

NASA ADVISORY COUNCIL
SCIENCE COMMITTEE

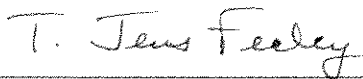
April 21 & 22, 2011

NASA Headquarters
Washington, D.C.

Meeting Minutes



Wesley T. Huntress, Jr., Chair



T. Jens Feeley, Executive Secretary

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Thursday, April 21

Remarks and Announcements

Dr. Wesley Huntress, Chair of the NASA Advisory Council (NAC) Science Committee (SC), convened the meeting. Dr. T. Jens Feeley, SC Executive Secretary, made some brief logistical announcements and informed members that the October meeting is being rescheduled to avoid conflict with the next NASA-ESA bilateral space science meetings scheduled for the same period; the Committee later agreed to schedule its last meeting of the year for October 31-November 1, 2011, at NASA Headquarters.

Earth Science

Dr. Byron Tapley noted that the Earth Science Subcommittee has not met since the last SC meeting, adding that the Subcommittee members participated in a February teleconference to be briefed by NASA on the President's fiscal year (FY) 2012 budget request. He also reviewed topics for the next Earth Science Subcommittee meeting scheduled for May 11-12, 2011.

Dr. Tapley introduced Dr. Michael Freilich, Earth Science Division (ESD) Director. Dr. Freilich reported that ESD received a substantial increase in the FY10 and FY11 budgets. ESD's proposed budget for FY12 is significantly above both the level envisioned in the FY10 budget request and the FY11 allocation contained in the recently-enacted full-year Continuing Resolution (CR). Dr. Freilich noted that it is far more appropriate to focus on what is included in the current budget request than to fixate on what is not included. Dr. Freilich reported that due to limited outyear funding levels, ESD removed specific content from programs commensurate with the available funding, leaving a program with 13 robustly-funded, upcoming launches in the next decade. In response to a question, Dr. Freilich indicated that ESD was able to help the Administration understand the climate initiative and its synergies during discussions on how to deal with the reduced outyear budget levels. In spite of some initial discussion about canceling the CLimate Absolute Radiance and REfractivity Observatory (CLARREO) and the radar portion of the Deformation, Ecosystem Structure and Dynamics of Ice (DESdynI) mission, ESD was able to place both into suspended animation. Dr. Scott Hubbard asked if ESD could detect an organizing principal in this year's budget decision process, to which Dr. Freilich theorized it would be to take out content to match the reduced funding levels, and that the preferred way to do that was to focus on removing large missions with large budgets that do not launch within the current 5-year budget horizon of FY12-16. In response to a question from Dr. Huntress, Dr. Freilich indicated CLARREO's projected cost was slightly less than \$1 billion. It did not appear that there was an independent technical basis for the reduced outyear funding levels, but that they were driven by broad fiscal realities. With respect to the impact that removal of the missions will have on the long term, Dr. Freilich explained that for CLARREO-1, it is a radiation balance issue; for DESdynI in the ice arena, it is a data quality issue; for the solid Earth community, it is a quality and coverage issue. For the LIght Detection And Ranging (LIDAR) mission, NASA was tasked to identify an international partner to supply the entire mission; unfortunately, there does not appear to be any international partner with that capability or interest to do this at this time. In response to a question from Dr. Kalnay about other instruments that might make up for CLARREO-1, Dr. Freilich replied there are none to the precision and stability necessary for early trend detection.

ESD's 13 fully operating missions are old and almost beyond their design lives; in fact, some are already there. Dr. Freilich cited CloudSat which, within the last few days, is losing a battery cell. Aquarius, a joint mission between NASA and the Argentine space agency (Comision Nacional de Actividades Espaciales or CONAE), is scheduled for a June 2011 launch, and the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) is scheduled for an October 25, 2011, launch.

The Landsat Data Continuity Mission (LDCM), a joint mission with the United States Geological Survey (USGS), is on track for a December 2012 launch. A potential issue with LDCM is that any launch delays beyond early 2013 (which are not expected) would result in substantial additional launch vehicle costs that could jeopardize the mission. Delays beyond early 2013 would require the launch vehicle, which had been ordered under the previous NASA Launch Services contract (known as NLS I) would have to be renegotiated under the terms and increased costs included in the current NASA Launch Services contract (NLS II). In response to a question from Dr. Hubbard about testing of the thermal infrared instrument, Dr. Freilich explained that should problems occur with testing that require time to resolve, the ESD will work with the Project to strike a balance between schedule and risk

management. While a problem is not anticipated, all risk is being concentrated in the thermal infrared instrument, which is not mission critical.

The Orbiting Carbon Observatory (OCO)-2 was continuing towards a February 2013 launch; however, budget and the fact that OCO-2 was to be the next launch on the failed Taurus-XL is something the ESD is examining. There are potential issues with the Global Precipitation Monitor (GPM) because of the recent earthquake and tsunami in Japan. In response to a comment from Dr. Huntress, Dr. Freilich explained there were two parts to GPM -- the core spacecraft and a low inclination orbiter. Because of budget, ESD had to descope the orbiter to just the instrument, the data downlink, and the associated science and accommodation costs; ESD had budgeted for these items, but not the spacecraft or the launch vehicle. The Soil Moisture Active-Passive (SMAP) mission will likely be delayed four to five months due to insufficient allocation in the FY11 budget. There are also launch vehicle issues with SMAP and the Ice, Cloud and land Elevation Satellite (ICESat)-II.

Dr. Freilich reviewed a slide showing the host of Airborne Sciences Field Campaigns that ESD supports, indicating that there is now a separate budget line for Airborne Science Infrastructure and new tools such as the Global Hawk Unmanned Aerial System (UAS).

Venture-Class is fully funded with three strands: a suborbital/airborne strand that is moving forward; EV-2, described by Dr. Freilich as small satellites with total development costs of \$150 million including launch vehicle; and EV-Instrument, Spaceborne instruments for flight on Missions of Opportunity (MoO). Dr. Huntress counseled that ESD should pursue the experiment, but must ensure a sustainable program. He cited unfortunate experience with a previous satellites in the Earth System Science Pathfinder (ESSP) Program. Dr. Freilich explained that Venture-Class management is different than previous Earth Systems Science Pathfinders in that Venture missions are Principal Investigator (PI)-led. The PI has control over descopeing which, when done to the threshold level, creates a go/no go decision point. Also, instead of multi-step selections, one selection will be done. In response to a question, Dr. Freilich indicated that the Earth Systems Science Pathfinder Program Office at Langley Research Center (LaRC) will provide support similar to what the GSFC Explorer Program Office provides for Astrophysics and Heliophysics programs. Dr. Freilich stated that there is an overall commitment to a balanced portfolio in the ESD Decadal Study (DS), and there is a commitment to have the program rather than a specific measurement or quality. Dr. Tapley commented that the actual DS requirements for programs were there in order to build a capability within the community; no specific science measurement requirements were assigned to Venture-Class. In response to a question, Dr. Freilich noted that CloudSat, the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), and the Gravity Recovery And Climate Experiment (GRACE) are PI-led missions.

The Glory mission was lost due to a launch vehicle failure on March 4, 2011. A carbon copy Glory recovery mission will not be developed. Glory had two main instruments, one focused on total solar irradiance, and the other focused on aerosols. Glory's total solar irradiance instrument was intended to supplement and eventually replace similar instruments on the Solar Radiation and Climate Experiment (SORCE) and Active Cavity Radiometer Irradiance Satellite (ACRIMSAT) missions. Both are expected to continue through at least 2016. The next generation instrument is being developed by NASA under a reimbursable agreement with the National Oceanic and Atmospheric Administration (NOAA). Funded by NOAA, this instrument will be delivered in late 2012; however, there currently is no spacecraft or launch vehicle to fly that instrument alone.

Two studies were initiated in March relative to Glory's other instrument, the Aerosol Polarimetry Sensor (APS): a 90-day science viability study due in late June, and a 120-day implementation study due in late July. ESD will review study results to decide if funds will be requested. It is possible that there could be opportunities for EV-2 to address some of these measurements.

With respect to the launch vehicle crisis, Dr. Freilich reported that ESD, the Science Mission Directorate (SMD), and NASA are losing reliable, predictable access to space via affordable, proven launch vehicles. After two consecutive failures of the Taurus-XL, a commercial launch vehicle, there is no certified U.S. launch vehicle with capacity between the Pegasus and the Atlas-V. Launch vehicle availability and reliability problems are causing delays and cost increases and will have greater impacts on the Earth and Space Science programs in the coming decade.

Dr. Freilich reviewed the list of current U.S. launch vehicles. In terms of failure, a launch vehicle failure does not change certification. Dr. Freilich strongly urged the Committee to delve into the reliability issue, which is an access

to space issue and a challenge for the Agency. He expressed hope that the Committee will help highlight and articulate some of these challenges and suggested that it might be worthwhile for the Committee to hear from the Launch Services Program.

The Delta II launch vehicle is no longer in production. Aquarius and NPP are manifested on two of the last three Delta IIs. Dr. Hubbard pointed out that the issue with the Delta IIs is that the Air Force has withdrawn its subsidy for the launch infrastructure. A launch services proposal is the only way to identify the exact price that will be charged for a specific mission. The Atlas V launch vehicle is large and reliable, but exceptionally costly under NLS II, which is why LDCM, if delayed, could cost \$100-150 million more to launch. There is a crowded manifest for Atlas Vs. Minotaur-IVs are not commercially available and there are national space policy issues associated with using them to launch non-defense payloads. Also, there is a possible fairing commonality issue with the Taurus XL. At present, the Falcon 9 and Taurus II launch vehicles do not have the capability to launch from sites, like Vandenberg Air Force Base, that are need to reach polar orbits, which are crucial to many Earth science missions.

Dr. Freilich reviewed the list of upcoming launches: Aquarius and NPP are both on Delta IIs; OCO-2 is under contract to launch on a Taurus XL; GPM will launch on a Japanese launch vehicle; the Stratospheric Aerosol and Gas Experiment (SAGE) 3 is an instrument to fly on the International Space Station (ISS); OCO-3 is also an instrument to fly somewhere as an instrument of opportunity and possibly on the ISS; and ICESat-2 is working to get an interagency ride-share with the Department of Defense (DoD) on Atlas V. The GRACE follow-on will be an international partnership with the Germans that could open up international launch vehicle possibilities. In response to a question, Dr. Freilich explained that when NASA supplies components or instruments and another country supplies the spacecraft, it is possible to fly on an international launch vehicle.

Education/Public Outreach (E/PO) Education Design Team/Education Coordinating Council (ECC)

Ms. Stephanie Stockman, E/PO lead for the SMD, presented the E/PO mission and vision and the Education Design Team recommendations as they impact the SMD and its E/PO Program. Each SMD Division has an E/PO point of contact. SMD is aligned to the NASA education portfolio that is set up to attract and retain students in Science, Technology, Engineering and Mathematics (STEM) disciplines.

NASA's education goals are approved and monitored by OMB. In response to a question, Ms. Stockman stated that there is no coordinating council for E/PO across federal agencies; however, there are partnerships among some federal agencies. SMD's E/PO program lead is a member of the ECC which, at this point, has not been organized. In response to Dr. Tapley, Ms. Stockman explained that the Space Grant Program is not an SMD education project; rather, it falls under the NASA's Office of Education. However, Planetary Science, Astrophysics, and Heliophysics support Space Grant undergraduate students who act as our ambassadors for local outreach in their universities as well as interact with SMD divisions. Ms. Stockman added that Space Grant budget does not impact the SMD the same way that it impacts the Office of Education. In response to a comment from Dr. Tapley, Ms. Stockman indicated that SMD E/PO and NASA share the same education objectives. Dr. David McComas asked for comment on the current relationship between the Office of Education and SMD compared to previous relationships—e.g., when the Office of Education set policy and the individual Directorates implemented it, or when all funding went to the Office of Education with some distribution to the Directorates. Ms. Stockman replied that today, the Mission Directorates are all aligned to NASA's education goals. Mission Directorate E/PO leads and the Center Education Directors are voting members of the ECC.

Ms. Stockman reviewed the E/PO program objectives with the Committee. Dr. Tapley asked Ms. Stockman to comment on the statistics being gathered to measure the impact of E/PO's public engagement outreach. Ms. Stockman replied this is not part of the reporting criteria, but something SMD does as part of its education goals and objectives. The system set up for education does have numbers and statistics. Survey forms are currently being designed that will go along with the education portfolio for participant completion; however, survey activation is pending an ongoing OMB process.

SMD Program and Mission E/PO activities are embedded in every SMD mission and in coupled programs such as the Global Learning and Observations to Benefit the Environment (GLOBE) Program. All SMD missions are required to fund an E/PO program of at least one percent of the cost of the mission, excluding the launch vehicle. Program and mission E/PO activities represent the biggest part of SMD's E/PO budget. Four Science Education and Public Outreach Forums (SEPOF) began work in 2009. The Astrophysics, Heliophysics, Planetary Science, and

Earth Science forums all have integrated activities organized around one of the science themes. The GLOBE program is mandated by Congress and is a line item in the Earth Science education budget.

The Mid-Size Activities Program is PI-led and solicited proposals are selected based on competitive peer review. As part of Research Opportunities in Space and Earth Sciences (ROSES), mid-sized activities offer educational opportunities in Earth and Space Sciences. With a \$2M annual budget for new starts, E/PO can select and fund approximately 15 proposals a year and offer funding for up to three years. Mid-Size Activities provide data through annual reports and evaluations that participants are required to complete. The Research Supplements are small E/PO activities led by research PIs that augment individual research investigations.

The Education Design Team (EDT) was established by NASA to improve the Agency's education offerings and establish goals, structures, processes, and evaluative techniques to implement an improved STEM Education Program. EDT consists of 12 members who, when combined, represent nearly 45 years of teaching experience and provide a wealth of broad education, NASA-discipline, and classroom teaching experience. EDT examined NASA's education program and STEM education landscape and developed improvement opportunities. The recommendations that impact SMD include the following:

- NASA K-12 programs should be focused to address middle school pre- and in-service STEM educator training to build STEM competencies to inspire students at a critical time in their education.
- The Mission Directorates and the Office of the Chief Technologist should maintain a commitment to provide graduate and fellowship opportunities.
- Partnering with informal learning providers enhances NASA's ability to increase capacity to help scale up informal learning.
- The Office of Education should take the following actions: develop a comprehensive strategy for education partnerships; take advantage of joint solicitations; participate in National/State STEM policy discussion; and expand the ECC charter.
- NASA should establish a structure that allows for the Office of Education, Centers, and Mission Directorates to implement a strategically integrated portfolio.
- ECC members should be empowered to make educational decisions within their organizations.
- NASA's Office of Education and Office of Communication should be involved in early planning and requirements definition of major NASA missions. *Observation:* the major NASA missions have not yet been defined.

Each of the above recommendations has a working group, and Ms. Stockman indicated that she would look closely at the group defining major NASA missions. In this regard, she asked the Committee to champion the following question: What is the influence of the NASA Office of Education versus the influence of the ECC or the E/PO lead for the organization to the NAC Education Committee?

Dr. Hubbard agreed that focus should be on the K-12 education period and asked what needs to happen to make it sustainable over the long term to get the desired results. Ms. Stockman replied that the EPO forums are of particular value in this regard. A number of missions and some Divisions also have education ambassadors, such as the MESSENGER Educator and the Heliophysics Ambassadors Programs.

In response to a question, Ms. Stockman confirmed that the Department of Education does not have in-house STEM expertise to run its own STEM program and, in fact, is looking to NASA and other technical agencies for this expertise. This could be an opportunity for a joint solicitation.

Dr. Feeley commented that plans are being made to have a joint meeting with E/PO at the August meeting. This has not been confirmed yet, but the idea of bringing all the committees together to facilitate these kinds of discussions and discuss how SMD's E/PO will fit into the larger Agency E/PO will be valuable.

In response to a question from Dr. Alan Boss, Ms. Stockman indicated that there are two ways to get information about the key motivations of STEM students. Because of privacy rules, students under the age of 18 cannot be surveyed; however there are organizations that do gather this data for the schools. By partnering with the school system, one can tap into this data to see what impact NASA-related programs have on K-12 students. Students in higher educational programs can register online to receive annual email surveys. Also, other independent research studies are generally available. Dr. Boss added that it would also be helpful to know what the primary drivers are

for undergraduate students' field-of-study decisions. Ms. Stockman responded that in terms of majors, the primary driver is typically the earning power of the chosen field. With engineering salaries beginning to rise, we may see an increase in the majors in this area. Dr. Greeley suggested that we also need to know what is turning students off to STEM. Ms. Stockman advised that the American Institute of Physics does surveys and inventories into which NASA can tap. In response to a question from Dr. Tapley, Ms. Stockman explained that every Federal agency must go through the same process before it can collect data from the public. Dr. Tapley added that Space Grant has a major emphasis on K-12 and suggested that E/PO work with them to frame the questions; Space Grant might even take on that task. Ms. Stockman responded that it makes more sense for Department of Education to work with Space Grants. Dr. Tapley suggested a more pro-active approach by SMD E/PO to ensure questions are framed appropriately.

In response to comments from Dr. Eugene Levy on diverse agencies tackling the same problem, Ms. Stockman noted that federal agencies have different mind sets; the STEM agencies have different goals and objectives with respect to what they're looking for. Dr. Levy opined that there is a lot of redundancy among agencies that step outside their core expertise in a singularly ineffective way to engage this problem. He cautioned that NASA should be focusing on its core expertise. Ms. Stockman replied that the NASA brand excites people, especially kids, giving NASA an "edge." NASA's charter is often interpreted to mean NASA has an obligation to share the science and technology with the public. Dr. Kalnay suggested that NASA's focus should be on improving teachers' STEM knowledge. Ms. Stockman agreed that for the most part, U.S. teachers don't have sufficient STEM background. Noting a recent article in *Nature* magazine about over-production of PhDs in the U.S., Dr. Boss opined that the EDT recommendation to "remain committed to providing graduate student and faculty fellowships" was interesting. Perhaps more support is needed for middle school teachers and more engineers with bachelor degrees instead of more PhDs.

James Webb Space Telescope (JWST) Update

Mr. Rick Howard reviewed the JWST schedule. The Program is working on a re-plan to develop realistic costs and a schedule that provides the earliest possible launch date in view of budget constraints. The re-plan is targeting an 80 percent confidence level. JWST is still on track with the schedule to complete assessments of the re-plan and Joint Confidence Level (JCL) and start internal and external reviews in the April/May timeframe. Center and Headquarters reviews will occur in May. The Agency Program Management Council (PMC) will occur in late June/early July, assuming the current baseline continues. A change to the baseline will impact the schedule, and significant changes to guidelines will require restart of the entire process. In response to a question from Dr. Noel Hinnners on why JWST is working with the 80 percent confidence level instead of 70 percent, Mr. Howard explained that the Casani report recommended that JWST be funded at the 80 percent confidence level; however, the Program will look at what the JCL says, how much difference there is between 70 percent and 80 percent, and why there is a difference. But the intent is to try to get to 80 percent.

A Test Assessment Team (TAT) report last summer recommended actions to increase the schedule reserve. The last three years is well defined and not compressible. The FY11 budget is final, and there is a CR for the rest of the year. For FY12, JWST is still working with the \$375 million number. In response to a question from Dr. Torbert, Mr. Howard stated that \$471 million was the President's budget request for FY11, and JWST's budget will not be any lower than that for FY11. If JWST finds that the schedule can be wisely accelerated in FY11, it will be considered. A flat-lined budget for FY12 and beyond of \$375 million per year is insufficient to support a 2018 launch.

Mr. Howard explained the process used to get to the new working baseline of a launch in 2018. JWST contractors examined a number of things that needed to be factored into the baseline to obtain an 80 percent confidence level. This assumes that the budget cannot go to \$1 billion in 2013 and accelerate the schedule by six years. Changes to the phasing of work must occur. The budget request in FY12 is \$100 million less than FY11, and that became a real "pinch point" for how much work needed to be accomplished and how it should be laid out. In response to a question from Dr. Tapley regarding manpower, Mr. Howard responded that there must be a realistic profile in terms of the workforce, both for the short term and the long term. Mr. Howard reviewed a chart showing the near-term schedule and milestones for work planned during next 18 months.

Mr. Howard provided a pictorial review of JWST technical accomplishments, showing progress on the telescope architecture in fabrication. The Pathfinder structure was built and delivered to Northrop Grumman (NGST) on March 25, 2011. Major accomplishments at NGST include completion of the spacecraft Preliminary Design

Review, the Optical Telescope Element, the Sunshield and Mission Critical Design Review (CDR), the Ground Operations Control Room, and significant development and risk reduction testing. The ambient Optical Telescope Element (OTE) assembly stand fabrication is in work; the initial load test was in February. Expected completion is summer 2011. The installation into the Goddard Space Flight Center (GSFC) Spacecraft Systems Development and Integration Facility (SSDIF) is scheduled in FY12. JWST now has 11 flight mirrors, including the Engineering Development Unit (EDU), which is a flight spare. Final polishing on the mirrors is completed. The gold coating is finished and ready for final acceptance testing at Marshall Space Flight Center (MSFC), and the mirrors are ready for final cryo testing.

Mr. Howard highlighted several concerns resulting from FY11 and FY12 funding. The biggest concern is the potential loss of key government and contractor personnel due to schedule stretch-out and long storage periods before integration. Another concern is the need to re-evaluate both the sparing philosophy and the parts aging/obsolescence issues based on a four-plus year launch date change from June 2014 to October 2018. The JWST systems engineering team is currently assessing this issue as well as the low near-term reserve posture in FY 11 and FY 12.

JWST is continuing to try to get the project 'risk scrub' and risk quantification effort into the baseline. The JCL project will be completed by the end of April or early May. Reconciliation of the "bottoms-up" estimate to JCL is scheduled for early May. Once everybody is comfortable with the JCL and the baseline plan for 2018, a series of reviews will occur that will lead to Agency approval of a new baseline. In response to a question from Dr. Huntress, Mr. Howard replied that up to now the only fiscal constraints are in FY11 and FY12. The re-plan appears to be a reasonable approach. The Program needs to see what the confidence level will actually be – 70 percent, 80 percent or 90 percent. Mr. Howard emphasized that this is the crucial period because 2013 and out will have fiscal numbers larger than \$375 million. In response to a question from Dr. Tapley about cost, Mr. Howard replied that the Program worked closely with the contractors at all levels to obtain a detailed Rough Order of Magnitude (ROM) estimate showing high probability costs, funding, workforce requirements, etc. JWST is using this approach because there is a budget profile with only FY11 and FY12 constrained, and the President's budget request is flat all the way out. Dr. Hinnners observed that the planned reserve posture looks like it is lower than one would ideally like. Mr. Howard indicated that this is one of the concerns; however, only FY11 and FY12 reserves are short.

Astrophysics

Mr. Geoff Yoder began his review by inviting everyone to visit SMD's new YouTube channel at <http://www.youtube.com/user/ScienceAtNASA>. The first Astrophysics Science Cast was released March 31 on the recent Chandra Superfluid core result. The tentative schedule for the current round of NASA Explorer proposals includes Step 1 selection announcements in September 2011, the Phase-A concept report target due date in August 2012, and the down-select for flight target in February 2013. There are 15 Astrophysics explorer mission proposals for \$200 million plus launch vehicles and 11 Astrophysics SALMON/Missions of Opportunity proposals which includes both Partner MOs and Small Complete Missions for \$55 million. The Division is considering releasing a SALMON MoO AO call later this fall.

About one year ago, in Australia, one of the balloons went awry for various reasons, resulting in a balloon stand-down, investigation, and implementation of corrective actions. The balloon program is on a return-to-flight path with the Antarctica and Australia sites approved for flight. The most recent balloon flight in Antarctica went quite well. On April 18, the High Energy Replicated Optics (HERO) payload was launched on a balloon from Australia, the first time since last year's mishap that NASA had launched a balloon from Australia. To operate effectively, HERO needed to be at a minimum altitude of about 115,000 feet. Within about two hours of launch the balloon reached 127,000 feet where it remained for most of the mission. The mission criterion was a minimum of 24-hours at altitude. HERO concluded on April 20, after staying in the air a little over 34 hours and maintaining greater than 115,000 feet over the entire timeline. Data coming in is better than expected and more than anticipated.

Kepler and Fermi will complete the Level 1 requirements compliance review prior to entering the call for Senior Review proposals around the end of July. Other missions will drop off, including: the Rossi X-ray Timing Explorer (RXTE), which is going through its final decommissioning phase; the INTERNATIONAL Gamma Ray Astrophysics Laboratory (INTEGRAL), which is finished; and the GALaxy Evolution eXplorer (GALEX), which is coming up for completion.

Astro-H is a joint mission with the Japanese Aerospace Exploration Agency (JAXA). A meeting with JAXA is scheduled for next week to continue looking at potential schedule impacts of the recent earthquake and tsunami in Japan. NASA assigned a new, more experienced instrument manager and a more experienced finance team to put more focused discipline and rigor with management of Astro-H instrument. The Engineering Model (EM) is nearing completion. The adiabatic demagnetization refrigerator (ADR) has just completed its vibration testing and is ready for integration and testing. The next science workgroup meeting is mid-July. The hardware CDR is at Goddard in the June timeframe.

The Nuclear Spectroscopic Telescope ARray (NuSTAR) instrument integration and testing is wrapping up at the Jet Propulsion Laboratory (JPL) with instrument completion planned for mid to late April 2011. The NuSTAR x-ray optics modules were both completed and installed into the instrument structure and aligned. The overall NuSTAR Observatory completion is currently planned for November 2011 to support a February 2012 launch from Kwajalein Island. A question exists with the Pegasus launch: Are there implications because of the fairing issue that happened to Glory on the Taurus-XL? An independent team is examining this question. The February launch date could be in jeopardy. In response to a question from Dr. Tapley, Mr. Yoder explained that launching from Kwajalein Island will place the satellite in a better orbit than launching from Florida. Mass measurements were done last week and everything looks like the program is within the maximum budget.

The short science flight number two on the Stratospheric Observatory for Infrared Astronomy (SOFIA) was just completed. This is a series of three flights with the German Receiver for Astronomy at Terahertz Frequencies (GREAT) instrument. Mr. Yoder showed the Committee an image released after the first flight. The aircraft received approval for Reduced Vertical Separation Minima (RVSM), which greatly increases observatory flexibility/capability, opening up flights between 29,000 and 41,000 feet. The international certification will come after avionics upgrades are complete. The program is getting ready to start the basic science campaign in early May.

Mr. Yoder gave an update on the Laser Interferometer Space Antenna (LISA) and the International X-ray Observatory (IXO). Three candidate concepts were competing for the ESA L-1 class 2020 opportunity: LISA, IXO and the Europa Jupiter System Mission (EJSM)/Laplace, each with significant partnership. Because none of the three were ranked very high in the U.S. Astronomy and Astrophysics Decadal Survey, and given constrained projected out-year resources, ESA concluded that a 2020 schedule is not feasible for any of the three candidates. ESA has started an exploratory activity to see which of the science goals of the three missions could be implemented as a Europe-only mission, targeting an early 2020's launch date. The Astrophysics Division is continuing on the baseline funding for FY11. The Division will consult with the community about strategic investments in gravity wave and x-ray astrophysics in future years within the context of the New Worlds, New Horizons (NWNH) DS. Dr. Greeley commented that the mission to Europa was actually a top priority from the Decadal Survey that was just released in March 2011. Mr. Yoder explained that his comments and the reference from ESA were in the context of the Astro 2010 Decadal Survey.

An email was sent out to the community in March regarding the Inflation Probe Science Analysis Group (IPSAG). To date, 37 members have shown interest (28 U.S., 9 international). The Technology SAG is at the teleconference stage to prepare for inputs to the National Research Council (NRC) study, and a key face-to-face meeting is scheduled for May. The Cosmic Origins Program Analysis Group (COPAG) activities for the technology roadmap included a workshop on March 27. Inputs were submitted April 15, focusing on two core areas: High Quantum efficiency, and ultraviolet (UV) coating technologies. The Exoplanet Exploration Program Analysis Group (ExoPAG) is teaming up with the COPAG for UV optical telescope missions. There will be a joint COPAG and ExoPAG meeting on April 26, and the down-select approach will be discussed. This will be a joint activity between the UV/optical and Exoplanet Imaging missions.

The Division is examining options for instrument concept studies for contributions to international missions, e.g. ESA's third medium-class mission (or M-3) and its first large-class mission (L1) from their Cosmic Vision competition, and Space Infrared Telescope for Cosmology and Astrophysics (SPICA). An international workshop is being considered for the 2012 timeframe; the goal is to have a science-driven workshop as opposed to a NASA/ESA bilateral discussion. Dr. Tapley asked for a status on the Wide Field Infrared Survey Telescope (WFIRST). Mr. Yoder reported that the science definition team is still active, and the Division wants to take the science definition team activities to fruition. In response to a question from Dr. Tapley, Mr. Yoder noted that the down-select on the ESA portion of the dark energy mission has not occurred; it is still in competition, which ends in the early fall. The down-select is scheduled for October. There will be no dialogue with ESA on Euclid until there is a down-select.

An observation was made that the WFIRST science team is engaged in planning without knowing what the strengths will be. In response to a question from Dr. Huntress, Dr. Boss noted that all possibilities are being considered, including a U.S.-led mission (for which no money is available) and possible combined missions.

Dr. Boss reported that the Astrophysics Subcommittee (APS) has not met (other than a teleconference two weeks ago) since the last SC meeting. Not much has changed other than the release of the President's budget. In response to a question from Dr. Torbert, Dr. Boss indicated that only the full blown WFIRST activities are on hold relative to the re-plan.

Heliophysics Update

Dr. Richard Fisher began with a brief overview and pictorial demonstration of Kepler's new ability to accumulate an enormous amount of data from red or M-Class stars. He described Kepler's new accomplishment as confirmation of informed theoretical speculation. We are now able to look at the interior structure of some M-class stars to gain insight into their core burning and how they exhaust their cores, as well as detect the pressure wave from the integrated signal of the star. This will provide a tool to estimate space weather effects, a capability we will have for about ten years. We now can utilize remote sensing and the best models to access the circumstances of the solar system. For the first time we have stellar oscillation data comparable to what we have for the Sun.

Dr. Fisher reviewed the budget with the Committee, noting that the future budget line is consistent over the years; however, it is still too soon to know the impact of the CR. There are three flight programs continuing to completion: Living with a Star, Solar Terrestrial Probes, and the Heliophysics Explorer Program; which is now separated from the Astrophysics Explorer Program. The National Research Council is currently conducting a decadal survey in Heliophysics. With respect to the budget, Dr. Huntress commented that it appears that in later years, Living with a Star takes a large jump in 2015, and Solar Terrestrial Probes takes a large decrease. Dr. Fisher explained that in 2015, the big mission in Solar Terrestrial Probes will be launched. Beyond that, the Solar Probe Plus (SPP) launch is targeted for 2018. To remain an executable program, a borrow/payback will be necessary, which will create a large asset in Solar Terrestrial Probes in 2018-2019. Launch vehicle cost increases have led to the descope of the Solar Orbiter collaboration. A Senior Review (a set of decisions on the value of extended missions) was completed for 2010. The next Senior Review is in 2013.

Dr. Fisher briefly discussed the status of the Transition Region And Coronal Explorer (TRACE), the Magnetospheric MultiScale (MMS), the Radiation Belt Storm Probes (RBSP), the Balloon Array for Radiation-belt Relativistic Electron Losses (BARREL), Space Environment Test Beds (SET), the Sounding Rocket Program, and Bristol, a Canadian-made sounding rocket. Dr. Fisher reported that Heliophysics will be reviewing proposals for the current Explorer Announcement of Opportunity (AO). The Division will try to get to Phase-B formulation on Solar Probe Plus; a key issue is to understand the costs. The Division is also planning for development of the last Explorer mission selected for Heliophysics, called Interface Region Imaging Spectrograph (IRIS). Heliophysics is aiming toward a successful system integration review for MMS. Commitments to ESA and the Solar Orbital collaboration will be maintained by providing the launch vehicle and two instruments.

Half of the Heliophysics program is flight missions, and the other half includes suborbital programs, research, technology development, data analysis and management. Explorer proposals are on the order of 22 full Heliophysics Explorer proposals and 20 MoO proposals. The current approach is to make a Step 1 selection announcement of a small number of candidate missions, followed by a Phase A concept study report that would be available around August 2012. A down-selection would be made around January 2013.

Dr. Fisher briefly reviewed the status of the missions in flight—the Solar and Heliospheric Observatory (SOHO), the Advanced Composition Explorer (ACE), the Solar TERrestrial RELations Observatory (STEREO), and the Solar Dynamics Observatory (SDO). IRIS is under development and set for launch in 2012. Solar Orbiter, in collaboration with ESA, should launch in 2017 and Solar Probe Plus a year later. There is enormous value from these two missions working together over a period of time. The Interstellar Boundary Explorer (IBEX) is a mission in high Earth orbit which looks at the boundary of the Earth and our solar system with the galaxy. Voyagers 1 and 2 are continuing, and it is felt by some experimenters that Voyager 1 is near the boundary of our solar system.

The Planetary Division is launching Juno which, in part, has a magnetosphere sensing component for Jupiter's magnetosphere; the same is true for the Mars Atmosphere and Volatile Evolution Mission (MAVEN) which will

launch in late 2013. By that time we will have considerable assets at Mercury, Mars, Jupiter and Earth, as well as Venus, if Venus Express is still operating. This may be the best time for the comparative magnetospheric studies.

Dr. Fisher introduced Dr. Roy Torbert, who began with a review of the Heliophysics Subcommittee (HPS) work plan, indicating a couple things had been changed in preparation for the HPS meeting last week. The first item on their plan, “monitor and advise on NASA’s science launch capabilities for small, medium and large missions” has not changed. The dearth of appropriate launch vehicle availability is still a major issue in the Heliophysics Program. The upcoming DS is due in March 2012. The Subcommittee did discuss the ongoing pace of its activity, which keeps the Heliophysics Division plan current. There was discussion about the sequencing of road maps. Heliophysics will be moving to a four-year sequence that clearly fits into the NASA science plan. The HPS had an interesting discussion about ongoing problems with flight parts, an issue that is shared by many. In response to a question from Dr. Hinners, Dr. Torbert noted that the issue with flight parts exists across every part of NASA, as well as the Department of Defense (DoD), NOAA, and the Department of Energy (DoE).

Dr. Torbert indicated that the last item on their work plan, “Advise on the possible restructuring of the R&A program in Heliophysics.” is an interesting task that the HPS has taken on. There was some discussion about reorganization of the entire competed Research and Analysis (R&A) program within Heliophysics. In the next three meetings, Heliophysics will undertake a review of R&A programs and how they may be structured.

Dr. Torbert reviewed three findings that the Subcommittee brought forward:

Finding: HPS is aware the Explorer program has been separated into Heliophysics and Astrophysics. It is concerned that the level of funding may not allow for an appropriate funding profile to support the life-cycle of projects. This may lead to project inefficiencies in flight development or impact the scope of future Explorers. The HPD is urged to seek some mechanism to allow higher program spending at peak times that could be readjusted when not needed.

Discussion: The concern of the Subcommittee is that whereas the DS in Astronomy and Astrophysics did recommend that additional funds be added to the Explorer Program for Astrophysics, that is not currently the case for Heliophysics. Any action is pending the output of the Heliophysics DS, which could recommend an increase in that Explorer line for Heliophysics. If that were the case, it would be difficult to accommodate the size of an impact of Heliophysics Explorers with a flagship-funding profile that does not allow for any increase to the program. A process for moving money back and forth to allow for peak spending in any one program is needed.

Finding: The Subcommittee heard a presentation about a potential re-purposing of the International Sun Earth Explorer (ISEE)-3/International Cometary Explorer (ICE) spacecraft. The spacecraft has not been maintained for many years. It will re-enter near-Earth space in 2014, and it is thought the spacecraft could be revived and used to study the Earth’s Geotail and Orbit L-1, and then perform an encounter with the Comet Wirtanen. The Subcommittee found the concept interesting and recommends this concept be considered at the next Heliophysics and/or Planetary Science Division Senior Review.

Discussion: Dr. Torbert reflected back to an earlier presentation with mention of the ICE III spacecraft revisit in 2014. Dr. Torbert advised there could be a new purpose for this spacecraft, as noted in the finding. He suggested this be included in the next Senior Review and competed against other science topics. In response to a question from Dr. Huntress, Dr. Torbert indicated that the scientific merit is the primary criterion used in the Senior Review process.

Finding: The data produced by space missions is of potentially great future value. To realize this potential, the data must be archived with adequate documentation. Creation and maintenance of these archives have significant cost that may be unsustainable if all the data and their variants are retained. The legal and scientific obligations needed to constrain this process should be carefully defined. NASA should provide this guidance for current and future missions.

Discussion: This is a common problem. A discussion with a data working group about uncertainties and the extent that we are required either legally or scientifically to archive some data from our missions should occur. The issue is the potential for exhausting the complete data storage if requirements about the level of data archive are followed. Dr. Torbert asked the SC for guidance on the minimum legal requirements for data

archiving. He also asked for guidance on formulating the scientific requirements in a way that does not exhaust the ability to store. This issue may need to be addressed at a higher level in the organization.

Dr. Huntress opined that an issue like this needs a champion. He noted that there is a group that looks at data issues, archives, and distribution of data across the scientific community. Dr. Huntress asked Dr. Torbert to take the lead; Dr. Torbert responded that the issue will be reviewed again within the data group, and they will have a report at the June Heliophysics Subcommittee meeting in preparation for the August Science Committee meeting. Dr. Huntress asked the other Committee members if they had similar issues. Dr. Greeley responded that this is always an issue in Planetary. Dr. Boss inquired as to whether “cloud” storage could help. Dr. Torbert opined that he didn’t think that would satisfy NASA’s legal requirements.

In closing, Dr. Torbert shared a selection of pictorial slides: a STEREO view of the Coronal Mass Ejection (CME) taken on February 15, 2011; global views of the Sun; solar wind speed; Earth satellite activity on the Solar Shield Project; prediction of solar spot minimum; Ring Currents; new results from the Time History of Events and Macroscale Interactions during Substorms (THEMIS) on the origin of pulsating aurora; and the Magnetospheric Variability at Mercury from MESSENGER.

Committee Discussion

Dr. Huntress reviewed the budget proposal, noting that the President’s budget proposal a year ago for SMD was \$4.5 billion in FY10. The President’s FY11 proposal was for \$5 billion in FY11 and which climbed to almost \$6 billion in FY15. For FY12, the budget proposed was \$4.5 billion. Dr. Huntress reported that while SMD will lose a great deal in the budget, the Directorate will still be able to do many great things. He added that the President’s budget request removes about \$3.2 billion from SMD over the 5-year budget horizon, and some content will need to come out. The effects of the FY12 budget proposal on SMD cause a serious blow to Earth and Space Science in terms of what the Directorate could have done. Earth Science lost half of its climate initiative, reduced a lot of its augmentations, and had to defer two of four Tier 1 flight projects. Planetary Science will not be able to fulfill the recommendations of the newly released DS report. Constrained by the FY12 budget, Planetary will have to severely descope or eliminate its flagship missions; two of the five flight program lines are eliminated. JWST is flat-funded, which is not a viable profile for flight programs. The organization will have to find money somewhere to provide what is required for a successful flight program. There is no funding for WFIRST until after the JWST launch, which now is delayed from 2014 to at least 2018. This means that the Astrophysics flagship mission for the next decade is not going to be WFIRST. All of this will require renegotiating with ESA. SMD is in the process of restructuring its entire program to meet the budget challenges.

Planetary Protection

Dr. Eugene Levy presented two pressing issues to the Committee. The first issue concerned the potential for introducing terrestrial organisms that could thrive and survive on the surface of Mars. Recent information indicates the presence of weather ice prevalent on the surface of Mars. The Mars Science Laboratory (MSL) carries radioisotope thermoelectric generators (RTGs); in the event of off-nominal contact with the Mars surface, the burial of a spacecraft with RTGs that carries a microbial organisms from Earth in Martian soil potentially creates an instantaneous incubator for terrestrial organisms that could thrive. The Project is currently engaged in analysis of the implications of distribution of ice across the subsurface of Mars. At a meeting in May, the Planetary Protection Subcommittee will hear substantial presentations from the Project on the implications and, in particular, whether or not our new understanding of the issue dictates any changes in the protocols for site selection. In response to a question regarding the significance of a crash landing on Mars, Dr. Levy explained that the issue is the heat source and the inadvertent construction of an incubator on the surface of Mars.

NASA is a small scale participant in a mission in development for a Russian launch. Under the protocols and rules of the Agency, if NASA is to provide support, then the missions flown by partner countries must adhere to the same guidelines that NASA follows. The challenge is to understand the vernaculars that Russia uses compared to vernaculars that both the U.S. and ESA use. Dr. Levy indicated that a Statement of Planetary Protection Protocol has not been received from Russia. Both ESA and the Planetary Protection Office share this concern. Dr. Levy recommended that this subject be discussed at the next meeting and pointed out that this is a combination of substance and protocols. Dr. Ed Weiler commented that he had only just learned of NASA’s involvement of one scientist at a certain level; at a recent meeting, it was suggested that NASA’s involvement could increase. He added that this is not an SMD issue; this issue is at the NASA Advisory Council (NAC) level. Dr. Huntress said the Committee would note this. In response to a question from Dr. Huntress, Dr. Levy indicated that the protocol is an

international Committee on SPace Research (COSPAR) protocol, and that NASA's rules reflect COSPAR. In response to a question from Dr. Hinners, Dr. Levy explained that if the site becomes contaminated, it will be removed from the sample return site list.

Friday, April 22

Planetary Decadal Survey

Dr. Huntress introduced Dr. Steven Squyres, Chair of the Planetary Science DS, who reviewed the study process. Dr. Squyres described the two implications that came from directions in the Survey task statement: more detailed definition of recommended missions for costing purposes; and decision rules that could be used to adjust the plan as necessary for any conceivable budget outcomes.

NRC sought the community's views through multiple channels, including town hall meetings, white papers, and webcast meetings. From this input, 25 mission candidates were chosen for study. Rather than use Agency numbers, the NRC contracted with Aerospace Corporation to create independent cost and technical evaluation (CATE) estimates.

The criteria used to assign priorities included: science return per dollar, programmatic balance, technological readiness, and availability of appropriate trajectories. Recommendations were guided by community input; prioritization was done by the panels. Cross-panel prioritization was done by the steering committee. In response to a question from Dr. Tapley, Dr. Squyres explained that they did not quantify the science per dollar; rather, they assembled experts to help them make the judgment.

Dr. Squyres reviewed the NRC recommendations:

Ongoing and Approved Missions

- Continue missions in development, and missions in flight subject to senior review

Research and Analysis Program

- Increase the NASA planetary R&A budget by five percent above the total finally approved FY11 expenditures in the first year, and then by one and a half percent above inflation each successive year.

Technology Development

- A planetary exploration technology development program should be established and carefully protected from incursions on its resources.
- This program should be funded at six to eight percent of the total NASA Planetary Science Division budget.

The Discovery Program

- Continue the Discovery program at its current funding level, adjusted for inflation, with a cost cap per mission also adjusted for inflation (i.e., to \$500 million in constant FY15 dollars).
- Assure a regular, predictable, and rapid (preferably 24-month or less) cadence of Discovery AOs and selections.

Discussion: No recommendations are made for Discovery mission priorities; this is left to the AO and peer review process.

Mars Trace Gas Orbiter

- Carry out this mission as long as the division of responsibilities with ESA is preserved.

The New Frontiers (NF) Program

- Change the NF cost cap to \$1.0 billion in constant FY15 dollars, excluding launch vehicle costs.
- Select NF missions NF-4 and NF-5 in the decade 2013 – 2022

Discussion: NF missions can address high priority and technically complex science goals that are beyond the capabilities of Discovery missions. In response to a question from Dr. Weiler, Dr. Squyres noted that the committee

discussed a more severe budget environment for Discovery, and concluded that the selection rate was the most important aspect. The recommended Discovery cap excludes the launch vehicle.

New Frontiers 4 Selection

- Select NF-4 from among: (Specific targets for AOs) Comet Surface Sample Return; Lunar South Pole-Aitken Basin Sample Return; Saturn Probe; Trojan Tour and Rendezvous; and Venus *In Situ* Explorer

Discussion: Dr. Squyres noted that these are not called “flagships.” The team did not discuss the possibility of doing “flagship science” in the NF budget; the idea of NF is mission-specific.

New Frontiers 5 Selection

- The remaining candidates from NF-4, plus Io Observer and Lunar Geophysical Network

Flagship Missions (in priority order)

1. Begin NASA/ESA Mars Sample Return campaign: descoped Mars Astrobiology Explorer-Cacher (MAX-C)/ExoMars
2. Descoped Jupiter Europa Orbiter (JEO)
3. Uranus Orbiter and Probe (First in-depth exploration of an Ice Giant planet)
4. Either Enceladus Orbiter or Venus Climate Mission (no relative priorities assigned)

Flagship Priority 1: Max-C/ExoMars

- Fly MAX-C/ExoMars only if it can be conducted at a cost to NASA of less than \$2.5 billion in constant FY15 dollars.
- Descope must be equitable between NASA and ESA. It is critical that the partnership with ESA be preserved.

Discussion: In response to a question from Dr. Huntress regarding a strategic approach to Mars exploration, Dr. Squyres indicated that the position of the Mars science community is that we have reached the point where only fundamental advances will come from study of returned samples. MAX-C/ExoMars will perform *in situ* science and collect and cache samples, beginning a three-mission campaign to return samples from Mars. Of the three missions in the campaign, only MAX-C/ExoMars is recommended for 2013-2022. In response to questions from Dr. Huntress, Dr. Squyres noted that the Mars panel determined that sample return came out on top when compared to other missions on a science-per-dollar basis. The team made recommendations on the following: (1) the amount of *in situ* characterization to obtain the right samples; and (2) the importance of the landing site. The approach of *in situ* analysis/results returning to Earth would be limited. On Earth the very best laboratory environment can be applied to the samples; in addition, samples can be analyzed for years and years. The CAPE estimates are NASA numbers if NASA does the program alone. This is what makes partnership with ESA so important. The NASA numbers were factored into the science return per dollar. In response to a question, Dr. Squyres observed that if ESA does not partner in the full program, the survey team would not recommend that NASA do it.

Need for a Descope

- Fly MAX-C/ExoMars only if it can be conducted at a cost to NASA of less than \$2.5 billion in constant FY15 dollars.
- NASA and ESA redesign the mission to make it fit within \$2.5 billion. It is critical that the partnership with ESA be preserved. If it can't be done under \$2.5 billion, then defer the mission to the subsequent decade or cancel.

Discussion: As previously planned, Mars 2018, a joint NASA-ESA mission, would have delivered two rovers to the Martian surface. Recent analysis has confirmed that the resulting mass and volume would require redesigning and enlarging the entry and landing system used for MSL. The team asked Aerospace to cost delivery of just one rover to the surface using only NASA money, which came out to \$2.4 billion. That being the case, if ESA brings significant resources to the table, \$2.5 billion is achievable. Dr. Squyres stated there is no “Plan B” for Mars.

Flagship Priority 2 JEO – Europa

- Fly JEO only if changes to both the mission and the NASA planetary budget make it affordable without eliminating other recommended missions.

Discussion: This will require a reduction in mission scope and cost. JEO will probably also require a new start that would increase the overall budget of NASA's Planetary Science Division.

- NASA immediately begin an effort to find major reductions

Discussion: The CATE cost for JEO was \$4.7 billion. Dr. Turner commented that there have been similar issues--where NASA had a mission that was too expensive and was not technically ready, so it was set aside. If the descope is a factor of two, it appears that the technology is not yet ready. Dr. Squyres noted that that is not the case with JEO; it just has too much scope.

Flagship Priority 3

- Uranus is preferred over Neptune for 2013-2022 for practical reasons involving available trajectories, flight timelines, and cost.

Technology Development Priorities

- High priority missions for future study and development include: the Titan Saturn System Mission; the Neptune mission; and second and third missions in Mars Sample Return Lander and Orbiter Campaign.

Discussion: Dr. Squyres reviewed the cost wedge that his team used for planning purposes along with an example of what a cost-constrained program looks like versus the recommended program. The President's budget request for Planetary Science in FY12. However it is followed by notional funding levels for FY13-FY16 that consistently go down. In response to a question from Dr. Turner, Dr. Weiler explained that the DS was working to PSD's planning budget that was in the President's FY11 budget request. The President's FY12 budget request is \$1.1 billion less from FY12 to FY16. Dr. Squyres stated that if less funding is available than envisioned by the DS Steering Committee, the following decision rules should guide NASA's implementation strategy: descope or delay flagship missions; slip NF and/or Discovery missions only if adjustments to flagship missions cannot solve the problem; and place a high priority on preserving R&A and technology development funding.

There are implications from the decision rules in the face of declining budgets, which include protecting R&A, technology, Discovery and NF to the greatest extent possible. The team recommended that NASA fly MAX-C/ExoMars only if the cost to NASA is no more than \$2.5 billion and it realistically leads to sample return. If MAX-C/ExoMars does not meet these criteria, the second priority is JEO. If JEO is not affordable, the third priority is Uranus Orbiter and Probe (UOP). If UOP is not affordable, the fourth priority is Venus Climate Mission or Enceladus Orbiter. If none of these are affordable, then there will be no flagship missions. In response to a question from Dr. Turner, Dr. Squyres indicated the recommendations came from the DS.

Launch vehicle costs are rising and tend to be a larger fraction of mission costs than they once were. The team suggested several things to reduce these costs, which include using dual manifesting (two missions on a single launch vehicle), making block buys across NASA and with other agencies for launch services, and exploiting technologies that reduce flight system mass, allowing the use of smaller launch vehicles.

Plutonium-238

- JEO should switch to Advanced Stirling Radioisotope Generators (ASRG) for power production.

Discussion: Development of ASRGs is the single highest priority technology recommendation. Without a restart of plutonium-238 production, it will be impossible for NASA to carry out important planetary missions, particularly in the outer solar system.

Interaction with Human Exploration

- Where NASA is going to conduct peer-reviewed, AO-selected science missions to a target that could be a target for human exploration, there are two key points: (1) any requirements coming from human exploration should come with dollars attached, and (2) they should come at the outset of the process.

Discussion: There is significant potential for valuable partnerships with the human exploration part of the Agency; however partnerships need to be entered into carefully. Lunar Reconnaissance Orbiter (LRO) is a good recent example of such a partnership. In response to a question from Dr. McComas regarding the plutonium supply issue, Dr. Squyres replied that SMD can do the recommended program with the current stockpile of plutonium if the

Europa mission switches to ASRGs. Dr. Weiler added that a couple of years ago, DoE's solution was to build new facilities; later they determined that NASA's needs could be accommodated with modifications to existing facilities at Oakridge at a cost of about \$15 million each. However, the congressional subcommittees that oversee DOE's appropriations bill have not approved the requested \$15 million for DOE. This is still an ongoing issue.

In response to questions from Dr. Turner, Dr. Squyres replied that a follow-up committee would not be necessary. Planetary was in an advantageous position—the Planetary DS was done after the Astrophysics Decadal. The Planetary DS CATE process was also similar to Astrophysics, the major difference being that the Planetary DS established rules to follow in the process.

Planetary Science

Dr. Jim Green gave an overview of the Planetary Science Division (PSD) status and the responses to the DS. He began by sharing a few "science nugget" slides with the Committee, reporting that a great milestone occurred on March 17 when MESSENGER went into orbit to start the global imaging campaign of Mercury. A major press conference is coming up in May. Dr. Green also showed pictures of Mercury, the footprint left by Saturn's Moon, Enceladus, and Cassini activities.

Dr. Green reviewed the PSD plan for responding to the DS. The Discovery-12 evaluation is in progress and on schedule for April/May. Three NF Step 2 proposals were received on January 28; they are being evaluated and are on schedule for May/June.

The DS was released about six weeks ago. Since then, there have been about ten town hall meetings, and PSD has had discussions with OMB and the Office of Science and Technology Policy (OSTP). The FY11 budget passed in mid-April is a continuing resolution through September 30, 2011. The FY 12 budget discussions in Congress are ongoing, and the development of the FY13 budget request for PSD has begun. The FY13 budget will reflect DS recommendations. The FY 12 budget has quite a precipitous drop, so PSD is assuming a flat budget profile.

Based on decadal results, the PSD top priorities are: healthy Discovery and NF programs, R&A, technology and current commitments, and descope and delay of flagships. PSD has also been directed to set aside about \$10 million per year for cooperative activities with human exploration. Since the full DS recommendations greatly exceed the President's FY12 budget, the decision-making rules from the DS will be used to develop a balanced program. Dr. Green reported that in response to DS rule 9-6, PSD is maintaining a balanced program, maintaining a partnership with ESA, and descopeing flagship missions as a first resort. Dr. Green indicated that if the descopes are insufficient, PSD will stretch out the release of NF and Discovery AOs.

PSD worked with ESA at the last bilateral to chart a course to determine if, collectively, the bare minimum requirements for sample return can be maintained, with Mars 2018 being the first step. For the Dual Rover Mission, a new approach is necessary because the mission's technical complexity created unacceptable cost and risk. The new approach is to merge the rover design to leverage both partners' strengths, to focus on decadal science/sample caching, to use a build-to-print MSL SkyCrane decent stage for landing, and to support ESA's priorities to focus on mobility and drilling. The joint engineering for this began April 6, and a joint science team is being organized to set science objectives and level-1 requirements. NASA will provide the launch vehicle and hopes to receive multiple vendor proposals. A key decision gate for ESA is May 26-27. The joint Mars sample return working group is continuing its activities and will ramp up as the 2018 Joint Rover Mission takes shape.

PSD is interacting with ESA on its Cosmic Visions competition. ESA has a competition underway for three L-Class missions. From a planetary perspective, PSD is very interested in Laplace. Dr. Turner expressed concern over the NASA-ESA partnership, which appears to be having difficulties. Dr. Green noted that ESA has tasked their new study teams to look at an ESA-only approach to each of the three L-Class concepts; they will report to ESA's senior management in February 2012. Dr. Weiler observed that ESA's budget realities are just like NASA's. ESA also reads our decadal surveys, and they know what has been assigned a low priority. NASA and ESA are in different environments in spite of similar science goals. NASA must try harder to fit into the budget. Together with ESA, it might be possible. NASA and ESA need to work together, but even working together the budgets are not increasing.

PSD is creating a notional budget by capping the R&A budget at \$200 million a year. For the next Discovery, PSD will look at a 36-month cadence. A selection for NF-3 is planned, and selections for NF-4 and NF-5 will occur

within the next decade. PSD wants to have an extended mission budget for operating missions. The residual Lunar Quest Program moved to Discovery and the dedicated lunar R&A will transfer to other PSD R&A programs; then PSD will start funding in FY11/12 descope studies for a joint mission to Europa.

PSD created a funding wedge for the 2016 and 2018 missions in the Mars program that leaves about \$1.2 billion for the 2018 mission plus launch vehicle. The DS rules will enable PSD to at least begin to work with ESA in good faith in terms of honoring the decadal. Over next year, PSD hopes to close on architecture that does the minimum science to obtain the samples and meets ESA's highest priorities. In response to several questions, Dr. Green confirmed that the budget includes money for the launch vehicle.

Dr. Greeley continued the Planetary Science presentation by first thanking Dr. Squyres and his team for their outstanding work on DS. He reported that the Planetary Science Subcommittee (PSS) is encouraging the entire community to speak with a uniform voice in support of the DS, despite their discipline and organizational diversity. It is understood that the DS was conducted before the President's FY12 budget request was released and before the full implications of increased NLS-II costs were understood. It is not the PSS's role to revise the DS, but rather to consider and recommend implementation approaches.

The DS was released March 7, followed by the Outer Planet Analysis Group meeting on March 17-18 with input from other planetary analysis groups. This was followed by a PSS meeting April 17-18 to discuss the DS processes and recommendations. Next steps include the PSD drafting a response for PSS for review and a teleconference with PSS in June. Dr. Greeley stated that the notional budget details by PSD is commendable, adding that a strategic goal is to try to keep a balance of small, medium and large mission. The DS includes many recommendations beyond missions to be costed and prioritized. PSS is grateful for maintenance of the R&A line at its current level.

PSS recognizes that flagships aren't going to happen without descopes or delays; thus, PSS recommends that flagship costs and requirements be thoroughly scrubbed. This is already underway. Clearly, international partners must be considered. The Jupiter-Europa Orbiter will require substantial descoping, so ESA joint flagship missions are being explored and options are being kept open should the situation change.

PSS urged the formation of appropriate science working groups to include Center and planetary community scientists working directly with engineers and technologists throughout the descope process to identify the minimum acceptable science. Additionally, PSS suggested that a schedule be established with critical decision milestones, keeping in mind the iterative nature of the process. In terms of independent costing, PSS recommended the same entity be used to assess all candidate flagship options that occur.

Dr. Green indicated that he is okay with all of the PSS recommendations. Dr. Weiler commented on the importance of PSS understanding the situation so that it can be communicated to the community. NASA does not have \$2.5 billion to do a Mars mission in 2018. If NASA and ESA cannot put together the Mars mission with NASA's contribution limited to \$1.5 billion, there is a real problem. Dr. Squyres added that it is important to continue to look at creative ways to get a Europa mission down to \$2 billion or in that range, because there are a lot of ways the Mars program can fail. This involves a complicated international partnership and depends on doing the follow-on two missions as well as the 2018 mission. A good study process going forward is key. Dr. Weiler agreed in principle, but emphasized the need to fit within the budget. He observed that studies cost money, and every dollar spent for a study comes out of the program budget.

PSS agreed that sample return is the next major step for Mars science, albeit it is not the culmination of Mars science. The value of sample science must be communicated to the broad community. In response to a question from Dr. Hinnert, Dr. Greeley replied there are some even within the Mars community that do not understand the importance of sample return. This is why communication is so important. If the joint NASA/ESA project moves forward, a joint AO should be released for negotiated, competed payload. Dr. Greeley noted that the descope for the Europa mission is being examined. He agreed with Dr. Squyres' suggestion that it does not necessarily have to be an orbiter. If the Ganymede Orbiter is selected by ESA, NASA should consider the opportunity for U.S. instruments or participation. PSS urged that at least before the end of the decade, an Outer Planet Flagship should be vigorously pursued, consistent with the DS recommendation.

Dr. Greeley acknowledged that the need for plutonium remains a high priority, and support for the technology development should continue. The critical aspects for all classes of missions should be undertaken, especially for

small missions. A PSD technology group is being established to manage activities. With regard to R&A, the timeline is right for a “comparative planetology” program. PSS recommended periodic Senior Review of all R&A programs. It also recommended using existing relevant science groups to examine appropriate issues.

Discussion with Dr. Weiler

Dr. Weiler reviewed the SMD budget with the Committee. In the chart, the President’s proposed budget with 5-year run-out is shown,; after that, only increases to cover inflation were assumed. It should be noted that 2004 was a key year. The science budget at NASA, with momentary rise, has been declining in buying power for the last sixteen years. In the President’s budget, the big changes from FY11 to FY12 were in Earth Science and Planetary. Earth Science lost about \$1.7 billion over 5 years and Planetary lost about \$1.1 billion over the same period; that is because they were the only Divisions that increased in 2011. Dr. Weiler reiterated that the numbers are notional, but they are the numbers SMD must plan to.

The Committee and Dr. Weiler discussed their understanding of the term ‘notional.’ In response to a question from Dr. Huntress regarding more funds in the out-years, Dr. Weiler observed that if JWST needs more SMD funding in FY11 or FY12, he is not sure where it will come from. The only way to generate large amounts of money in the near term is to cancel missions that have not launched. Dr. Weiler noted that he has not been asked to recommend that and refused to speculate on what that might be if asked. The Administrator has said that JWST is now a NASA issue, not just an SMD issue. With respect to the launch vehicle problem, Dr. Weiler stated that the SMD cannot control launch vehicles or decide on the launch vehicle. Citing his concern over not having a reliable mid-range launcher, he indicated that he is open to buying Delta-IIs if they become affordable. If NASA could negotiate block-buys, it might be able to get the price down. Launch vehicles costs are getting to the point where scientific content must be taken out. In response to a comment from Dr. Boss about not having sufficient funds to fly any flagships during the next ten years, Dr. Weiler reminded him that during the next ten years, SPP will launch and it is a flagship; MAX-C will launch, also considered a flagship by the DS, and during the next ten years, SMD hopes to launch JWST, also a flagship. In response to a question from Dr. Boss, Dr. Weiler commented on the idea of an SMD-wide competition, similar to what Cosmic Visions does for the Europeans, to get more flagships flying; he indicated that he did not want to engage in cross-Division competitions within SMD. However, , it may be feasible and should not be dismissed, especially if budgets continue to deteriorate. Dr. Weiler emphasized that he is totally against any concept that NASA should never do flagships again; that would be a huge step backward for our American culture.

Dr. Turner shared his concerns about partnering with ESA, citing the “mess” NASA is in with the three extraordinary L-class mission candidates. In response to a question, Dr. Weiler opined that the economic situation in Europe isn’t any better than it is here. ESA science is not likely to have a budget that goes up dramatically while NASA’s budget is decreasing. ESA has three L-Class missions; one will be selected, but only if the cost can be reduced to about half of what was proposed. Dr. Weiler added that he does not really know what they will do, although he does believe that the door is never closed on European collaboration. SMD is closer with ESA than it has ever been.

Dr. McComas commented that SMD continues to provide an increasingly growing part of the exciting work coming out of NASA. That should provide an opportunity to resell the value and importance of the Agency to the nation. Dr. Weiler noted that there are tough budgets ahead, and science and technology may look like a luxury to some. The number of U.S. participants in the engineering and science fields is dwindling. It is important to keep science going at NASA. Dr. Torbert noted that a recent CNN program reported that many people still respond in favor of NASA. Dr. Weiler added that one of the reasons SMD requires that that one percent of each project’s budget must be spent on education and public outreach is to comply with the Space Act and share the great things NASA is doing with the people who are actually paying the bill. Dr. Weiler revisited Dr. Boss’ earlier comment about cross-divisional competitions and observed that maybe it is time to try to develop joint priorities in concert with ESA. NASA has actually broached this idea to some ESA people, and they do not necessarily disagree. To do the right thing for the future, NASA and ESA must find ways to work together between our National Academy and their equivalent. Dr. Huntress cited ISS as an example of a treaty-driven organization. Dr. Weiler commented that NASA was first to land humans on the Moon and first to land on Mars; perhaps NASA should stop competing with other countries and start working together more.

On behalf of the Committee, Dr. Huntress thanked Dr. Weiler and his staff for their hard work.

Committee Discussion/ Findings /Recommendations

Finding: The Administration's FY12 budget proposes a significant reduction in the five-year run-out of the NASA Earth and Space Science program relative to the FY11 budget. This reduction puts at serious risk NASA's ability to accomplish the goals set out in several recent Decadal Surveys for Earth and space science, undermines SMD's international collaborations, and threatens the health of the Earth and space science enterprise.

Finding: Small and medium missions, which comprise a major element of the SMD portfolio, are increasingly less affordable. Lower cost flight missions require prudent but less conservative mission assurance and review processes than flagship missions. A return to affordable missions requires, in part, that NASA tailor NASA 7120.5 for lower cost SMD mission categories and instill this tailoring into the engineering (TMCO) review process.

Recommendation #1: The Science Committee recommends that NASA work diligently to moderate the cost of expendable launch services through whatever means possible. This may include block buys or other innovative approaches in the NLS II contract, and pursuing alternate sources such as new commercial entries and international collaborations.

Major Reasons for the Recommendation: The new NLS II contract greatly increases the cost of launch services, resulting in loss of the number of flight missions that SMD can afford and reductions in the science content of missions launched.

Recommendation #2: The Science Committee recommends that NASA do something to acquire reliable mid-range launch vehicle services (Taurus-XL to Delta II class) to address loss of access to space issues by its Earth and Space Sciences flight missions.

Major Reasons for the Recommendation: There is a crisis in access to space in Earth and Space Science. The current stable of mid-range launch vehicles is not reliable; in some cases uncertified (i.e. Minotaur, Taurus II and Falcon 9) and unreliable (Taurus-XL has failed in 3 of 4 launches). There are SMD flight missions for which there are no reliable launch vehicles available. It should be noted that launch failures do NOT change the certification level!

Public Comment

Bethany Jones from the American Astronomical Society posed two questions to the Committee. Her first question asked for re-clarification on the issue of not being able to proceed with flagship missions because of budget. She specifically asked about MAX-C, Europa, and Uranus. Dr. Huntress responded that they are working on descoping MAX-C and Europa, but will continue studies on outer planet missions. Her second question concerned language in the recent continuing resolution--that NASA cannot work at all with China on projects. She asked the Committee if they had any opinions about working with China or why the language is there. Dr. Huntress informed Ms. Jones that was a NASA decision and not a Committee decision.

Second Day Wrap-up

Dr. Huntress asked for any additional comments or discussions on the meeting. Dr. Levy commented that one of the Committee's most pressing issues is how to construct the role of international collaboration. Perhaps this is something the Committee should pursue.

The meeting was adjourned.

NAC Science Committee

April 21-22, 2011

Agenda

Thursday, April 21 (MIC-5/5H45)

8:30-8:45am	Remarks and Announcements	Huntress, Feeley
8:45-10:00am	Earth Science	Tapley/Freilich
10:00-10:15	Break	
10:15-11:30pm	E/PO Education Design Team/ECC	Stockman
11:30-1:00pm	Lunch on Own	
1:00-1:30pm	JWST Update	Howard
1:30-2:15pm	Astrophysics	Boss/Yoder
2:15-2:30pm	Break	
2:30-3:30pm	Heliophysics	Torbert/Fisher
3:30-3:45pm	Committee Discussion	
3:45-4:00pm	First Day Wrap-up	Huntress, Feeley
4:00pm	Adjourn for the day	
5:00pm	<i>Dinner (members only)</i>	<i>Cava Mezze</i>

Friday, April 22 (MIC-5/5H45)

8:30-8:35am	Remarks and Announcements	Huntress, Feeley
8:35-9:45am	Planetary Decadal Survey	Squyres
9:45-10:00am	Break	
10:00-11:15am	Planetary Science	Greeley/ Green
11:15-11:30pm	Planetary Protection	Levy/Conley
11:30-Noon	Committee Discussion	
Noon-1:00pm	Lunch on Own	
1:00-2:00pm	Discussion with AA	Weiler
2:00-2:15 pm	Public Comment	
2:15-3:00pm	Findings and Recommendations	
3:00-3:15pm	Second Day Wrap-up	Huntress, Feeley
3:15pm	Adjourn	

Future Meeting Dates:

August 2-3 at ARC with Other Committees

October 31-November 1 at NASA HQ

Member List
NAC Science Committee

Dr. Wesley T. Huntress, Jr. Chair	Director, Emeritus, Geophysical Laboratory Carnegie Institute of Washington
T. Jens Feeley Executive Secretary	NASA Headquarters Science Mission Directorate
Dr. Byron Tapley Vice Chair	Director, Center for Space Research University of Texas, Austin
Dr. Alan P. Boss	Carnegie Institution for Science Department of Terrestrial Magnetism
Dr. Ronald Greeley	School of Earth and Space Exploration Arizona State University
Dr. Noel W. Hinners	Consultant
Dr. G. Scott Hubbard	Department of Aeronautics and Astronautics Stanford University
Dr. Eugenia Kalnay	Department of Atmospheric and Oceanic Science University of Maryland
Dr. Charles F. Kennel	Space Studies Board Scripps Institution of Oceanography, UCSD
Dr. Eugene H. Levy	Provost & Professor of Physics and Astronomy Rice University
Dr. David J. McComas	Space Science and Engineering Division Southwest Research Institute
Dr. Byron Tapley	Center for Space Research University of Texas, Austin
Dr. Roy B. Torbert	Space Science Center University of New Hampshire
Dr. Michael S. Turner	Kavli Institute for Cosmological Physics The University of Chicago

NAC Science Committee Attendees

Committee Members

Wesley T. Huntress, Jr.	Carnegie Institution of Washington
T. Jens Feeley,	Science Mission Directorate, NASA Headquarters
Byron Tapley	University of Texas, Austin
Alan P. Boss	Carnegie Institution for Science
Ronald Greeley	Arizona State University
Noel W. Hinners (via Webex)	Consultant
G. Scott Hubbard	Stanford University
Eugenia Kalnay	University of Maryland
Eugene H. Levy	Rice University
David J. McComas	Southwest Research Institute
Roy B. Torbert	University of New Hampshire
Michael S. Turner	The University of Chicago

NASA Attendees

Mark Allen	NASA HQ
Dan Woods	NASA HQ
Michael Meyer	NASA HQ
Marian Norris	NASA HQ
Catherine Conley	NASA HQ
Chuck Gay	NASA HQ
Michael Freilich	NASA HQ
Jim Green	NASA HQ
Geoffrey Yoder	NASA HQ
Peter Hacker	NASA HQ
Hashima Hasan	NASA HQ
Stephanie Stockman	NASA HQ
Charles Goodrich	NASA HQ
Michael White	NASA GSFC
Vicki Elsberd	NASA HQ
Jennifer Rurburg	NASA HQ
David Rusch	NASA HQ

Other Attendees

Steven Squyers	Cornell University
Bethany Johnson	American Astronomical Society
Marcia Smirl	SpacePolicyOnline.com
Carolyn Sue Cook	P B Frankel, LLC; Zantech

NAC Science Committee
List of Presentation Materials

1. Remarks and FY11 Budget	Huntress/Feeley
2. Planetary Decadal Survey	Squires
3. Planetary Science	Greeley/Green
4. Planetary Protection	Levy/Conley
5. Discussion with AA	Weiler
6. Earth Science	Tapley/Freilich
7. E/PO & Education Design Team	Stockman
8. JWST Update	Howard
9. Astrophysics	Boss/Yoder
10. Heliophysics	Torbert/Fisher