle. ST-7, a program started in the former New Millennium program, will take the form of a contribution to the ESA LISA Pathfinder mission, launching in 2013. Astro-H is a planned mission of opportunity for a JAXA mission. Gravity and Extreme Magnetism (GEMS) is the next small Explorer (SMEX) for APD and is undergoing phase B trade studies. JWST is in the midst of being re-planned with a new launch date to be determined later in the Spring. GEMS is planned for launch in

2014 on a launch vehicle yet to be assigned. APD's budget strategy for FY12 is centering on responding to Decadal Survey recommendations, and the outcome is a plan that meets all Decadal Survey recommendations, except for large missions beyond JWST (WFIRST, LISA and IXO); technology and mission concept development only is now planned for these latter 3 missions. Explorer augmentation, the suborbital program, the Astrophysics research program, and support for prime missions such as Herschel, Planck, etc., will continue. APD will use the Senior Review process to prioritize funding for extended missions. Dr. Morse noted that the Astrophysics budget has been declining since 2006, a continuing trend. The FY11 budget request is already at the FY10 level. The division currently awaits Congressional output, and expects no increases.

### ***APD Budget Changes***

Rather than \$1.1B per year, APD is now planning on a budget line of \$600-700M, with the JWST numbers removed. The future Explorer mission line has been split in two between APD and HPD; each division will manage its own Explorer resources beginning in 2012. Support for concept planning and technology development for large future missions will continue. The SOFIA budget was increased to restore science and preserve second-generation instrument selection and development. Support will be terminated at the end of FY11 for RXTE and GALEX, and for the INTEGRAL and Suzaku Guest Observer (GO) programs. The Joint Dark Energy Mission (JDEM) and Space Interferometry Mission (SIM) mission lines were closed out because they were not recommended in the Decadal Survey. Reductions will also take place in the operations and GO programs for HST, Chandra and Swift. Keck Observatory operations will remain the same. Asked how the implementation of the Decadal Survey would be overseen. Dr. Morse replied that interaction with the community is very vigorous, and the division also consults NRC regularly for specific mission studies. The NRC mid-decade review, as well as the Astronomy and Astrophysics Advisory Committee (AAAC) will monitor the Decadal Survey.

There is no big budget wedge for top priority missions such as the Wide-Field Infrared Survey Telescope (WFIRST) until JWST launches. SMD will focus on the JWST re-plan, but in parallel will also be working on how to achieve WFIRST science goals. This includes funding relevant technology (NIR detectors) and supporting a Science Definition Team to design a framework of a possible, cost-effective mission. In the meantime, APD is approximately doubling its Explorer program to achieve increased mission cadence to meet the flight rate recommended in the Decadal Survey. Dr. Torbert remarked that the Heliophysics community is concerned about phasing wedges between HPD and APD. Dr. Morse noted that there is no requirement that APD and HPD have the same cost cap in an AO, and that he planned to work with HPD on AO opportunities; both divisions already work with the GSFC office to coordinate planning. APD budget numbers also reflect planning for future Senior Reviews on HST, Chandra, Spitzer, Fermi, and Kepler, which will constitute a heavyweight competition. The structure of APD seamlessly reflects the three main themes of the Decadal Survey: Cosmic Dawn, New Worlds, and Physics of the Universe. WFIRST, LISA and IXO have some concept development funds and placeholder funds in the outyears. NASA is also examining a partnership with ESA on a joint dark energy mission, if selected, consistent with option B from the NRC December report. APD is not pursuing the 20% funding option for Euclid participation at this time. While anticipating a written response from ESA concerning the Euclid architecture, APD is also assuming that NASA will not be a partner during the M-class competition. After the selection takes place in October 2011, the two agencies will resume the discussion. APD is proceeding as directed by the NAC Science Committee, and is happy to have both Administrator Bolden's support and direct communication with ESA.

Asked about plans for a dark energy mission now that JDEM is removed from consideration, Dr. Morse responded that WFIRST would be that mission. Dr. Michael Turner commented that WFIRST treats dark energy, exoplanets, survey science, and many other science issues, while Euclid is a precision cosmology mission. Euclid doesn't have same science goals, but has the hardware necessary to address U.S. science goals. Dr. Morse further noted that APD will carry forward a WFIRST Science Definition Team (SDT),

and has welcomed DOE membership on the team. Dr. Morse added that APD's intention is to engage DOE when it is appropriate, after SDT and ESA discussions have produced results. However, it must be recognized that DOE funding is pretty flat as well. No doors have been closed. The WFIRST SDT also has international representation. The SDT is tasked with producing a first report by June 2011 with a reference mission for realizing the science goals of WFIRST at the lowest possible cost.

Dr. Morse reviewed the notional plan for Decadal Survey space activities, with some areas being augmented by larger increases in the outyears, in particular nearly \$500M over the course of a decade for the Explorer program. It also remains to be seen what ESA will select in its L- and M-class missions. There are no funds for accomplishing multibillion-dollar missions, in either ESA or NASA, by 2020. The L-class mission downselect had been scheduled to take place in June 2011, after which NASA and ESA can enter a discussion. ESA has indicated some flexibility for the L-class mission. However, it is also clear that the LISA Pathfinder is slipping (launch date is now 2013). In the meantime, APD plans an AO every other year for Explorers, in response to Decadal recommendations for 4 new missions and 4 new missions of opportunity by the end of the decade.

The call for the WFIRST SDT had 82 nominations, indicating great interest in the community. The team of 21 includes members with exoplanet expertise, and those who are familiar with Euclid, and an instrumentation expert with no partisan interests in the mission who is serving as Co-Chair. The SDT will start with science and then will look at the budget. The SDT is also consulting the community at large. Dr. Huntress commented that he understood the strategy, but was concerned that unconstrained science would produce something unexecutable. Dr. Morse stated that the SDT had been provided a reasonable cost estimate of \$1.5B. Combining WFIRST and Euclid missions would create an effort larger in size and complexity, but Dr. Morse felt that a seamless merger of the two would not result in something faster; in fact, this might take longer even in an optimal budget climate.

Addressing the Decadal Survey Implementation Advisory Committee (DSIAC), Dr. Morse reported that NASA is working with the NRC to revive an appropriate advisory structure (i.e. the Committee on Astronomy and Astrophysics; CAA). The structure needs to be compatible with the needs and mechanisms for agency chartering and funding of NRC panels and committees, the NAC, AAAC, and advisory needs of other federal agencies such as DOE, and other SMD divisions. The resultant body would be compatible with the original concept of a DSIAC, with nothing generically different about the process APD would use to respond to the Decadal Survey- the harder issue is to figure out the roles of the various advisory bodies. Dr. Turner commented that the Decadal Survey had anticipated multiple committees, and had identified the DSIAC/CAA to deal with the strategic issues. Citing a past issue, he remarked that CAA issued a letter report that was very valuable and which enabled the OSTP, OMB, NSF to decide on a de-scoped mission. The other issue is how to pursue the WFIRST/Euclid interface from a standpoint of high-level, independent, strategic advice. Dr. Torbert felt that NASA could obtain independent reviews from many sources, and was concerned about too many committees tripping over themselves; he added that devices such as the Heliophysics roadmaps and mid-decade reviews are already sufficient. Dr. Turner noted that the Astrophysics community is not in the habit of doing a mid-decadal review. Dr. Morse disagreed, adding that APD would be consulting with the NRC and CAA on a regular basis on WFIRST, LISA and IXO. The APD budget reflects option D from the December NRC report. It is a tricky issue, and it is not clear how APD will go forward with each issue. Dr. Huntress agreed that it is a challenge to have well-defined roles in committees; Dr. Morse felt that APD would have a more precise answer by next Science Committee meeting in April.

The Independent Cost Estimate (ICE) process and risk assessment of candidate mission concepts helped the Decadal Survey build a more realistic program for APD. Challenges, however, are that programmatic circumstances and budget projections can change dramatically over the Survey reporting process. The embargoed nature of the budget process hinders real-time updates to the Decadal Survey; thus future

recommendations should emphasize scientific importance to allow for implementation approach modifications. Dr. Morse acknowledged the need for a mid-decade review. Synchronizing with international partners will also remain a problem, thus NASA is suggesting holding an international science conference to aid in a mid-decade review. Dr. Morse requested feedback from participants in the Survey for improving the process.

Dr. Boss reported briefly on the Astrophysics Subcommittee (APS) reaction to the budget. Essentially APS is commiserating with NASA on the sad state of affairs, and praised Dr. Morse for pursuing as many of the science priorities set forward by the Decadal Survey as possible. Action items for APS include obtaining more information on JWST, the DSIAC creation, and the potential science loss from missions terminated by the Senior Review. Dr. Huntress agreed that the most recent APS findings need not be elevated to the NAC.

Dr. Huntress remarked that there seems to be an increased reliance on international partners for large high-cost missions and asked whether it was worth doing. Dr. Morse noted that a NRC report has recommended against interagency collaborations unless there are clear advantages, and that there are lessons to learn from GLAST (Fermi) with respect to NASA's partnership with DOE. There are also many missions in Astrophysics where lead roles are shared with ESA. Thus far, APS is pretty comfortable it can work out something with ESA; and has even included launch vehicles in the partnerships with ESA (e.g., the Ariane V for JWST). Dr. Torbert recommended more focused discussions on Lessons Learned from NASA missions shared with international partners.

#### Planetary Protection Subcommittee

Dr. Eugene Levy, Chair of the Planetary Protection Subcommittee (PPS), discussed in general how its activities have been responding to the requirements of the international community. Protection of Earth and terrestrial biota from contamination resulting from exploration of the Solar System is both a matter of safety and of public perception. The extraterrestrial environment must also be protected from terrestrial contamination, as a matter of ethics in carrying out scientific quests. Both missions are complicated by the dearth of knowledge of how life is represented in the universe. Citing the existence of extremophiles in deep, hot terrestrial biospheres, Dr. Levy posited that one of the most profound scientific questions is the transition of matter to life. Planetary Protection challenges flow from these issues, and it must be ascertained where to draw the line- this is an unresolved question for the agency.

There are four matters currently under consideration in PPS. The first concerns planned sample return initiatives at Mars (Mars Sample Return; MSR) in terms of both backward and forward contamination. These are serious issues that are not yet ready for action by the NAC. It is clear that NASA needs to ensure a better incorporation of Planetary Protection earlier in the planning process for MSR, to develop technology to handle samples properly. There are concerns about Planetary Protection interfering with the mission as well as extra costs involved. PPS will review these issues at its next meeting, and may have a formal recommendation by August 2011. The second major issue is technology development. At present there are relatively few resources devoted to technologies for Planetary Protection. PPS has met with OCT to begin to raise this question to ensure inclusion. Dr. Hubbard asked whether OCT could address mission-specific technology capabilities vs. generic technology. Dr. Levy felt that OCT was sensitive to both issues, and that there was a need to allocate resources in both SMD and OCT for Planetary Protection technology development. Dr. Torbert commented that OCT should not be reserved for generic development, as Planetary Protection is an agency-wide need based on agency resources. Dr. Levy felt the matter could be worked out under several structures.

A third issue under PPS review is the development of an independent technology roadmap for Planetary Protection. Planetary Protection Officer Dr. Cassie Conley noted that while needs have not changed,

Planetary Protection should update its roadmaps from the late 1990s, which include microbial monitoring for infections. There are crosscutting issues for both human and robotic missions.

Dr. Levy reported that PPS is also grappling with how to extend Planetary Protection responsibility to missions carried out by non-national agencies, such as the Google X-Prize. What is that level and where is that responsibility taken, and how is it imposed? This matter is the subject of an International Moot Court this year. Each year at the International Astronautical Congress, a question is argued and a prize is awarded. There is no established legal framework for dealing with private sector space exploration. Some examples of pertinent problems include the fate of Apollo artifacts left on the Moon. From a biological science point of view, these artifacts are interesting. The fate of the microbiota is interesting after 50 years of exposure and the science needs to be protected. As there is no known biota on the Moon to protect, to the best of current scientific understanding, one wonders if Planetary Protection has any relevance. No evidence that any organisms survive on the Moon.

The fourth item under PPS review is that of the MSL mission profile in light of new information about the distribution of water ice on Mars. New information suggests that, globally, ice is closer to the surface of Mars than previously thought. In particular if there is a failure and radioisotopic thermal generators (RTGs) are embedded in icy soil, an artificial terrarium could be created. The new evidence dictates a re-analysis, and the MSL team is undertaking the analysis. Dr. Hubbard added that between the data collected by the Phoenix and Odyssey spacecraft, it seems definitive that there is water ice in the top meter of the surface of Mars.

#### HPD Update

Dr. Richard Fisher, Director of the Heliophysics Division, reported on the division status. The APD budget has eroded steadily since 2004, and is reduced by \$1.2B in FY12; this reduction has had an effect on carrying out Decadal Survey missions. Between now and 2015, HPD is anticipating a smaller fleet. Launch vehicle costs and instrument costs have been increasing in the Solar Orbiter (SO) mission. The current budget strategy includes reviewing proposals for the current Explorer AO, pursuing significant progress in phase B of Solar Probe-Plus (SPP), and ensuring the launch of the Radiation Belts and Storm Probe (RBSP) mission in 2012 (on schedule thus far). The Atlas V launch queue has been impacted by MSL, and HPD is especially concerned for an August launch for RBSP. A Systems Integration Review has been completed for the Magnetospheric Multiscale (MMS) mission, and HPD is maintaining its commitments to international partners on Hinode and Solar Orbiter.

Increased launch vehicle costs will necessitate a de-scope of SO collaboration. Following a Senior Review, TRACE and Ulysses operations have been terminated; TRACE data became obsolete due to the successful Solar Dynamics Orbiter (SDO) mission. Milestones in the Living with a Star (LWS) program include the BARREL balloon mission having completed a successful test of its power system. SPP is continuing to work a thermal protection system issue. MMS has completed its mission CDR and has done loading of I&T. The small Explorer mission, IRIS, also had a successful mission CDR; Norway has agreed to provide some ground station report for this mission. HPD received 22 full-mission proposals in its latest Explorer call, and 20 MoOs. The downselection for this call is targeted for February 2013. The current Black Brant 9 rockets in inventory will sustain the suborbital schedule until May 2011; HPD is also carrying a budget for some Wallops Island research range operations. The sounding rocket success rate remains the same.

#### ***Impact of budget on HP program (2003-2013)***

Dr. Fisher outlined the strategy for finishing the Decadal Survey, which is to follow the Heliophysics Roadmap. Future missions budgeted out to 2022 have been provided to the next Decadal Survey; there is \$1.9B available in the outyear line. After the impact of new launch vehicles is absorbed, this amount is



reduced to \$1.5B. The SMD plan over the next 9 years is to launch SO, SPP, MMS, IRIS, SET-1 and RBSP; there are some additional opportunities for the community within the Juno and MAVEN missions, and the re-purposing of the former Triana mission as a solar wind monitor. Dr. Fisher predicted a launch hiatus between 2019 and 2021; thereafter, HPD can afford one \$400M mission every two years. HPD will have accomplished about 80% of Decadal Survey goals by 2015, not 2013. Dr. Fisher expressed optimism that a new Decadal Survey would be executable, particularly if it refrained from recommending large missions. The DSCOVR mission now has a place in SMD but has not yet been executed; there is also some funding in the defense budget for 2014 for a launcher. The budget impact on the Senior Review will primarily be felt in the trade space of R&A, SR&T, etc.

Launch issues remain a concern, in part due to a launch delay with Atlas V that increased costs on SDO; there is a problem managing the launch queue. In addition, the Pegasus launchers have loads that are not well known, which have caused late adjustments in missions. Ms. Vicki Elsbernd added that HPD continues to work closely with the Launch Services Program to resolve these issues.

Dr. Torbert, Chair of the Heliophysics Subcommittee (HPS) reported on its most recent meeting. The subcommittee is replacing some members who have rotated off and is relatively stable. The HPS work plan will be revised. Continuing issues are launch capabilities for all missions; how to monitor relevant Decadal Survey objectives and fold them into the HP roadmap; Lessons Learned in mission life cycle costs; working with the LEAG; working with NAC Science Committee on stimulus initiatives; establishing an L1 solar monitor; and deriving maximum science from the Heliophysics Observatory program. Some older HPS findings relate to the ongoing question about incorporating needs for Heliophysics science in the OCT, as current funding is not adequately supportive of HP systems science; and the budgetary balance between missions operations and data analysis (MO&DA), and new missions.

Dr. Torbert reviewed Heliophysics science highlights, including an SDO image of an X-type solar flare, and a Stereo view of a moderate coronal mass ejection (CME). Multiple spacecraft have detected evidence of coronal x-ray sources and a reconnection event. Observations of fast solar winds have shown higher ionization states of neon. Recent global views of the Sun have made contributions to the understanding of space weather. In attempting to understand the unusual solar minimum, controversial observations now claim to be able to predict characteristics of coming solar minima by incorporating accurate measurements of solar plasma flows into models. Observations from Stereo on oxygen escape from Earth were also noted, as well as a view from IBEX of the Earth's magnetosphere, demonstrating evidence of ring-current, charge-exchange atoms. An ionospheric "superfountain" was observed by the TWINS spacecraft. MESSENGER found evidence of magnetospheric variability at Mercury (with evidence of reconnection activity), and an ongoing analysis of IBEX results is unveiling the Solar System's interaction with the galactic environment.

#### Discussion

Dr. Huntress and the Science Committee deferred findings and recommendations to a future meeting, and anticipated potential findings on launch vehicles and budget impacts. Dr. Weiler urged the PSS and the Science Committee to prepare for the outcome of the Planetary Decadal Survey. Dr. Huntress adjourned the meeting at approximately noon.

## Appendix A Attendees

### NAC Science Committee members

Wes Huntress, *Chair*, Carnegie Institution of Washington  
Alan Boss, Carnegie Institution, Chair Astrophysics Subcommittee  
Ronald Greeley, Arizona State University, Chair Planetary Science Subcommittee  
Noel 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  
Byron Tapley, University of Texas, *Vice Chair* and Chair Earth Science Subcommittee  
Roy B. Torbert, University of New Hampshire, Chair Heliophysics Subcommittee  
Michael Turner, University of Chicago  
Greg Williams, NASA Headquarters, *Executive Secretary (Acting)*

### NASA Attendees On-Site

Lynn Cline, NASA Headquarters  
Catharine Conley, NASA Headquarters  
Dick Fisher, NASA Headquarters  
Claude Freaner, NASA Headquarters  
Laurence Friedl, NASA Headquarters  
Rebecca Gilchrist, OGC/NASA Headquarters  
Barbara Giles, NASA Headquarters  
Jim Green, NASA Headquarters  
Madhulika Guhathakurta, NASA Headquarters  
Colleen Hartman, NASA Headquarters  
Hashima Hasan, NASA Headquarters  
Jeffrey Haye, NASA Headquarters  
Paul Hertz, NASA Headquarters  
Rick Howard, NASA Headquarters  
Deirdre Jurand, NASA Headquarters  
Mona Kessel, NASA Headquarters  
Cliff Leiftao, NASA Headquarters  
Margaret Luce, NASA Headquarters  
Steven Mekowitz, NASA Headquarters  
Doug McCuiston, NASA Headquarters  
Mike Moore, NASA Headquarters  
Jon Morse, NASA Headquarters  
Jeff Neimitz, NASA Headquarters  
Marian Norris, NASA Headquarters  
Andrea Razzaghi, NASA Headquarters  
Lillian Reichenthal, NASA Headquarters  
Rita Sambruna, NASA Headquarters  
Wilton Sanders, NASA Headquarters  
Eric Smith, NASA Headquarters  
Ray Tolomeo, NASA Headquarters  
Craig Tupper, NASA Headquarters

Azita Valinia, NASA GSFC  
Ed Weiler, NASA Headquarters  
Dan Woods, NASA Headquarters  
Geoff Yoder, NASA Headquarters

Non-NASA Attendees On-Site

Bill Adkim, ASG  
Turner Brinton, Space News  
Dom Conte, Orbital Sciences  
Randall Correll, Ball Aerospace  
Walt Faulconer, Strategic Space Solutions  
Brad Keelor, British Embassy  
Miriam Quintal, California Institute of Technology  
Richard Rogers, Stellar Solutions  
Joan Zimmermann, Zantech IT

Remote Participants/Webex

Francesco Bordi, Aerospace Corp.  
Dennon Clardy, NASA MSFC  
Stephen Clark, Spaceflight Now  
Michael Freilich, NASA HQ  
Richard Griffiths, NASA HQ  
Alana Harris, NASA  
Andy Hoskins, Aerojet  
Stephanie Johns, AAS  
Thomas McCarthy, NASA GSFC  
Stephen Merkowitz, NASA  
Nicholas White, NASA GSFC

## Appendix B NAC Science Committee Membership

Wesley T. Huntress, Chair  
Emeritus  
Geophysical Laboratory  
Carnegie Institution of Washington

Alan P. Boss  
Department of Terrestrial Magnetism  
Carnegie Institution of Washington

Ronald Greeley  
School of Earth and Space Exploration  
Arizona State University

Noel Hinners  
Consultant  
Littleton, Colorado

G. Scott Hubbard  
Department of Aeronautics and Astronautics  
Stanford University

T. Jens Feeley, Executive Secretary  
Science Mission Directorate  
NASA Headquarters, Washington, D.C.

Eugenia Kalnay  
Department of Atmospheric and Oceanic Science  
University of MD

Charles F. Kennel, *ex officio* member  
Chair, Space Studies Board  
Scripps Institute of Oceanography  
University of California, San Diego

Eugene H. Levy  
Professor and Provost, Physics and Astronomy  
Rice University

David McComas  
Space Science and Engineering Division  
Southwest Research Institute

Byron Tapley, Vice Chair  
Director, Center for Space Research  
University of Texas, Austin

Roy B. Torbert  
Space Science Center  
University of New Hampshire

Michael S. Turner  
Kavli Institute for Cosmological Physics  
University of Chicago

## Appendix C Presentations

1. Overview of the FY12 Budget Request, Including JWST; *Edward Weiler, Rick Howard*
2. Annual Ethics Briefing for Special Government Employees; *Rebecca Gilchrist*
3. NASA Launch Services-II (NLS-II) Update; *Lynn Cline*
4. Planetary Science Division and Subcommittee Update; *James Green, Ron Greeley*
5. Science Mission Directorate Mission Cost Growth Analysis; *Claude Frenner*
6. Earth Science Division and Subcommittee Update; *Michael Freilich, Byron Tapley*
7. Astrophysics Division and Subcommittee Update; *Jon Morse, Alan Boss*
8. Planetary Protection Subcommittee Update; *Eugene Levy*
9. Heliophysics Division and Subcommittee Update; *Dick Fisher, Roy Torbert*

## Appendix D AGENDA

NAC Science Committee  
March 3-4, 2011

Agenda  
(all times EASTERN)

Thursday, March 3 (9H40)

8:30-8:45am	Remarks and Announcements	Huntress, Feeley
8:45-9:45am	Overview of FY12 Budget Request Includes JWST component	Weiler/Howard
<b>9:45-10:00</b>	<b>Break</b>	
10:00-11:00 am	Annual Ethics Briefing	Gilchrist
11:00-Noon	Launch Vehicles Costs (NLS II)	Cline
<b>Noon-1pm</b>	<b>Lunch on Own</b>	
1:00-2:00pm	Discussion with NASA Chief Scientist	Abdalati
2:00-3:15pm	Planetary Science	Green/Greeley
3:15-3:45pm	Costing Analysis & Results	Freaner
<b>3:45-4:00pm</b>	<b>Break</b>	
4:00-5:00pm	Earth Science	Freilich/Tapley
5:00-5:15pm	First Day Wrap-up	Huntress, Feeley
5:15pm	Adjourn for the day	

NAC Science Committee  
March 3-4, 2011

Agenda  
(all times EASTERN)

Friday, March 4 (MIC-3)

8:30-8:35am	Remarks and Announcements	Huntress, Feeley
8:35-10:00am	Astrophysics	Morse/Boss
10:00-10:45am	Planetary Protection	Conley/Levy
10:45-11:00am	<b>Break</b>	
11:00-12:00pm	Heliophysics	Fisher/Torbert
<b>12:00-1:00pm</b>	<b>Lunch on Own</b>	
1:00-1:15pm	Public Comment	
1:15-2:00pm	Findings and Recommendations	
2:00-2:15pm	Second Day Wrap-up	Huntress, Feeley
2:15pm	Adjourn	