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SCIENCE COMMITTEE

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Goddard Space Flight Center
Greenbelt, Maryland

MEETING MINUTES

David McComas, Acting Chair

T. Jens Feeley, Executive Secretary

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Opening Remarks

Dr. T. Jens Feeley, Executive Secretary for the NASA Advisory Council (NAC) Science Committee, opened the meeting at 8:45 a.m. He explained that under the rules of the Federal Advisory Committee Act (FACA), the meeting provided public access but not public participation. He then asked Committee members to identify any conflicts of interest.

Dr. David McComas, filling in for Committee Chair Dr. Wesley Huntress, added that there would be a joint session with the Human Exploration and Operations Committee (HEOC) in the afternoon to hear about the Mars Program Planning Group (MPPG) and the joint robotic precursor activities.

Center Welcome

Christopher Scolese, Director of NASA's Goddard Space Flight Center (GSFC), welcomed the Committee to the Center. Mr. Scolese explained that Goddard was NASA's first Space Flight Center, with a focus on everything from understanding Earth to understanding the cosmos. The Center hosts the largest collection of scientists and engineers in the United States, including individuals who have received Nobel prizes and other prestigious awards. Scientists and engineers make up 61 percent of the workforce, with the rest being support staff. There are 3,400 civil servants and 6,400 local contractors for a total workforce of 9,800. All data that have ever come from a human spacecraft have come through GSFC. Lines of business include astrophysics, heliophysics, planetary and lunar science, Earth science, human exploration and operations, communication and navigation, suborbital platforms, and cross-cutting technologies and capabilities.

Mr. Scolese reviewed a number of noteworthy GSFC accomplishments, including the SUOMI National Polar-orbiting Partnership (NPP), the Sample Analysis at Mars (SAM) that was to land on Mars within a matter of days, the Robotic Refueling Mission (RRM) that is designed to robotically service spacecraft that are beyond the International Space Station (ISS), Operation Ice Bridge, and the Nuclear Spectroscopic Telescope Array (NuSTAR), which was done in conjunction with the Jet Propulsion Laboratory (JPL).

GSFC has five facilities, including the Wallops Flight Facility in Virginia, which is now the base for the new HS3/Global Hawks. The Global Hawks will be used to collect hurricane data from the storms' formation through their lifespan, staying over the hurricanes as needed. They are scheduled to deploy in August 2012. Orbital Sciences Corporation plans to launch its Antares rocket from Wallops; this launch vehicle will fit into the niche previously occupied by the Delta 2, which is no longer being manufactured. If the Antares is successful, it can help in the resupply of the ISS.

Mr. Scolese next reviewed upcoming missions that are set to launch in the areas of Earth science, heliophysics, planetary science, astrophysics, and space communications and navigation. GSFC also develops, launches and conducts on-orbit checkout of reimbursable weather satellites for the National Oceanic and Atmospheric Administration (NOAA). GSFC missions are sometimes in partnership with other government organizations, such as the U.S. Air Force (USAF). The Center turns much of the data from these missions into usable form, enabling even more scientific research.

Discussion

In response to a question, Mr. Scolese explained that Antares will launch only from Wallops for the foreseeable future, but Orbital plans to use the Kennedy and Vandenberg launch sites eventually. Wallops presents a number of advantages despite some infrastructure support costs to NASA. The discontinuation of the Delta 2 was a business decision by its manufacturer, United Launch Alliance (ULA). ISS requires two to three launches each year in order

to continue functioning. InI the absence of the continued availability of the Delta II, NASA is using the Atlas V for our science missions.. The latter is a good vehicle, but it is bigger than what NASA requires for many missions.

Heliophysics/Heliophysics Subcommittee (HPS)

Dr. Barbara Giles, Director of NASA's Heliophysics Division (HPD), updated the Committee on Division activities. HPD's mission is to understand the Sun and its interactions with the Earth and the solar system, which involves learning more about the physical processes involved, understanding the role of solar variability and planetary magnetic fields, and developing the capabilities needed to predict extreme and dynamic conditions in space. To accomplish this mission, HPD also supports development of next-generation systems for NOAA and other agencies.

HPD operates four broad programs: Solar Terrestrial probes, Living with a Star, Explorers, and Research. Dr. Giles reviewed recent and upcoming missions in these four areas. The Magnetospheric Multiscale (MMS) mission is now at the Goddard clean room. It is committed to launch by March2015. . This mission will help understand the fundamental processes behind magnetic reconnection. Dr. Giles explained that magnetic reconnection physics occur on such a small scale that it is difficult to probe it without disturbing the process. One way to address this situation is to use multiple instruments. Therefore, the MMS will have four copies, with eight particle detectors on each spacecraft, for a total of 32 instruments.

The Living with a Star program will launch Radiation Belt Storm Probes (RBSPs) in August 2012. NASA is formulating the Solar Orbiter Collaboration with the European Space Agency (ESA), to be followed by the next flagship mission, the Solar Probe Plus, launching in 2018, which will make multiple orbits very close to the Sun. The next Explorer, the Interface Region Imaging Spectrograph (IRIS) will launch in2013. The Research program has been very active, with an extremely successful rocket program and a number of balloon missions.

Later in 2012, HPD will have another Explorer come into development. The Division also has six Explorer missions under study. Three full missions will be submitting concept study reports in September 2012. There are also three Missions of Opportunity (MoO). HPD will select one of each, depending on the review process and the available budget. All three full mission concepts address ionosphere/magnetosphere coupling from a multi-point perspective, but are otherwise different. The three MoOs offer excellent science. The Division has 17 missions now in flight, and some of these have near- real-time capabilities. The missions as a group are trying to understand the Sun's effects and processes from the Sun's interior to the edge of our solar system.

The release of the HPD Decadal Survey (DS) is scheduled for August 15 and will be accompanied by roll-out activities to the science community in cooperation with the National Research Council (NRC), the National Science Foundation (NSF), NOAA, and NASA. The release will be streamed over the Internet worldwide so that the community can ask the DS authors questions in real time. Although Dr. Giles will not know what is in the DSDS before release, she has been able to glean that it will be something feasible that the community can support.

In November 2012, the NRC will hold a workshop about the usefulness of the Decadal Surveys for all of the Science Mission Directorate (SMD) science units. The workshop, in Irvine, California, will allow members of the community to discuss issues and document lessons learned. Dr. Giles urged Committee members to pull their opinions together for the record. Each of the other SMD divisions has a standing committee to help execute the Decadal Surveys. Once the Heliophysics DS is released, the Standing Committee on Solar and Space Physics will be re-formed.

The Fiscal Year 2013 (FY13) budget for HPD supports future launches and selections of the next two Explorers, though not the solicitations for the following two. The budget can support the operating missions fairly well, and an upcoming senior review will help determine whether to carry all or only some of these missions forward.

Discussion with Dr. Giles

In answer to a question about how much modeling HPD does, Dr. Giles replied that when she came into the position, she found that there is modeling in every single program, connected to either missions or independent investigations. Researchers who have assimilated data and created models can go to the Community Coordinated Modeling Center and put their models in a system that others in the community can then use. Investigators can order runs for their own research in this system. Over the course of 1 or 2 years, the models in the system become robust and stable, which leads to testing for operational purposes and possible use by NOAA, which will then seek validation testing. This testing is done by the community and NSF, and NOAA then decides whether to use this model in their operational forecasts. This system will transition three to five models over the next year or so. The most robust aspect of the system is that the community helps perform the validation.

Through the NASA internal processes, HPD is in contact with the Human Exploration and Operations Mission Directorate (HEOMD) regarding the Directorate's information needs and requirements. A similar process exists for the USAF. For example, a space radiation working group meets at least monthly. The Johnson Space Center (JSC) is sometimes involved in these communications. Dr. John Grunsfeld, SMD's Associate Administrator, added that there is a major cooperative program with HEOMD on the Mars science laboratory.

In regard to young people entering the field and getting their initial grants, Dr. Giles did not have data immediately available but noted that the NRC surveyed the community for that information and will release the results with the DS in August. She noted that HPD offers opportunities for newcomers to work on hardware early in their careers, but the research program funding is not sufficient to support all of those who wish to enter the field. She hopes the balance will change over time to support the research side better.

HPS Presentation

Dr. Maura Hagan, the HPS Chair, said that she and Dr. Giles had been discussing the possibility of expanding the Subcommittee's membership. A recent HPS meeting focused on the Performance Assessment Report (PAR), in addition to program updates. One issue of concern was the escalation in mission costs, and while there was no finding, the Subcommittee will address this issue further at a future meeting. There was a similar discussion about the success rate of proposals and funding for the community, again with no findings at this time.

The upcoming senior review is scheduled to begin with a draft call for mission proposals in October 2012 and end with a final report in June 2013. After that, affected missions have 60 days in which to respond. As Dr. Giles mentioned, the NRC will release the HPD DS in August 2012. NASA will develop a roadmap to align the HPD science strategy with the DS, creating a notional design. The timeline is very aggressive, with a deadline of December 2012.

As part of NASA's compliance with the Government Performance and Results Act (GPRA), HPS was asked to assess HPD's planned progress toward the annual performance goals. These goals fall into three areas: fundamental physical processes, impacts of solar variability, and development of capabilities for maximizing safety. Given the Division's available resources, HPS gave HPD nine "green" votes.

Dr. Hagan closed by reviewing some of the Division's areas of accomplishment, such as imaging of ultrafine loops in the Sun's corona and discovery that the heliosphere has no bow shock.

Planetary Science /Planetary Science Subcommittee (PSS)

The next speaker was Dr. James Green, Director of the Planetary Science Division (PSD). The next major mission activity in the Division is the landing of the Curiosity Rover on Mars on August 5, which was only 12 days away at the time of the meeting. In addition, the Dawn spacecraft was leaving the asteroid Vesta to head toward Ceres.

In the New Frontiers (NF) program, the New Horizons mission is en route to Pluto, while the Juno mission is making its way to Jupiter and the Origins, Spectral Interpretation, Resource Identification, Security –Regolith Explorer (OSIRIS-REx) is going to an asteroid that is believed to have much organic material. It is hoped that OSIRIS-REx will provide context to how life emerged on Earth and the role, if any, that asteroids may have played. The mission will make three attempts to gather a sample, though it may need only one. Any samples will be curated at JSC.

NASA is operating a number of Discovery missions, including Deep Impact; Mercury Surface, Space, Environment, Geochemistry, and Ranging (MESSENGER); Dawn; and Gravity Recovery and Interior Laboratory (GRAIL). Deep Impact just completed its extended mission and will be extended following the senior review process. Developing missions include the Mars Atmosphere and Volatile EvolutioN (MAVEN) mission and the Lunar Atmosphere and Dust Environment Explorer (LADEE), both of which will launch in 2013. The next round of Discovery missions are still conceptual; NASA is evaluating three candidate studies for Discovery 12 and will announce a selection soon, while the Discovery 13 Announcement of Opportunity (AO) has been delayed until FY15.

Regarding the Near Earth Object (NEO) program, Dr. Green described B612, a nonprofit organization dedicated to preventing future asteroid impacts on Earth. B612 is trying to obtain private funding for a mission to launch a satellite dedicated to locating and helping to characterize near-Earth asteroids. They also sought a Space Act Agreement (SAA) in order to have NASA participation. NASA signed off on the agreement in June with participation from SMD and HEOMD. NASA's role involves technical engineering advice, Deep Space Network (DSN) tracking and telemetry, coordination and interface with the existing NEO data network, and cooperation with a science team that has yet to be determined. B612 is now raising funds and working on a spacecraft design that will use an infrared detector. Tentative plans envision a launch in mid-2017. NASA and the larger science community will have full use of the mission's discoveries, which could help in the effort to detect asteroids down to 140 meters within 5 years of operations. This effort could benefit HEOMD by identifying potential targets for a human exploration mission to an NEO. Under the SAA, the NASA investment is small and uses existing infrastructure. In addition to defining roles and responsibilities, the SAA also delineates technical gates and milestone dates that would lead to nullification of the SAA.

In the area of the outer planets, ESA selected the Jupiter Icy Moons Orbiter Mission (JUICE), a large-class mission in the ESA Cosmic Vision program that will study Ganymede, Europa, and Calisto. In addition to orbiting Jupiter for 2.5 years, the mission will orbit Ganymede. The latter is larger than Mercury, has its own magnetic field, and is believed to have a deep ocean. Europa is also an extremely important object. The launch will be 2022, arriving at Jupiter in 2030 and at Ganymede in 2032. NASA will participate in JUICE with a financial contribution of up to $100 million. Within this budget, NASA expects to fund up to two U.S.-led instrument investigations, a number of instrument components, and a co-principal investigator (PI) on non-U.S.-led instruments. NASA has coordinated with ESA on the AO process. The lead time on proposals is short, but the community has known about this for a while and has discussed it with NASA.

Discussion with Dr. Green

In response to a question about the surface of asteroids, Dr. Green explained that this will be examined in great detail. The Japanese Space Agency (JAXA) mission to an asteroid found a range of sizes of objects for samples. Regarding LADEE, the altitude will be 50 km, but it will eventually crash into the Moon at the end of its mission.

The Artemis mission is flying by the Moon regularly at 25 km altitude and has a long boom to measure dust impacts. LADEE will have a UV imager that will look at different kinds of sun-reflected light and light from dust.

Dr. Green did not have at hand the details about the B612 mission milestones and gates, but he noted that they will be similar to NASA Phase A and B reviews. The Agency plans to maintain a light touch in terms of involvement. While NASA will remain flexible and wants this mission to proceed through completion, the Agency does not intend to step in and take over in the event of difficulties.

Dr. Megan Urry said that since private groups are now beginning to do space exploration, it would be helpful to know how NASA determines which groups to help. Dr. Green explained that the B612 organization is very familiar with what NASA does in near Earth asteroid studies and characterization.. The Agency's resources are indeed modest and the B612 organization wants to help speed up progress in this area. In terms of other groups that might approach NASA, the Agency would examine the proposals and conduct a cost-benefit analysis that could lead to an SAA. Dr. Green believes that B612 is taking a good approach in finding NEOs that NASA has not identified thus far. The NASA infrastructure is set up to identify the potentially hazardous NEOs, which makes this a good synergy. While B612 formed with the assumption of NASA collaboration, the organization does have fundraising activities and access to technical expertise. Without NASA, the group would have had to step back in order to make up for NASA's nonparticipation. As it is, B612 is arranging its own launch services and other crucial program elements.

PSS Presentation

Dr. James Bell, Vice Chair of PSS, presented on behalf of Subcommittee Chair Dr. Janet Luhmann, who could not attend the meeting. He began with an overview of the Assessment Groups and Analysis Groups associated with PSS. These include:

- Venus Exploration Analysis Group (VEXAG)
- Small Bodies Assessment Group (SBAG)
- Outer Planets Assessment Group (OPAG)
- Mars Exploration Program Analysis Group (MEPAG)
- Lunar Exploration Analysis Group (LEAG)
- Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM)

VEXAG has been participating in international activities related to the observation of Venus, including a Comparative Climatology of Terrestrial Planets Conference in Colorado as well as worldwide activities associated with the Venus transit in June 2012. The Conference purpose was to develop a roadmap for predicting the climate of Earth and Earth-like entities; a book reflecting the proceedings will be forthcoming.

SBAG is following the activities of the NEO Wide-field Infrared Survey Explorer (NEOWISE), which detects NEOs in four infrared wavelengths. NEOWISE has identified about 600 NEOs thus far, and indicates that there could be as many as 4,700 Potentially Hazardous Asteroids (PHAs), plus or minus 1,500. The Tagish Lake Meteorite offers important clues as to how left-handed-based protein life might have started on Earth.

OPAG will be looking at the five moons orbiting Pluto, including two recently discovered ones. Six close-gravity flyby's of Titan, Saturn's largest moon, found large "solid" tides consistent with liquid water under an ice shell, a possible reservoir for the atmospheric methane.

For MEPAG, the big event is the upcoming landing of the Curiosity Rover. In addition, the High Resolution Imaging Science Experiment (HiRISE) has provided super-high-resolution (less than 1 meter/pixel) data supporting landing site selections as well as general Mars science, and the Mars Exploration Rover Opportunity concluded its winter campaign with images and other data that show the surface expression of the planet's past watery history.

Current LEAG projects include GRAIL; the Lunar Reconnaissance Orbiter (LRO); Moon Mineralogy Mapper (M3;); the Acceleration, Reconnection, Turbulence, and Electrodynamics of the Moon's Interaction with the Sun (ARTEMIS) mission to study the moon's interior; and LADEE. LEAG has participated in a number of important meetings, including the recent Conference on the Lunar Highland Crust. LEAG has also modified its roadmap to reflect strategic knowledge gaps of special interest to HEOMD. One issue to address is concern within the lunar community about the expansion of the NASA Lunar Science Institute (LSI) to a multi-destination institute serving both SMD and HEOMD.

Science highlights for CAPTEM include a very robust paper on planetary materials and cosmochemistry, published in *Science*, examining the reduced organic carbon component in martian basalts. Also published in *Science* is a paper about tiny pieces of impact breccias found among the Apollo 16 samples.

General Issues and Concerns

Budget issues are of concern, especially in regard to the Mars Program reprogramming activity on future plans for the Mars Sample Return (MSR) mission and Research and Analysis (R&A) programs. The lunar community is very concerned that the expansion of NLSI foretells a smaller role for the Moon in future PSD budgets. Delays in the next Discovery and New Frontiers (NF) AOs on potential sample return missions could have a profound impact. The The recent Planetary Decadal Survey (DS) noted the divergence from the desired 24-month pace of Discovery AOs.

The recent PSS meeting produced seven findings:

- There is a need to restore funding and proper cadence to the PI-led mission programs such as Discovery and NF, consistent with the DS.
- While the new coordination of efforts among PSD, HEOMD, and the Office of the Chief Technologist (OCT) toward long-term exploration of Mars and small bodies is a positive development, the focus should be on science priorities, consistent with the DS.
- PSS supports NASA's commitment to participate in ESA's JUICE mission, and wants PSD to seriously consider the results of the newly completed studies toward a descoped Europa mission.
- PSS supports NASA efforts to work with DoE to restart Pu-238 production.
- The Subcommittee recommends that the Division Director support better management of the R&A program, with some specific suggestions as to how to do this.
- Increasing proposal pressure and stagnant staff size in the R&A program are unsustainable and likely to worsen with decreasing mission activities, which makes additional staffing necessary.
- PSD should improve the effectiveness of communications with the community.

Upcoming issues include JUICE and budget threats to PSD. PSS plans to be proactive regarding PSD plans to implement the DS, and will carefully follow and assess the implications of any plans for joint missions and programs. A concern is that delays and timing inconsistencies between NASA and Congress led to some funding issues that must be revisited. This should not have happened.

Discussion

In regard to the recommendation to increase staffing in R&A, Dr. Green said that PSD was short at least one full-time equivalent (FTE). There are issues regarding the budget and the number of civil servants available to the Division. Use of detailees from the Centers has helped address similar issues, as these individuals are already accessible civil servants. The use of scientists from academia under the Intergovernmental Personnel Act (IPA) can be problematic for managing peer reviews when their home institution proposes.

Dr. Feeley explained that the Committee had to consider the findings and send them to the full NAC before they could go to the NASA Administrator. Informal transmittal is not consistent with the NASA General Counsel's (GC's) interpretation of the Federal Advisory Committee Act (FACA).). Dr. McComas advised reducing the number of findings later in the meeting.

Annual Ethics Briefing

The Committee held its annual ethics briefing as a working lunch.

Status of Mars Program Planning Group –Joint Meeting with HEOC

The members of the Human Exploration and Operations Committee (HEOC) met with the Science Committee in a joint session. Dr. Grunsfeld explained that with the landing of Curiosity Rover to occur within days, it is time to frame the next discussion. With that in mind, and in light of the need to address fiscal and budget issues as well, NASA Administrator Charles Bolden has asked Dr. Grunsfeld and other key NASA leaders to study a framework fo restructuring NASA's Mars exploration program. One point of emphasis is making good use of the external community to develop options. The successful landing of Curiosity will start a public resurgence of interest in Mars. NASA needs to be ready for that and look for synergies beyond a DS science program especially with the priorities of HEOMD and the Office of Chief Technologist (OCT).

Mars Program Planning Group (MPPG) overview

Doug McCuistion, Director of SMD's Mars Exploration Program, explained that at NASA, a "project" has an endpoint, while a "program" is ongoing. The Mars Exploration Program was conceived in 1999 as a set of missions that began in 2001, all interconnected, with early discoveries leading to later mission requirements. Mr. McCuistion reviewed the missions to date, which were strategically aligned and have presented immense science potential. Now the MPPG is looking at 2018 and beyond, and seeks to create a series of missions on a 10-year timeframe. The SMD Divisions' Decadal Surveys come into play, as this is a science-driven program with human exploration capabilities. The budgets are lower than NRC envisioned in the Decadal Surveys, but MPPG has set a target of human exploration in the 2030s and is moving backwards from that in the planning.

Dr. Stephen Condon of the HEOC observed that the formation of MPPG is the right step to bridge the gap between ongoing activities and the future challenges. However, he noted that they are talking about an adventure that spans several administrations, at least five. Therefore, for this effort to become a reality, there must be public excitement at the level that also keeps Congress excited about continuing to fund this type of effort. His feeling is that only a very small portion of the public knows that the President laid out this challenge. The question then becomes how to energize the public to translate the excitement into funding.

Mr. McCuistion replied that this is an Agency-level responsibility. NASA is taking advantage of the Curiosity landing with a big effort worldwide to generate excitement and interest. Within that messaging, NASA is wrapping in the future and what the Agency plans to do. People are excited about this and the potential of sending humans to Mars; they understand it. The point is that people are ripe for this kind of excitement in space. Education and outreach are part of the charge.

Dr. Grunsfeld added that to build up to an eventual human landing on Mars, NASA must have worldwide public enthusiasm. There are a lot of activities occurring right now, such as campers across America being engaged in watching the Curiosity Rover landing. While Curiosity makes discoveries, NASA has a 2-year window in which to keep this discussion in the forefront. The Agency is trying to build a framework and match the strategic planning process to engage the public. NASA has a strong communications office with a great staff, according to Mr. McCuistion, and HEOMD and SMD each have their own outreach people. He agreed with Dr. Condon that the

effort must result in long-term excitement and support from the public. A clear vision and focus helps engage the public.

MPPG has been working hard for months, trying to complete their work in time to influence the President's FY14 budget request. There is so much happening so fast that information creation exceeds the information approval cycles, making this both a race and a challenge. The near-term focus is on the 2018-20 window, taking into consideration both the DS priorities and the constrained budget environment. Collaboration with HEOMD is consistent with the President's goal of human travel to Mars in the 2030s. The report from the MPPG will come out in Fall 2012.

OCT is currently funding technologies that will assist in both robotic and human exploration of Mars. Radiation measurements of Mars are essential, as they will affect the ability of humans to visit the planet. The strategic technology investment thus far has allowed NASA to substantially reduce the landing area in Mars' Gale Crater. Regarding ESA, it is important to become a reliable partner again, and NASA is cooperating with that agency on a number of Mars-related projects, such as instrumentation for a potential ESA Rover in 2018. The arrangement might never be 50/50, but there are ways to cooperate that will improve global capabilities. Dr. Grunsfeld added that NASA is still a good partner with ESA on many fronts. One of the fundamental differences has to do with the ways in which NASA and ESA fund projects, creating a timing mismatch and creating risk where there should be none.

In order to reach the broader audiences needed to generate excitement about the Curiosity landing, there have been many TV interviews. Science centers nationwide are having sleepovers for children, and there have been promotions via the American Library Association, since many people who lack home Internet access go online at libraries. That has proven to be a very effective way to reach those individuals.

MPPG activities

The MPPG leader, Orlando Figueroa, reviewed the Group's recent activities, which included presenting options to NASA based on a science-driven approach, collaboration, and engagement opportunities. MPPG envisions significant collaboration among HEOMD, SMD, and the Office of the Chief Technologist OCT. The MEP has been very successful due to its strategic program that follows the theme of understanding the possible habitability of Mars, as well as the programmatic strategy of following water. A science-driven program must also look for connections and intersections with HEOMD and OCT.

The DS science recommendation is for Mars Sample Return (MSR), on the basis of the best support for the search for evidence of ancient life, along with broad community support. MSR is a complex endeavor. The campaign must span a decade in order to keep yearly budgets manageable. MPPG evaluated alternatives to MSR and looked at lower cost options as well. As of yet, the team has not gone as deeply as they would like in the international area.

MPPG developed figures of merit to guide the mission and architecture options. These include the following:

- Advance the overarching scientific goals/objectives of the DS and MEPAG;
- Advance the knowledge and capabilities required to enable human exploration;
- Infuse and promote technology and capability;
- Provide opportunities for robotic and human spaceflight program interconnections;
- Hold costs to credible levels within an acceptable risk posture; and
- Provide opportunities for community participation.

The team did not assign weights to these figures of merit.

The President's FY13 budget narrows the options for 2018, essentially eliminating the current Rover options but may make an Orbiter possible. The risk to the 2018 opportunity remains; some key activities must occur quickly for the Orbiter opportunity to remain viable. MPPG has been following the DS, resulting in pursuit of multiple science options, some now deemed less important than others but all reviewed. In addition, the door has been left open for MSL discoveries. The focus is on seeking signs of ancient life, although the team is also looking at viable options that do not include MSR.

A Committee member noted that in terms of the risk reduction philosophy, spreading out elements fits into the budget philosophy and diminishes the risk of losing an element. But there was concern that retaining Entry, Descent, and Landing (EDL) capability might be problematic. Mr. Figueroa replied that after 2018, the concern is preserving capability if a landed campaign is part of what is sought. There is also concern about the keeping the communications infrastructure going for maximum data return. Dr. Grunsfeld added that NASA is still working with ESA. An EDL-only mission could include aerocapture techniques. MPPG has the flexibility to look at all of this.

Mr. Figueroa explained that MPPG also examined NASA's need to replace or augment the communications infrastructure. This will likely be necessary no later than 2022. Such issues are part of the study of the reliability of current assets. The team has worked on very targeted challenge areas, bringing in communities of practice for a Lunar and Planetary Institute (LPI) workshop on Mars Concepts and Approaches. The workshop generated ideas on lower-cost missions and synergistic technologies, and reinvigorated collaboration across the science, engineering, technology, SMD, and HEOMD communities. MPPG has used the workshop ideas to charter subgroups "out of the box" approaches to MSR, also known as "Pathway C."

A graphic illustrated the Curiosity Rover can provide direction going forward, opening up opportunities to move forward to MSR. Even with non-MSR options, NASA is still learning much about Mars. However, without a cohesive program involving MSR, it is hard to string together information into a larger piece. The various Rover concept features, with EDL information, are being defined well enough for independent cost estimates and NRC comparisons.

Synergy with human exploration; Technology infusion

Dr. Michele Gates spoke next, noting that the analysis began with the assumption that Mars samples would be collected via robot, not human exploration, due to programmatic implications and the costs of sending humans to Mars. MPPG conducted architecture trade studies of sending humans to Mars, using risk as a differentiator. From that perspective, there are increased risks to the crew in a Mars orbit-only mission, including cosmic radiation, behavioral health, etc. These risks must be better understood despite the benefits of human exploration. Robotic missions play a key role in reducing the risk to humans.

MSR has extreme promise for developing innovative ideas, and MPPG is looking at ways to retrieve samples that are then returned to Earth by astronauts. NASA chartered a Precursor Strategic Analysis Group (P-SAG), which developed several recommendations for scientific measurement priorities, including Mars climate conditions, the surface radiation environment, and characterization of Mars samples. P-SAG cross-referenced the scientific objectives with Strategic Knowledge Gaps (SKGs), then assessed gap-filling activities, priorities, timing, and location of measurement. The team is now working on some integrated strategies.

Risk reduction is possible in the area of ISS extension, deep space testing, and early operations. The launch campaign will involve measurements, technology development, and risk mitigation. A sustainable human exploration program to Mars would, by definition, require a human mission to Mars. MPPG has looked at this in terms of risk reduction, gap filling, and human subscale technology development and testing. Notional timescales are also under development; MPPG has looked at technology feasibility but not the budget or programmatic aspects.

Another option under consideration is for robots to collect samples and take them to the moon, where astronauts can retrieve them. This scheme presents two substantial benefits. One is safety for humans, and the other is cost savings, as the robotic mission will obviate the need to have a re-entry system for humans. One of the benefits of having a human crew look at samples before bringing them to Earth is safety. The samples would first be examined tele-robotically. If the samples pass that level of scrutiny, the crew would then take possession. There are levels of concern regarding contamination, including the safety of the container.

Mr. Figueroa noted MPPG would like to restart some of the technologies that have suffered from lack of funding. OCT has been investing in technologies beneficial to the Mars program, such as an atomic clock and aerodynamic inflatable decelerators. Cross-technology opportunities fall into two categories: early missions, and mid- to late missions. Early mission technology opportunities are in the area of precision landing, communications, the atomic clock, and the Mars Ascent Vehicle (MAV). Mid- to late mission opportunities include pinpoint landing and hazard avoidance, in situ resource utilization (ISRU), ISRU-enabled MAV, mitigation of dust effects, and higher performance propulsion and power systems.

A public engagement exercise showed that the most popular topics are: permanent settlement and colonization; partnering with private industry; public support; reduced travel time to Mars; the race with other countries to get there first; and terraforming Mars. When the forum probed to see why there was little interest in the search for life on Mars, it was discovered that much of the public takes it as a given that life is everywhere.

Discussion

In answer to a question about having an independent look at the MPPG options, Mr. Figueroa said that the Group is on a tight timeline but has identified key community members who can provide further input if NASA wishes. As for the level of support from Congress and OMB, Dr. Grunsfeld explained that that is why MPPG sought to have recommendations ready to go by August, for FY14 budget submission purposes. The President's FY14 budget will be embargoed, but there has been dialogue about this topic, and there is continued interest in Mars and science. It was added that the FY13 budget request cut PSD funding substantially, though Congress has proposed adding back some of the reduced funding. This makes the FY14 request a delicate issue that could be complicated by the possibility of sequestration.

The presenters were asked how much of the plan came from the broader discussion and how much had been on the table for a while. Mr. Figueroa explained that about half of the Pathway C "outside the box" approach came from the LPI workshop. Some ideas were brought in as low-cost approaches, and some of the Rovers are being analyzed in-depth for costs. MPPG hopes to provide NASA with a basis for estimates.

Joint Robotic Precursor Activities

Ms. Victoria Friedensen, Joint Robotic Precursor Activity (JRPA) Manager, and Dr. Michael J. Wargo, Chief Exploration Scientist, spoke next. Ms. Friedensen explained that while the proposed joint activities are to begin in FY13, an internal planning team has been working on JRPA for about a year. The goal is to inform selection of future destinations, support development of exploration systems, and reduce the risks of human exploration while promoting the maximum science. The team is developing an integrated set of priorities that will be used to identify investments relevant to human spaceflight. To this end, JRPA seeks to fund R&A, perform strategic studies, and lay the groundwork for future precursor missions. Beginning in FY13, JRPA is funded with $20 million from HEOMD and $10 million from SMD. This is not all for procurement, as it includes costs for civil servants. Both mission directorates are committed to protecting JRPA as a budget priority.

The activity flows through the NASA strategic plan. With input from the relevant Analysis Groups, the team has defined SKGs and identified timelines; prioritization is ongoing. The focus is on understanding the timeline. For example, if the goal is to have humans land on an asteroid by 2025, JRPA walks that back to identify which actions

need to be taken when. Another goal is to have a MoO or full flight opportunity. For guidelines, JRPA has taken the PSD DS recommendation to focus on peer-reviewed missions and not incorporate human exploration requirements after the mission has been selected and development has begun. At the same time, HEOMD has a mandate to employ NASA civil servants to extent possible. Dr. Wargo will play a pivotal role in maintaining a balance between these obligations.

The priorities are to fill SKGs, which will guide instrument, mission, and R&A investments. The team will work collaboratively to prioritize proposals; each directorate is responsible for the scope assignments, irrespective of costs. Dr. Wargo explained that SKGs are what NASA must know before the Agency can safely and effectively explore beyond Low-Earth Orbit (LEO). SKGs encompass timing and level of fidelity as well. With JRPA, the intent is to identify the knowledge needed to prepare for human exploration at a given destination, making the SKGs mission critical.

To generate the SKGs, the team asked the Human Spaceflight Architecture Team (HAT) Destination Leads to identify the data or information needed that would reduce risk, increase effectiveness, and aid in planning and design. The science community was then pulled in for their feedback. For some destinations, a lot of work has already been done through such groups as LEAG, which had a lunar exploration roadmap. Similarly, MEPAG has been working on a roadmap for years. The Small Bodies Analysis Group (SBAG) got a late start and is working on completing their analysis. With the necessary knowledge identified well for some destinations, the SKGs will provide NASA with a foundation for moving forward internationally, and will provide a means of coordination in order to determine where to apply limited funds.

JRPA found some common themes in the destination leads' comments. It is essential to understand radiation, regolith, and reliability before embarking on human missions, for example. Other themes were geotechnical properties, volatiles, propulsion-induced ejecta, in situ resource use, operations and operability, the plasma environment of the moon and Near-Earth asteroids (NEAs), and human health and performance. NASA has stood up the LEAG, MEPAG, and SBAG to review the draft SKGs. NASA will track the completed SKGs to the Agency's currently planned robotics missions, followed by a combined specific action team from the three assessment groups. This is an ambitious schedule, however, and NASA is trying to avoid overworking the research community.

International coordination is crucial, and to that end the Strategic Knowledge Gap Assessment Team (SKGAT) was formed within the Exploration Roadmap Working Group of the International Space Exploration Coordination Group (ISECG), which has begun creating a set of international SKGs using NASA's draft SKGs as a starting point. Dr. Wargo is the team lead; membership comes from France, Canada, ESA, and JAXA. In addition, Russia is receiving regular updates despite not responding to the invitation to participate. The international team has established coordination and criteria, and formulated a methodology for the test cases that it has begun running. The intent is to have the international set of SKGs incorporated into the next revision of the Global Exploration Roadmap.

Ms. Friedensen pointed out that in terms of dollars spent, NEAs have the most profound gaps. The proposed portfolio for JRPA will include both new and existing projects. Two HEOMD-funded Advanced Exploration Systems (AES) projects have aligned well: a significant improvement to the Goldstone radar capability to image NEAs, and Regolith and Environment Science and Oxygen and Lunar Volatiles Extraction (RESOLVE) lunar ice project. AES projects are funded for 3 years, followed by annual decision reviews. Another potential activity is for R&A to include participating scientists on robotic missions, competitive calls, and other efforts to improve working knowledge.

The initial HEOMD obligations consumed much of the available instrument/mission budget line through 2014. Therefore, the goal for FY15 is to repurpose those funds. Strategic studies for FY12 are focused on refining, prioritizing, and integrating SKGs within HEOMD and internationally, while FY13 efforts will include an analysis

of alternatives for robotic mission proposals to potential destinations. This small team has looked at what is needed for a good start in FY13, and they have been making competition and procurement decisions. SMD and HEOMD have different priorities regarding competition, and AES must employ NASA civil servants to the extent possible. Instrument and mission decisions need to be made in 2013.

Discussion

There was concern expressed about the competition for great ideas and how it might be filtered by the need to hire civil servants. It was explained that if JRPA participates in the next Discovery mission, the team might propose an instrument that could go into an AO, for which NASA teams are eligible. There is a significant workforce from human spaceflight areas that needs to be redeployed. The goal is to balance the two constructively without blocking community contributions. It was added that this is also a cost issue. Another observation was that back in the early 1970s, there were issues with NASA making unilateral decisions and limiting involvement to internal people. Dr. Wargo replied that this is an important point. The best current example of exploration and science is the lunar reconnaissance orbiter, for which NASA needed and received the best of the science community.

New Telescope Assets

Dr. Paul Hertz, Astrophysics Division (APD) Director, talked about the telescope assets received from the National Reconnaissance Office (NRO). NRO came to NASA with the offer of residual telescope hardware not suitable for future intelligence missions. NASA then had a small team take a preliminary look at the telescopes for their potential to advance DS priorities.

NASA has now taken control of the hardware. An ad hoc group of external scientists looked at using the hardware on NASA's request and did find potential in using the assets. The hardware is commonly misstated as being "two telescopes." More accurately, it is a collection of valuable space telescope parts for two space telescopes, plus some left over. The parts include, for example, optics, support structures with controllers, and the baffle for a space telescope. These are space-qualified and tested, and are in condition to use for a space mission. The assets are all completely declassified aside from some International Traffic in Arms Regulations (ITAR) sensitivities. There is as yet no guarantee that the assets might reduce costs for a mission. The cost of not having to produce the optical system could be balanced by the additional cost by having to build around a larger object. At the same time, the instruments are what matter – the spacecraft that would transport them is not such a big issue.

Dr. Hertz reviewed some of the details currently known about the assets. The optic is as big as that of Hubble, it is wide field, and it is extremely lightweight at 1,700 kg (Hubble is 30,000 kg). A graphic compared a wide-field observation that the NRO equipment might produce to Hubble's narrower view, similar to what a wide-field camera lens might produce compared to a telephoto lens. To do wide-field science, an instrument like Hubble is impractical.

Another graphic illustrated the possible layout of the field of view of the collecting area. In this case, the comparison is of taking one picture or 20. The fine point spread function (PSF) and larger mirror aperture were compared to the Wide Field InfraRed Space Telescope (WFIRST) Science Definition Team (SDT) design reference missions (DRMs). The NRO optics are ground to a higher fidelity than NASA would choose to do, but that choice would be due to budget issues. The NRO equipment would allow weak lensing and could also be used for coronagraphy. The assets could allow direct imaging around other stars, as well, and also enable exoplanet discovery.

The assets are in the ITT-Exelis facility in Rochester, where they are being maintained as they were for NRO. At this point, NASA has no budget line for building a mission around this equipment. The Agency is reviewing the opportunity through the Agency Strategic Implementation Planning process to help decide on a path forward.

Discussion

Dr. Hertz can obtain more specific information on the field of view for the Committee. He explained that the optics provide an opportunity for NASA to do something that complements Euclid. It is not yet clear what kind of role the assets could play in WFIRST. The big difference is that the NRO hardware works at room temperature, not the cold environment of WFIRST. This means a trade in the aperture, as the mirrors cannot be cooled. It was observed that the public will expect NASA to use these assets, and that the Agency will look bad if it does not do so. Storage costs are running about $75-,000-$100,000 annually. The assets have been in storage for a while. If NASA uses them, they will need to be recoated, but holding them longer will not preclude future use. As for mission costs, if NASA studies whether to use the assets, the costs will then be a part of the study.

Astrophysics/Astrophysics Subcommittee (APS)

Dr. Hertz next provided an update on APD. On June 13, NASA launched NuSTAR, a small Explorer. This is the first mission capable of imaging in its energy band, the wavelengths of medical x-rays, and it is important in examining nuclear emission lines. The focal length is 10 meters and the optics are to separated from the detectors with a deployable mast. Calibration is ongoing with a few easily patched glitches, as is to be expected. NuSTAR science was set to begin in early August.

The Kepler mission continues to produce interesting scientific results. For example, the mission discovered a planetary "odd couple" in which two planets pass relatively close to each other and raise each other's tides. One of the planets is bigger than Earth, though its 14-day orbital period makes it very hot. The other planet, with a 16-day year, is like a very hot mini-Neptune.

Recently, the Hubble showed that the Milky Way is destined to collide with the Andromeda galaxy in about 4 billion years. Eventually, the two galaxies will merge into a single galaxy. It has been determined that no stars are likely to actually collide, or there will be one collision at most.

The Galaxy Evolution Explorer (GALEX) was launched almost 10 years ago. The senior review recommended that NASA conclude funding for the mission, which NASA did as of March. However, the Agency also enacted a 3-year Space Act Agreement (SAA) to continue GALEX on a month-by-month basis with private funds raised by Dr. Chris Martin of CalTech. When CalTech is done with the mission, NASA will take it back and decommission it. This is the first time one of these missions has been operated with private funds. The arrangement results in no change in data access.

When the Gravity and Extreme Magnetism Small Explorer (GEMS) project came up for confirmation review, the recommendation was to terminate the mission. NASA has decided to do so. GEMS was an x-ray telescope with an x-ray polarimeter that would have provided a probe of the magnetic field's strength and structure. in neutron stars and supermassive black holes. The cost, schedule, and technical risk going forward were deemed unacceptable, as shown by internal and external cost reviews. GEMS proved to be a greater technical challenge than anticipated, and significant savings have already been taken leaving no further descope options. NASA is reviewing this termination independently and will take that report to Congress, at which point the Agency must wait 15 days before reallocating funds. After termination, the funds that would have been spent on GEMS will go into the Explorer budget and will allow APD to advance future AOs significantly.

Regarding the possibility of selecting a new mission from the current Explorer competition, Dr. Hertz said that he did not believe that option was considered, as it would have delayed the ongoing AO for a MoO. It was a matter of timing. Dr. Grunsfeld confirmed what Dr. Hertz said, as the constrained budget environment led SMD to push the next opportunity further out. One of the Committee members noted that the ratio of proposing effort to productive effort is a big issue within the science community. Dr. Hertz replied that APD does receive and listen to community

input about the frequency of opportunities. If the Division chose two missions from the last AO instead of going to the next announcement, NASA might miss an opportunity for the most current science.

The Stratospheric Observatory for Infrared Astronomy (SOFIA) is a flying observatory for which there was an AO for a new instrument. NASA selected two proposals for significant upgrades of a first-generation instrument, giving SOFIA next generation capabilities. This option allows NASA to have another SOFIA AO sooner than planned. SOFIA is currently under development with Segment 3 aircraft work. There are also more current avionics installed in the cockpit.

NASA has agreed to partner with ESA on Euclid, providing Near Infrared Spectrograph and Photometer (NISP) flight subassemblies known as "triplets." These consist of detectors, Application Specific Integrated Circuits (ASICs), and cryo-cables. This is a small contribution, so NASA will not manufacture anything that has not been demonstrated by ESA engineering models. The Agency did something similar for ESA's Planck mission. The science return is that NASA will select 40 members of the Euclid Consortium, and ESA will appoint a NASA-selected member to the ESA science team.

There are no new large missions in the President's budget despite the DS recommendation that WFIRST be the next priority. As a result, it will not launch this decade. APD did appoint the SDT to develop two DRMs for WFIRST. DRM1 is a proof of concept that a mission can be constructed that complies with the DS. DRM2 does not duplicate the capabilities of Euclid, the Large Synoptic Survey Telescope (LSST), or the James Webb Space Telescope (JWST). An independent cost assessment of DRM2 is underway. NASA is using the DRMs as the basis for WFIRST planning. The capabilities of the NRO telescopes have not yet been factored in. As noted, NASA will partner on Euclid to advance some of the WFIRST science, while at the same time supporting the technology and planning required for WFIRST as the budget allows. JWST is the top priority, and it does not launch until 2018. Dr. Hertz further explained that for DRM2, the tradeoff is how one designs and builds the mission. There are no consumables at this point.

There has been talk about having an Explorer AO this year, but the FY13 budget request does not support an AO for both full missions and MoOs. The first priority in the Explorer program is to complete the Explorers in development; the second priority is to down-select and fund the development of one full mission and one MoO from the projects currently conducting Phase A studies; the third priority is to issue new AOs leading to the development of new missions. Dr. Grunsfeld added that Virgin Galactic announced a potential new launcher, which could make for an interesting opportunity in 2016. Dr. Hertz noted that the concern is not so much with launch vehicles as with the launch industry industrial base.

APD had a total FY11 budget of $608 million, of which 45 percent was spent on operating current missions, about one quarter on development, and 20 percent on research. JWST is not included in those figures, as its budget is about as big as that for the rest of APD. The APD budget strategy is to follow DS priorities to the extent possible while maintaining the Division's core research, doing frequent Explorer missions, and continuing existing missions. New strategic missions are possible only if the budget retains a large portion of the SMD funds allocated to JWST. That could occur in FY18 after the JWST launch. The near-term focus is on using competed and directed technology programs to develop enabling technologies and mission concepts. In the middle of the decade, APD will start looking ahead to the new FY17 strategic mission. The Division will explain its strategy in a white paper timed so that it can be discussed in January at the American Astronomical Society (AAS) meeting in Long Beach.

Discussion

Dr. Grunsfeld explained that, in contrast to the rather nimble community-led missions, strategic missions reflect NASA priorities and deliberative processes. Dr. Charles Kennel noted that the Space Studies Board will have a lessons learned workshop this fall. The two key decisions that would inform the next DS would have to be made by

2017. Dr. Hertz replied that NASA must think about this in 2015. In February, the 5-year budget plan will encompass 2018, at which point APD can begin defining the out-year budgets. The total APD budget for the decade is not that different from what the DS anticipated, it is just that JWST was subsequently revised with more funding and a longer schedule, which changed everything. Another question went back to the NRO assets and whether NASA has considered having an AO around them. Dr. Hertz said no, there is no funding for a mission at this time. If NASA decides to study the use of the optics, it is possible that they might solicit white papers from the community.

Annual FACA Briefing

Dr. Feeley reviewed key points regarding FACA, which governs the activities of NAC, its committees, and its subcommittees.

Adjourn

The meeting adjourned at 5:35 p.m.

Tuesday, July 24

Opening Remarks/Announcements

Dr. McComas reviewed the draft findings that were to be discussed later in the meeting. They included one about the NRO telescope assets, one on SMD/HEOMD Mars interactions, and one from the Planetary Protection area. The seven from PSS would be condensed into one.

Earth Science/Earth Science Subcommittee (ESS)

Dr. Michael Freilich, Director of the Earth Science Division (ESD), reviewed the Division's activities. There are currently 16 Earth-observing satellites, which he briefly identified. In some cases, the satellites are well beyond their design life and have been repositioned or repurposed. For example, the Jason 1 altimeter to precisely measure sea levels is now doing a new mission, making measurements with high spatial precision. NASA had to lower its orbit level because the device has become harder to control. CloudSat, part of the A Train constellation of spacecraft, suffered a major battery anomaly and is operating on 10 percent of the designed battery capacity, so it has been moved as well. In better news, the first LandSat was launched 40 years ago and the program remains robust. For example, LandSat5 is in its 28th year, going far beyond its 5-year design life.

In May, the mid-term report on the DS came out from NRC. The primary finding was that "NASA responded favorably and aggressively to the Decadal Survey, embracing its overall recommendations for Earth observations, missions, technology investments, and priorities for the underlying science." Other findings include the following:

- The Earth Venture class program is being well-implemented by NASA.
- Alternative platforms and flight formations offer programmatic flexibility.
- NASA has made considerable efforts to secure international partnerships to meet its scientific goals and operational requirements.
- NASA's Applied Sciences Program has begun to engage applied researchers and governmental operational users.

The few recommendations essentially said that NASA should try to implement all missions as cost-constrained missions. NRC approved of the ESD approach of descoping the science capabilities in order to keep the mission costs under control; the goal is not to have the science done at any cost. NRC did recommend that a standing advisory group help design program priorities, and Dr. Freilich has sought clarification. There are FACA issues, among others, and continuous optimization is problematic, especially with missions at varying stages of maturity. Another recommendation reflects that, if available, low-cost, mid-range launch vehicles could open up options. In

addition, if the budget were to allow, NRC would like ESD to consider the frequency of Earth Venture stand-alone/space-based missions.

Venture Class is a Tier 1 DS recommendation. The science-driven, PI-led, competitively selected program has three strands:

- EV1 – suborbital/airborne investigations of 5 years duration;
- EV2 – small, complete missions of 5 years duration;
- EV-Instrument – space-borne instruments for flight on MoOs.

EV1 and EV2 are each solicited every 4 years, alternating so that there is one solicitation every other year. These projects are fully funded and schedule-constrained. If a project goes over schedule or budget, it is terminated. Every 15-18 months, the program does solicitations for Earth-observing instruments for which NASA will find a mission. This program helps the research and engineering communities present their ideas, and has been fully funded despite budget fluctuations. Regarding instruments for which there might not be a flight, the capacity of an instrument to be accommodated within existing or proposed projects is a criterion. Something that requires a unique orbit, for example, will be harder to fund. There are enough proposals so that this criterion is not much of a concern.

There are currently five EV1 missions, each operating independently and making progress. Four of the five have conducted test flights, while one is lagging. The first EV2 proposal selected, the CYclone Global Navigation Satellite System (CYGNSS), is a constellation of eight micro-satellites that use direct and reflected GPS signals to measure ocean surface wind speeds in order to help better understand the genesis and intensification of tropical cyclones. Intensity forecasts have been elusive thus far, and this project will help fill that gap. The primary science objectives of the project are to take frequent measures of ocean wind speed in almost all precipitating conditions, and to measure the inner core of tropical cyclones. The project is being done under an option of $100 million with an indemnified launch, instead of a flat $150 million. CYGNSS covers the entire tropical band and might address direction, but focuses on the high wind area where the L-band is best.

The ESD budget strategy is to have a balanced program that advances Earth science and technology development while promoting collaboration. In order to leverage other missions to the Division's science and applications, ESD coordinates domestically through a 13-agency United States Global Change Research Program (USGCRP) and international groups.

The ESD budget situation has not changed since the Science Committee's last meeting, and the FY13 request is essentially stable with the FY12 budget. Dr. Freilich takes this to mean that the Administration has decided that ESD is now where it needs to be. Congressional budgets have been negligibly different from the President's requests. Therefore, the Division does not have to change programs due to external budgetary influences, while internal costs for things like launch vehicles and possible positive developments in lowering costs or leveraging could help the budget situation. Dr. Freilich noted that the Division staff do not talk about what they should do, but instead focus on what they can do, then get it done.

During the FY13 appropriations process, the Senate suggested movement of weather satellites from NOAA's budget to NASA's budget. The House did not. If this proposal is enacted, there are sufficient funds for the new fiscal year, but future funding responsibility would come from NASA, though not necessarily ESD. This has not actually passed or even gone to vote yet, and the Administration is developing a position on the proposal. Dr. Noel Hinners said that this sounded like a horrible situation in which one organization sets requirements for another organization to implement and fund. NRC has said the same thing. The responsibility for requirements has to stay with the funding organization. There are many of examples of this kind of thing being problematic. The Senate language is carefully worded on those lines. NASA has made it clear that the Agency needs to know who sets requirements, and that that

organization must be the funding organization. Whoever implements the missions has to have the ability to make trades among cost, schedule, feasibility, and risks.

Dr. Kennel said that he wanted to play devil's advocate for a moment, stating that if the funding situation can be solved, this could be the best solution for the country. First, NASA does have the technical competence to build the spacecraft and has better financial competence than NOAA. Second, Earth science missions have an uncanny ability to be useful almost immediately to the policy and applications community. The upshot is that NASA often does a job that NOAA claims it should do but does not. Shifting the weather satellites could facilitate growth in this area. Dr. Freilich suggested reading the Senate's rationale. NASA is the civil space agency and the executing organization for some of NOAA's missions. ESD's entire annual budget is about $250 million smaller than the NOAA satellite budget. ESD does research missions and some other work, and the Division has stayed lean by virtue of balancing risks. The key is to keep a science program within NASA but not have NASA simply become an organization in service to the national security needs of environmental prediction and other national imperatives. Dr. Kennel agreed, adding that a research-driven program is more resilient than one that is driven by operational requirements.

Dr. Freilich reviewed the mission portfolio of launches through 2020, for which there has been good progress. Launch vehicles have been assigned to most of these missions. The Stratospheric Aerosol and Gas Experiment III (SAGE III) will go on ISS as designed. The Soil Moisture Active-Passive (SMAP) mission is a Tier 1 DS recommendation heading to a late October 2014 launch with the launch vehicle now fully funded. The Ice, Cloud, and Land Elevation Satellite 2 (ICESAT-2) is another DS Tier 1 priority for which ESD is seeking a launch vehicle. Orbiting Carbon Observatory 3 (OCO-3) is an instrument made from spare parts from the failed OCO-2. It is likely to go on the ISS.

ESS presentation

Dr. Byron Tapley reported that ESS reviewed the NRC mid-term report. There is some concern about the future satellite and instrument constellation, as some assets are aging. Mission cost growth is an ongoing concern, especially in regard to launch vehicle availability, cost, and reliability. There are also concerns about the impact that science requirements and risk reduction have on cost growth. Another concern is continuity of measurements, which ESS believes that NASA has not consistently addressed. Finally, ESS has concerns about interagency and international collaboration. It is also hard to understand what the mission of the other committee proposed by NRC will be, and whether it will continually recalibrate a mission portfolio that has programs and projects with multi-year timelines.

Dr. Tapley next addressed the ESD role in climate studies. NASA's goal in this area is well-documented as being one of studying Earth systems in order to improve prediction. ESS is particularly concerned about continuity of measurement. Modeling requires measurement over time, along with verification. The 2010 Climate Initiative allows NASA to address important scientific needs for the continuity of key climate observations, through modeling and assessment. In both the DS and the midterm report, NRC recognizes continuity as a national, multi-agency concern. Problems arise in a cost-constrained environment like the one in which ESD now operates. Continuity with NOAA has not always been successful. A plan is needed to ensure the continuation of important satellite-determined climate data records.

Regarding NRC's recommendation for the cross-disciplinary panel, there are needs that go beyond what ESS can do at the present time, and there is a tension between the briefings that are essential to stay current on what ESD does. There are also time limits on the ability of ESS members to do off-line study. The briefings are needed to keep the members informed. The inability of ESS to get input information might be something for NRC to examine. A working group could prove useful in getting down to the science level of some of the international requirements, which are often stated at a high level of assumption.

Discussion

Dr. Tapley explained that ESD has done measurements of the solar constant for a long time despite hoping that NOAA could have picked up the operations. Dr. Freilich added that NASA has an almost 30-year record of solar radiance monitoring. Glory crashed and had an instrument for that. NOAA has responsibility for solar radiance measures. There needs to be overlap to do this right.

Discussion with the Associate Administrator for SMD

Dr. Grunsfeld said that SMD has a great team trying to execute the best science program possible with the funds that they have. The appetite for science, especially "big science," is greater than the funding will allow. He hopes to set expectations based on the actual budget environment. The Decadal Surveys set expectations that NASA cannot always meet due to the budget. The NAC Science Committee members advise on the balance in this situation. He believes that SMD is the best activity in the U.S. Federal government, giving the best value of taxpayer investment. Dr. Grunsfeld gave examples of the return on the investment. The public continues to be engaged.

NRC issued a report on research universities that addresses the vitality of the universities in addressing critical Science, Technology, Engineering, and Math (STEM) issues. This is particularly important for NASA. The ability to produce great science, add value, and support the economy and survival flows through the universities, their faculty, post docs, students, and parents. The research universities should be more involved in K-12 education in order to encourage STEM students. Grades 6-8 are a big part of the problem, because that is where school takes the fun out of science. With the declining budgets, public universities are struggling. There has been a partnership with government there since the 1950s.

James Webb, NASA's second administrator, pushed to have NASA support research universities in order to transform America through the excitement of space research. Dr. Webb started 27 major centers around the country at universities, which then became major centers for space physics. That investment was responsible for much of the nation's space enterprise. Many of these centers are in decline now due to funding reductions. A pervasive model that engages people from the time they are very young and permeates almost all corners of our society is sports, which could be a model for engaging young people in science.

Dr. Kennel noted that his organization, the Scripps Institution of Oceanography, lost the discretionary funds that enabled it to seed new ventures when the state of California pulled back its support. It was a relatively small portion of the overall funding, but it mattered. If NASA were to look at the incentive funding within universities, that would be an important sign of faith and investments. Dr. Grunsfeld replied that he has talked to universities about creating virtual departments based not on students rather than buildings, but the universities often want to talk about funding before more creative ideas.

Dr. McComas said that he is struck by how hard it must be to manage SMD when a significant portion of what is needed is outside the organization, such as launch vehicles. He wondered if there has been progress in that arena, or if there was something the Science Committee could address. Dr. Grunsfeld said that launch vehicle acquisition is handled out of HEOMD, and the overhead is relatively low. The issue is when the costs of the launch vehicles go up faster than inflation. There are new entrants that are not yet operational but bring the potential for costs to stabilize. As for the Delta II, NASA is using the last of the stockpile. ULA made a business decision that the Delta II was no longer lucrative after the United States stopped launching GPS satellites. The new area to watch is commercial space flight. Some are skeptical, but there is a potentially huge benefit to SMD if they succeed. Commercial cargo flights to ISS are absolutely necessary. As long as Orbital and SpaceX operate and compete, NASA will have a regular cadence of the production of rockets. The price is competitive with the Delta II.

Dr. Eugene Levy asked about the end-to-end costs of these systems. The Space Shuttle did not quite work out in that regard. Dr. Grunsfeld said that if SMD were to ask for a fully developed launch vehicle created from scratch, it

would never happen. However, it does work in the other way, where SMD might be asked to add missions to existing launches in order to optimize schedules and space. That is the direction he would like to pursue. He was at the conversation that led to the creation of B612 and did not get involved further. Subsequently, the organization approached NASA, and now there is an SAA. He would like to see more private organizations taking the initiative, and he is not sure how it will evolve. However, smaller launchers with smaller payload capabilities might generate more of this.

Dr. Kennel said that the NASA education programs are baffling, as they seem to be a potpourri of programs that are not adequately assessed for their effectiveness and how they relates to NASA missions. He would like to see NASA improve the effectiveness of its education funding. Dr. Grunsfeld replied that this is being addressed government-wide. The metrics in education are easier to define than those in public outreach. One of the problems is that not everyone involved in measurement understands it. This is a nationwide problem.

Dr. McComas observed that the SMD office seems understaffed compared to a few years ago. Dr. Grunsfeld said that with 153 civil servants plus detailees, the staff is at 201 total, with an approximate budget of $5 billion. It was all probably 40 percent higher 10 years ago, with maybe 320 total staff. SMD is under constant pressure to reduce the staff, and there are program scientist positions that go unfilled. The context is that the budget is flat at best. Because SMD is under a mandate to reduce the staff, they are looking at efficiencies and what can be transferred to the Centers. One big concern is that they are burning people out. Dr. Hagan pointed out that NASA is not alone. At some point, SMD cannot keep doing everything it would like to do. Her question was about Dr. Grunsfeld's strategic thinking to preserve core activities. He answered that SMD has to be successful in executing missions, which requires a core of science systems engineering. Other activities have been farmed out to contractors and Centers, including much functional work. That is more mobile than engineering and science oversight, which must be done at NASA Headquarters. There are some excellent teams, such as that of Geoff Yoder and the JWST team.

Dr. Luhmann said that she was concerned about a previous experience with the Space Exploration Initiative (SEI) in the late 1980s/early 1990s. Much of what was done then parallels the replanning of the Mars program now. It was a hopeful time resulting in interesting reports, yet it all disappeared from the scene quickly. It would be good to use that experience, but it is not clear how. Dr. Grunsfeld said that there are important differences, starting with the fact that the economy was good. Now funds are declining. Mars is very important, so the challenge is to set that up for the future with limited funding. Another big difference is that science is leading the Mars planning activity. SMD wants to find synergy with HEOMD and is less concerned about infrastructure.

Planetary Protection

Dr. Levy explained that the Planetary Protection Subcommittee (PPS) is different from the program subcommittees. PPS is responsible for the planetary protection requirements of Agency programs. Planetary protection policies are governed by international agreements and formal NASA requirements. There are two broad areas in planetary protection. The substantive area concerns forward and back contamination risks. The public perception area addresses the fact that public perception of back contamination risks could present existential threats to any interplanetary return missions, whether those missions are returning rocks or returning people.

Planetary protection policy and requirements seek to control the interplanetary transfer of viable bio-organisms or spores back and forward. There are concerns about the health of astronauts in interplanetary human missions, but planetary protection is about planetary health – it is about protecting the planet. There are two pertinent scientific facts: 1. Life seems to have arisen on Earth very early in terrestrial history. 2. Terra life seems to occur in a much broader range of varieties than once believed. It thrives in a much wider range of environments than once thought, such as hot springs and highly acidic environments, many temperatures and pH values, and high concentrations of salt. All this suggests that life is more common than previously thought and exists in more places than thought, which adds impetus to both forward and back planetary protection. It alters our view of the origin of life.

Findings from the recent meeting

PPS had its most recent meeting on May 1-2, generating one recommendation and several findings or observations. The recommendation is for NASA, as soon as possible, to develop and adopt the appropriate implementing document to specify planetary protection procedural requirements for human extraterrestrial missions at a level corresponding to the current Committee on Space Research (COSPAR) planetary protection policy. This recommended document is necessary for NASA to comply with its own requirements and international agreements.

The first finding states that PPS noted that the Mars planning activities in MPPG inevitably engages on planetary protection issues of both forward and back contamination, and therefore the NASA Headquarters planetary protection officer needs to be informed and engaged in all such planning processes from the beginning.

The second finding reflects that PPS received a briefing on the JAXA Hayabusa2 mission, which will return samples from a NEO. If NASA were to participate, the Agency would be required to adhere to international planetary protection standards. The PPS concurred with JAXA's assessment of the Hayabusa-2 mission regarding compliance with international planetary protection guidelines, and recommended that this mission be considered 'unrestricted Earth return' under NASA policy, should NASA choose to participate in the mission.

PPS is also concerned that the Planetary Protection Office at NASA may not be adequate to fulfill NASA's national and international responsibilities and commitments to planetary protection. The Office is too understaffed and underfunded to do its job in supporting NASA missions.

Dr. Catharine Conley, the Planetary Protection Officer, explained that in the example of geo-biological assays, there are two areas of technology development. There is first a need to be able to measure and, second, sterilize/kill the samples. There is a corresponding need to provide related information to technology developers. Also, with the interest in human spaceflight, it is necessary to show that any sick astronauts are reacting to something from Earth, not something they encountered in space. A large biological community is looking at this kind of thing, which will be essential for Mars missions.

It was agreed that Dr. Levy would edit the recommendation for brevity so that it could go to NAC.

JWST Status

Mr. Yoder, JWST program director, reviewed the budget, which remains in line with the 2011 replan as JWST achieves its milestones within cost and schedule. Key accomplishments include the following:

- Successful cryo-testing of all flight optics;
- Completed Aft Optic System integration, alignment, and cryo-testing;
- Completed primary mirror backplane support structure center, with wing installation ongoing;
- Completed sunshield full scale Engineering Development Unit for layers 3 and 5, with layer 4 in test and analysis;
- Start of flight instruments delivery, with two of the four flight instruments now in-house.

The program brought some work back in with additional FY11-12 funds, including the backplane support frames, which were pulled in by 4 months; the Primary Mirror Backplane Support Structure (PMBSS) and end of flight optics integration, also by 4 months; and the start of wings by 18 months. Slips have been the Near InfraRed Camera (NIRCam) and the Near InfraRed Spectrograph (NIRSpec). Mr. Yoder pointed out the Unidentified Future Encumbrances (UFE) area of the budget, which is being used to handle problems in FY12 and not push work out to further years. The "earned value" is the value assigned to the work that has been accomplished. There are some milestones being pulled into FY13, but the schedule only credits earned value when the work is done, not accelerated planning.

The key is to stay focused by meeting commitments and doing a better job where possible; maintaining and increasing open communications with NASA senior management, partners, and stakeholders; and educating the public by highlighting the science returns to be achieved from JWST. Another objective is to maintain focus on all schedule paths (e.g., Spacecraft, Optical Telescope Element). High-level watch points are the Integrated Science Instrument Module (ISIM) cryo-vac tests, mass margins, the overall schedule margin and competing critical paths, workforce balance to avoid burn out, and a consistent message for the team.

Mr. Yoder told of his previous assignment in NASA's assessment office. In that capacity, he had participated in an ongoing look at JWST to see where it was with its baseline measures and direction. He showed a summary from the review, which indicated that the technology and cost/budget areas were "green." The schedule was also determined to be green, but with concern that the ISIM cryo-vac testing sequence and strategy are not yet fully understood and therefore carry some risks. This evaluation was encouraging as he took over management of the JWST program. Mr. Yoder showed a graphic of the critical path schedule. Since the replan, the project went from 13 months to 14 months of planned critical schedule. This is a good reserve and, while it will not all remain, it is a positive development. The program has numerous risk reduction activities to hold to the critical path and pull it in if possible.

The Mid-InfraRed Instrument (MIRI) is at Goddard, the Fine Guidance Sensor (FGS) is being reviewed in Canada, and NIRSpec is being reassembled following the discovery of a crack in its optical bench some time ago. The NIRCam A and B modules are being tested; some issues are coming up, but this is why they test. All primary mirrors are complete, and the same team is doing the gear motor replacement for all of them. The primary backplane elements are making great progress on an accelerated schedule. The sunshields are in testing, template layers 3 and 5 are complete, layer 4 is in data analysis, and layer 2 is being manufactured.

A recent storm and power crisis affected much of the area around Goddard near the end of testing for the Optical Telescope Element Simulator (OSIM). Fortunately, the team was able to complete the test, but the program is now looking at purchasing an emergency generator as a mitigation activity. Modification of Chamber A is complete, using funds from FY11. The program needed new equipment inside and out to meet the requirements for temperature and cleanliness. At JSC, a full test cycle is about 120 days, with ramp-down taking about 20 days.

The Space Telescope Science Institute (STScI) is nearing completion of the science operations design reference mission. If the team finds something wrong while in the test chambers, they need to have a lot of scenarios ready in advance, which is where the Science Working Group (SWG) comes in. The JWST program is asking them to leverage their expertise through the upcoming Integration and Testing (I&T) phases. The SWG is also providing charts to give to educators and laypersons. Mr. Yoder reviewed the milestones that his team tracks. There are challenges in I&T, but the right team is in place to execute the launch readiness date commitments.

Discussion

In answer to a question, Mr. Yoder said that the spacecraft Critical Design Review (CDR) is scheduled to occur in the fall of 2013. It is the next and final big hardware element to conduct its CDR. He also noted that the wave front sensor in NIRCam has been resolved prior to I&RT. When asked what keeps him up at night, he identified two concerns. First, the project is going into the I&T phase, where they do not know what will come up. So he wants to know what is possible and how to address it. His other concern is losing focus on the big picture and losing a key activity somehow. This requires focus at all levels. He has a lot of confidence in the team. Every time there is an issue, they nail it. They approach it right, work hard, and show that they are the right team. Dr. Urry asked where the program would compensate for any big problems that might come up, given the hard cap on the budget. Mr. Yoder said that the decisions have to be made in real time, and the team cannot be afraid to say "this is good enough."

Dr. McComas said that instead of the "stoplight" charts, he would prefer to have a single set of quantitative metrics that Mr. Yoder could show the Committee every time so they could see how JWST progresses. Mr. Yoder said that

he would look at recrafting his milestones chart. It was suggested that he add dollar amounts and things to look out for. Mr. Yoder took that as an action item, suggesting that he could pilot a new format at the next meeting.

Working Lunch – Sample Analysis at Mars
A science presentation was made while the members had lunch.

Public Comment
As required under the FACA rules, the meeting set aside time for public comment. No members of the public responded either in the room or by telephone.

Findings and Recommendations
With only the previously mentioned findings to review, Dr. McComas explained that the Committee would read the drafts, edit them, and come to consensus. For anything that was to go to NAC at the end of the week, he wanted a couple of background slides to precede the findings.

First recommendation
The first recommendation addressed the issue of PI-led mission cadence. The draft recommendation advised maintaining the planned PI-led mission program schedules, including Astrophysics and Heliophysics Explorers, PI-led Earth Science missions, and the Discovery and New Frontier cadence of Planetary Science opportunities. The reason for the recommendation was that PI-led missions are a proven vehicle for cost-effective, highly productive missions across all NASA science disciplines. The combination of budget restrictions and cost increases in larger missions are forcing delays in their initiation and implementation schedules. These smaller missions produce high-value, high-visibility science results.

Discussion began with Dr. Urry asking if this was really about funding. Dr. Hinners replied that it was about balance, a cautioning to not get so carried away with mega-missions that the budget no longer allows small missions. Dr. McComas agreed, stating that the funding removed from these programs affects the most important work PIs are doing. The recommendation is a reminder that the smaller PI-led program is at the core of what SMD does. Dr. Urry agreed that a balance is needed, noting that many in the astrophysics community have felt that the Explorers were both under-appreciated and more accessible to the public. However, if one looks at how scientists are supported in Astrophysics, there is more money per investigator on large missions. In addition, in all fields the huge successes of missions like Hubble lift all boats, making a huge difference in what NASA can invest in science. She felt the recommendation was lopsided.

The discussion then addressed whether the recommendation was too broad. Dr. McComas pointed out that it began as a recommendation from PSS, but he felt it needed to apply to all of the units within the Science Committee. Dr. Hagan noted that, from the heliophysics point of view, PI-led Explorer missions are extremely important, and there is a desire not to have budgets eaten up by large missions. Dr. Levy supported Dr. Urry's point. Dr. Bradley Peterson agreed that balance is important, and advised against a recommendation that suggest dropping flagship missions. Dr. Kennel observed that the Astrophysics DS chose WFIRST as a flagship, then recommended expanding the number of Explorer missions. In both APD and PSD, the Explorer program is a counterweight to flagship missions. The major missions are important for NASA's visibility and science.

With this recommendation being a priority for two of the four programmatic science subcommittees, there was some debate as to whether it made sense to send forward a recommendation that affected half of them. Some members thought that it should go forward, and others preferred to only send forward recommendations that reflected all four disciplines. Dr. Levy suggested taking more time at the next meeting to review the issue from different perspectives, allowing more deliberation and background.

Dr. Luhmann made the case that planetary PI-led missions are being compromised. She has participated in all sizes of missions. The balance is important. It is essential to keep the cadence of PI-led missions in order to maintain science and technology progress, and in order to have a healthy constituency and healthy progress. She saw too great of a risk in having huge lulls. This recommendation has the specific goal of maintaining the cadence.

Dr. Urry noted that these are good points that come up in the astrophysics community, which has had few Explorer opportunities in the past decade. Yet she thought the Committee had not discussed this sufficiently. She made the point that they were the science advisory committee, and their voice is most powerful when they speak with one voice. She said that she could not support slowing down anything. It might be possible to craft the recommendation to note that every DS says that balance is important. Although it seems to average out over time, balance might not exist in a given moment. In the late 1990s, the astrophysics budget was 50 percent larger than it is at present, and that includes adding the JWST funds back in. On the other hand, ESD's budget is up now, and it is important to take the larger view of whether high science priorities are funded and accomplished. The various Decadal Surveys have made this statement time and again.

Dr. Luhmann emphasized the last line on the "reason" statement: "At the present time, the Discovery and New Frontiers mission line schedules are in jeopardy and must be restored to address their many targets as laid out in the Visions and Voyages Decadal Survey. Dr. Kennel suggested noting that, over time, the Decadal Surveys have always emphasized balance between large and PI-led missions, and calling on NASA to pay special attention to this need for balance in the cost-constrained times.

Dr. McComas summarized the discussion by stating that there was an honest disagreement among the Committee members. Dr. Luhmann wanted something pointed and specific, but other members disagreed. Dr. Levy explained that he could not agree with Dr. Luhmann more. Yet he thought the Committee should cast its concepts in a more holistic sense rather than address one program element at a time. Having said that, he completely agreed that the small missions are a crucial part of SMD's lifeblood and must be supported. He just wanted more nuance than what was in the statement. Dr. McComas concluded that the Committee was not there, and he did not see much value in a "vanilla" comment. He did not see a consensus, and advised tabling the issue until they could discuss it further.

In Dr. Levy's opinion, this discussion spoke to the nature of this Committee and the NAC process. There is a stove-piping transmittal process. One presumes substantive conversations at these meetings, then the members extrude these recommendations and the Agency gets them, later sending out responses. At this level, he saw a lack of a deliberative process, however. It requires more engaged deliberation than they had time for. Dr. McComas agreed. Dr. Hinners also agreed. He characterized the Committee as a machine to push things up, but seldom have they spent time investigating a topic to which the members can add their knowledge and understanding. In that sense, the topic of the recommendation makes a viable focus for a session with the committee involved, looking at facts, and considering the realities of budget scenarios.

Dr. Feeley offered to table this topic for now and address it at the next meeting, at which time there will be a presentation and time for deliberation. It was suggested that the presentation and discussion include the perspectives of the Division Directors and input from the subcommittees.

When asked for the SMD perspective on balancing the budget and working with OMB and Congress, Dr. Grunsfeld replied that NASA already knows it needs to give more emphasis to PI-led missions. The Agency does not want to turn off Cassini or Hubble to do this, though. Those are things only NASA can do. Training large numbers of young scientists and engineers can happen on JWST, for example. That is the discussion he would like to have. NASA is trying to have balance. Dr. Levy agreed, but thought NASA should consider the dimension to small missions that gets young scientists into the guts of the design, implementation, and construction in a way that a big mission does

not. Dr. Grunsfeld responded by saying that the infrequent opportunities and the scale are pushing that out. There is no longer room for mistakes, so the most experienced teams are going forward from the organizations putting out the proposals. The balloons are more likely opportunities for specifically targeting young researchers. On NuSTAR, senior people are mentoring younger people. It is a mixed message that small Explorers promote younger people. The missions already require more than that.

Second recommendation

The second recommendation addressed the new telescope assets from the National Reconnaissance Office (NRO). The recommendation was for NASA to study possible scientific uses of the NRO-donated telescope components, to see whether the Agency can capitalize on this opportunity, exploring possible applications to the high-priority science identified in the Decadal Surveys in consultation with the broad scientific community. The major reasons had to do with the high-quality telescope assets, leverage opportunities for limited budgets, and the possibility that the assets could help with WFIRST.

To begin **discussion**, Dr. McComas stated that NASA does not know what it has and needs to look at it first. It is not hard to justify a study, so a consequence of no action would be that without a study, NASA will not know what it has and will have to decide whether to continue storing and maintaining the assets. He cautioned against singling out WFIRST, as the assets could be valuable for PSD or HPD, for example. He advised asking for a broad study to see where the assets might have the most leverage. Dr. Grunsfeld explained that NASA has a strategic integration process. On August 16, there will be a presentation of the context in which these assets might be used. Administrator Bolden will decide whether to do studies on the possible uses. The goal is to have a process that is more strategic than ad hoc. These assets essentially came out of nowhere. Dr. Grunsfeld himself thinks there is merit to doing a study. He added that NRO donated the assets on the condition that they not be used to observe Earth, so Earth Science is off the table. Astrophysics, Heliophysics and Planetary Science are possibilities, but he was not at liberty to say more. He cannot do studies without the stamp of approval from the Agency's strategic integration group. He was also not at liberty to say whether a recommendation might help.

The Committee unanimously voted to accept the recommendation, with Drs. Urry and Peterson in charge of developing the specific language.

Third recommendation

The third recommendation addressed the Planetary Protection procedural requirements document for human extraterrestrial missions. PPS recommended that NASA develop the appropriate implementing documentation to specify planetary protection procedural requirements for human extraterrestrial missions at a level corresponding to the current Committee on Space Research (COSPAR) planetary protection policy. The recommendation further specified that NASA should adopt the requirements as soon as possible. The reason given was that NASA Policy Document 8020.7G requires both the development of detailed documents delineating standards and procedures implementing compliance with those standards. Without the documentation and procedures, NASA will be out of compliance with its own policy requirements and with international agreements to which the United States is a party.

To start the **discussion**, Dr. Grunsfeld said that NASA currently has no human missions in design for beyond low-Earth orbit. When the Agency starts planning them, this is important. Dr. Conley explained that the concern is that there are certain things that need to be incorporated into the concept and technology development phases. If the requirements are not understood by those developing technology, for example, they might not be able to design back in the protections, or might only be able to at great cost. Therefore, it is important to have this formally in place for the early-stage design requirements. There was talk of writing the recommendation jointly with HEOC. Dr. Levy explained that SMD is responsible overall. The original, longer text that he shortened for purposes of this discussion

said that explicitly, and it will be in the background presentation. It was determined that the NAC Science Committee was the right place for the recommendation.

The Committee unanimously voted to accept the recommendation.

Fourth recommendation

The final recommendation spoke to responsibility for cross-directorate initiatives. It stated that NASA should arrange responsibility for independent, authoritative assessment and advice about the newly established cross-directorate partnership for the exploration of Mars.

Dr. McComas clarified in **discussion** that there are multiple reviews: internal NASA review, NAC review, and NRC review. He understood this as saying that NASA should also seek independent NRC input. While further discussion made it clear that the recommendation did not mean the same thing to everyone present, editing took the Committee members closer to a statement that had value for all of them. As Dr. Hagan explained, they were asking for an additional, independent look and assessment of whether and how the goals of the initiatives align with the Decadal Surveys. Dr. Kennel added that they had heard about critical knowledge gaps that stand in the way of implementing a human Mars program, but they did not see a list of priorities, which probably had yet to be developed. It would be useful for an independent group to look at this from the angles of both science and spaceflight, so that both sides can agree with joint priorities. An independent group might lend credibility to the process. Dr. Grunsfeld added that an NRC group is looking at how NASA is organized as an institution and where it is going.

The Committee unanimously voted to accept the recommendation.

Second Day Wrap-up

Dr. Urry raised an issue that bothered her, which was that in the commentary about a set of activities to be chosen for Mars, it was said that the activities would be influenced by how well they used the civil service population. Dr. Feeley clarified that that was in the unique context of the Joint Robotic Precursor Activities (JRPA), where one criterion is use of civil service abilities.

It was agreed that the next meeting should have presentations and discuss of the Committee's repeated desire to have better staffing at NASA headquarters. Also proposed for the agenda of the next meeting was more information about commercial and private enterprise getting into exploration, and exactly how that works with NASA. If there is more of this kind of activity, it will be important to know how to handle the growth. It was not clear if, beyond B612, others might have tried and failed. Dr. Feeley said that he would take an action item on how to present NASA's plan.

Another topic of concern was the possibility of meetings with other committees. Administrator Bolden has determined that all Committees will meet at same time once each year, but nothing precludes other overlapping meetings during the year, beyond the usual difficulty in scheduling the members. Related to this was what some members felt was the missed opportunity to talk with HEOC, since their time together was taken up with presentations. In general, much of the Committee's meeting time is taken up with presentations, limiting the time for discussion. Furthermore, not all of the presentations are oriented to the needs of the Committee. One member described a FACA-compliant group that has monthly 2-hour teleconferences that provide news and updates, allowing more time to talk at meetings. After more discussion of the presentation methods and discussion opportunities, Dr. McComas said that he and Dr. Feeley would communicate to the Chair the members' desire for more dialogue opportunities.

Adjourn

The meeting was adjourned at 2:28 p.m.

Appendix A
Attendees

NAC Science Committee members
David McComas, Southwest Research Institute, Acting Chair
Byron Tapley, University of Texas, Vice Chair and Chair Earth Science Subcommittee (via WebEx)
Maura Hagan, National Center for Atmospheric Research, Chair Heliophysics Subcommittee
Noel W. Hinners, Consultant
Eugenia Kalnay, University of Maryland
Charles Kennel, Scripps Institution of Oceanography (*ex officio*)
Eugene Levy, Rice University, Chair Planetary Protection Subcommittee
Janet Luhmann, University of California Berkeley, Chair Planetary Science Subcommittee (via WebEx)
Bradley Peterson, Ohio State University, Chair Astrophysics Subcommittee
C. Megan Urry, Yale University
T. Jens Feeley, NASA Headquarters, Executive Secretary

NASA Attendees
Ricardo Arevalo, NASA Goddard
Karen Baxbaum, NASA JPL
Dominic Benford, NASA Goddard
William Brinkerhoff, NASA Goddard
Marguerite Broadwell, NASA Headquarters
Ellen Cohen, NASA Headquarters
Catharine Conley, NASA Headquarters
Pan Conrad, NASA Goddard
Gerard Daelemans, NASA Goddard
Victoria Elsbernd, NASA Headquarters
Victoria Friedensen, NASA Headquarters
Michael Freilich, NASA Headquarters
Teresa Fryberger, NASA Headquarters
Michele Gates, NASA Headquarters
Barbara Giles, NASA Headquarters
James Green, NASA Headquarters
Adam Greenstone, NASA Headquarters
Richard Griffiths, NASA Headquarters
Linda Hargrove, NASA Headquarters
Hashima Hasan, NASA Headquarters
Paul Hertz, NASA Headquarters
Steven Hirshorn, NASA Headquarters
Jeffrey Hollingsworth, NASA Ames
Louis Kaluzienski, NASA Headquarters
Amy Kaminski, NASA Headquarters
Rob Landis, NASA Headquarters
Martha Maiden, NASA Headquarters
Douglas McCuistion, NASA Headquarters
Julie McEnery, NASA Goddard
Michael Meyer, NASA Headquarters
Rashawn Mitchell, NASA Headquarters
Michael Moore, NASA Headquarters

Michael New, NASA Headquarters
Jeff Newmark, NASA Headquarters
Curt Niebur, NASA Headquarters
Sarah Noble, NASA Goddard
Marian Norris, NASA Headquarters
Walter Oleniewski, NASA Headquarters
Robert Pappalardo, NASA JPL
Cathy Peddie, NASA Goddard
Bruce Pham, NASA Headquarters
Diane Pugel, NASA Goddard
Jonathan Rall, NASA Headquarters
Gary Rawitscher, NASA Headquarters
Lillian Reichenthal, NASA Headquarters
Joan Salute, NASA Headquarters
Rita Sambruna, NASA Headquarters
Wilton Sanders, NASA Headquarters
Mitch Schulte, NASA Headquarters
Christopher Scolese, NASA Goddard
Heather Smith, NASA Headquarters
Janice Smith, NASA Inspector General's Office
George Tahu, NASA Headquarters
Dimitra Tsamis, NASA Inspector General's Office
Shannon Valley, NASA Headquarters
Michael Wargo, NASA Headquarters
Greg Williams, NASA Headquarters
Geoff Yoder, NASA Headquarters

Non-NASA Attendees
James Bell, Arizona State University
Raymond Brown, retired
Pamela Clark, Catholic University
Anne Connor, House Science Committee
Richard Dissly, Ball Aerospace
Orlando Figueroa, Consultant
Jay Griffiths, Perkins Coie LLP
Joydip Kundu, OMB
Carol Lane, Ball Aerospace
Dan Leone, Space News
Judlyne Lilly, WNEW Radio
Ralph Lorenz, Johns Hopkins University
Thomas Magner, Johns Hopkins University /Applied/Applied Physics Laboratory
Michael Moloney, National Research Council
John Rummel, East Carolina University
Abigail Sheffer, Space Studies Board
Elizabeth Sheley, Zantech IT
Marcia Smith, SpacePolicyOnline.com
Paul Steffes, Georgia Tech
Rebecca Williams, Science Institute
Ana Wilson, Zantech IT

Appendix B
NAC Science Committee Membership

Dr. Wesley T. Huntress, Jr.
Carnegie Institution of Washington (Chair)

Dr. Byron Tapley
University of Texas (Vice Chair)

Dr. Maura Hagan
National Center for Atmospheric Research

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

Dr. Eugenia Kalnay
University of Maryland

Dr. Charles F. Kennel
University of California, San Diego (*ex officio member*)

Dr. Eugene H. Levy
Rice University

Dr. Janet Luhmann
University of California, Berkeley

Dr. David McComas
Southwest Research Institute

Dr. Bradley Peterson
Ohio State University

Dr. C. Megan Urry
Yale University

Dr. T. Jens Feeley
Executive Secretary
NASA Headquarters

Appendix C
Presentations

1. Goddard Space Flight Center Welcome; *Christopher Scolese*
2. Heliophysics Division Update; *Maura Hagan/ Barbara Giles*
3. Planetary Science Division Update; *James Bell/James Green*
4. Annual Ethics Briefing; *Adam Greenstone*
5. Status of Mars Program Planning Group; *Michael Gates/ Michele Meyer/ Orlando Figueroa*
6. Joint Robotic Precursor Activities; *Victoria Friedensen/ Michael Wargo /James Green*
7. New Telescope Assets; *Paul Hertz*
8. Astrophysics Division Update; *Bradley Peterson / Paul Hertz*
9. Annual FACA Briefing; *Jens Feeley*
10. Earth Science Division Update; *Michael Freilich /Byron Tapley*
11. Planetary Protection Office Update; *Eugene Levy/Catherine Conley*
12. JWST Status; *Geoff Yoder*
13. Sample Analysis at Mars (SAM); *Pan Conrad*

Appendix D
Agenda

NAC Science Committee
July 23-24, 2012

Agenda
(all times EASTERN)

Monday, July 23 (GSFC/Bldg 1, Room E100E)

8:30-8:40am	Opening Remarks – J. Feeley / D. McComas
8:40-9:30am	Center Welcome – C. Scolese
9:30-10:30am	Heliophysics / HPS – M. Hagan/ B. Giles
10:30-10:45am	**Break**
10:45-11:45am	Planetary Science / PSS – J. Bell / J. Green
11:45-1:00pm	**Working Lunch – Annual Ethics Briefing – A. Greenstone (TBC)**
1:00-2:00pm	Status of Mars Program Planning Group – M. Gates/ M. Meyer/ O. Figueroa – Joint meeting with Human Exploration & Operations Committee
2:00-3:00pm	Joint Robotic Precursor Activities – V. Friedensen/ M. Wargo / J. Green – Joint meeting with Human Exploration & Operations Committee
3:00-3:30pm	Joint Discussion/Recommendations – Joint meeting with Human Exploration & Operations Committee
3:30-3:45pm	**Break**
3:45-4:15pm	New Telescope Assets – P. Hertz
4:15-5:15pm	Astrophysics / APS – B. Peterson / P. Hertz
5:15-5:45pm	Annual FACA Briefing – J. Feeley
5:45 p.m.	Adjourn for the day

NAC Science Committee
July 23-24, 2012

Agenda
(all times EASTERN)

Tuesday, July 24 (GSFC/Bldg 1, Room E100E)

8:30-8:40am	Opening Remarks/Announcements – B. Tapley/D. McComas
8:40-9:40am	Earth Science / ESS – M. Freilich / B. Tapley
9:40-10:40am	Discussion with Associate Administrator
10:40-11:00am	**Break**
11:00-11:30am	Planetary Protection – G. Levy/C. Conley
11:30-12:00pm	JWST Status – G. Yoder
12:00-1:00pm	**Working Lunch -- Science Presentation** Sample Analysis at Mars (SAM) – P. Conrad
1:00-1:10	Public Comment
1:10-2:30 pm	Findings and Recommendations
2:30-2:45pm	Second Day Wrap-up – D. McComas/ J. Feeley
2:45pm	**Adjourn**