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MEETING MINUTES

Janet Luhmann, Chair

Jonathan Rall, Executive Secretary

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Wednesday, September 3, 2014

Welcome, Agenda, Announcements

Dr. Janet Luhmann, Chair of the Planetary Sciences Subcommittee (PSS) of the NASA Advisory Committee (NAC), called the meeting to order. She explained to the new members that PSS advises NASA's Planetary Science Division (PSD), discusses matters of importance to the planetary science community, and sends forth findings to the NAC Science Committee.

Introductions

Dr. Jonathan Rall, PSS Executive Secretary, asked the members to introduce themselves. New members included Drs. Amanda Mainzer, Clive Neal, Larry Nittler, and Anne Verbiscer. Two new members are pending.

Dr. Rall explained that PSS has three meetings each year, one of which is a teleconference. Additional teleconferences may be held as needed. The agenda items result from previous meeting topics, events, PSD activities, member suggestions, and input from the Assessment Groups (AGs). Members are encouraged to contact him and Dr. Luhmann with suggestions.

Ethics Training

PSS members received their annual ethics training session.

PSD Senior Review Update

Mr. William Knopf, a Program Executive within PSD, presented the results of the recent Senior Review, which looked at all PSD operating missions that will have completed prime operations by the end of Fiscal Year 2014 (FY14). The missions reviewed were Cassini, Lunar Reconnaissance Orbiter (LRO), Mars Exploration Rover (MER, also known as Opportunity Rover), Mars Express (MEX), Mars Odyssey, Mars Reconnaissance Orbiter (MRO), and Mars Science Laboratory (MSL, also known as Curiosity Rover). The Dawn, Mars Atmosphere and Volatile Evolution (MAVEN), Juno, and New Horizons missions were not reviewed, as they are still in prime operations. The Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) mission will complete operations at the end of FY15.

The review team sent guidelines for proposals to the flight projects, asking for science content and providing the grading criteria. All proposals had a 20-page limit except for Cassini, which was given 30 pages. The proposals were to address three budget scenarios based on financial targets from the guidelines, including a stripped down mission, and an enhanced mission. NASA's final approval of extended missions is tentative pending resolution of the FY15 appropriations process and formulation of the President's FY16 budget request.

The review panel was selected from the community, based on the members' lunar, Mars, and outer planets experience. One subpanel covered Mars missions, and the other covered Cassini and LRO. Both met in May. There were also several teleconferences beforehand to discuss the project proposals and to develop questions for the proposers. The panel had some members from the 2012 Senior Review, and a couple of individuals sat on both subpanels. In addition, a few external reviewers provided expertise through limited participation; these were not voting members. At the subpanel meetings, each project had 2 hours to present responses to written and ad hoc questions. The subpanel members then met, did the initial grading, and sometimes came

up with additional questions that the project presenters were to answer by the end of the next day. Additional votes were held as needed after the meetings broke. The final report went to PSD on July 18.

Ratings and Recommendations by Mission

Each proposal received a rating, sometimes with an alternate rating for descoped or enhanced missions:

- Cassini – Excellent (E);
- LRO – Very Good/Good (VG/G) and Excellent/Very Good (E/VG);
- Opportunity - E/VG;
- MRO – E/VG;
- MEX – Good/Fair (G/F) and Very Good (VG);
- Odyssey – VG/G and VG;
- Curiosity – VG/G and VG/G.

Final ratings for Cassini were determined to be Excellent for the guideline mission, and Cassini has a high likelihood of success during its final 3 years. PSD concurs with the panel findings and approves the proposed extended mission plan.

The Senior Review suggested descoping some LRO instruments that are at the end of their useful science mission. PSD agreed to descope the Miniature Radio Frequency (Mini-RF) instrument, but wants to continue the Lyman Alpha Mapping Project (LAMP) and Cosmic Ray Telescope for the Effects of Radiation (CRaTER) instruments due to their programmatic value.

Opportunity received an E/VG grade, and the Senior Review believes the extended mission will make important discoveries. PSD agreed and will continue the mission. MRO also received an E/VG grade. It was found to be in good condition, and it produces a high number of quality scientific publications from many non-team members. PSD concurs.

MEX is an international collaboration with the European Space Agency (ESA). NASA participation centers on the Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) and Analyzer of Space Plasma and Energetic Atoms (ASPERA) instruments. The panel did not find adequate justification for continuation in either the proposal or the presentation. Nor were the questions sufficiently answered. Observations in conjunction with MAVEN should be funded, but only automated aspects of the High Resolution Stereo Camera (HRSC) image processing should be supported at a very low level, and no other HRSC work should be supported. The Senior Review rated the mission VG with the suggested changes.

Odyssey will be moved into a new terminator orbit for its sixth extended mission. The panel rating is VG, but the mission might be coming to the end of its productive science life, as indicated by the declining rate of its data and some slight degradation. PSD approved the extended mission plan.

MSL is entering its first extended mission with strengths and weaknesses. The drilling pace of eight samples over 2 years of the extended mission is a poor science return for a flagship mission. The roles of the ChemCam and MastCam were insufficiently discussed, and the panel

ultimately said “drive less, and do more science.” The rating was VG/G. PSD agreed that there should be more efficiency of sampling and has asked the project to develop a new task plan that focuses more on in-depth geological exploration rather than looking at additional units. The mission is working on a response.

Conclusions and Discussion

Lessons learned included the following:

- There should be a single Senior Review panel. Composition of the panel is critical, and early identification of a chair and members is important.
- The panel needs at least 2 weeks to develop questions.
- The panel also needs an entire day free of presentations in order to complete its business.
- The lead project scientist or principal investigator (PI) for each mission should be at the presentation. Their presence should be required.
- NASA Research and Education Support Services (NRESS) staff did a great job of supporting panel.
- Proposals should address why operations cannot be reduced in preference to science.

Dr. Hap McSween said that project lead attendance at the Senior Review was an issue, because some PIs felt that they did not get sufficient lead time to prepare their travel schedules. Mr. Knopf agreed that that is important, especially since some missions have critical maneuvers to plan. However, the Senior Review had endpoints and a timeframe, and the reviewers felt somewhat rushed as well. Dr. Neal added that while it is important to determine how much time the project scientists need, a lot of money is involved, these are unique assets, and the panel did the best they could. He was on the panel and felt that they were fair and applied the metrics evenly across the board.

Dr. Luhmann said that there had been concern that adding Cassini and MSL to the review would affect the outcome; she wondered how that played out. Mr. Knopf replied that the Headquarters perspective was that the pool of funds was established, and that no projects were going to be completely happy. One problem was that the project teams spent a lot of time working on their presentations for the enhanced budgets, when the lower rates were known to be more likely. The panel worked very hard. Knowing that there are budget constraints, they wanted to know the science. Some missions that have been out a long time still do great science, and nobody wants to turn them off despite the presence of new missions.

PSD R&A Update

Dr. Rall reviewed the current status of the research and analysis (R&A) program in light of the recent restructuring. Step-2 proposals have come in for Emerging Worlds (EW), Solar System Workings (SSW), Solar System Observations (SSO), Exobiology, Exoplanets (XRP), and Laboratory Analysis of Returned Samples (LARS). Step 1 proposals have been received for all but Habitable Worlds, the only program that has not yet had any due dates. For Step-1 proposals, the average time to notification has been about 3 weeks, though Planetary Data Archiving, Restoration, and Tools (PDART) had some issues and was extended, and LARS notifications went out in just 3 days.

There were three kinds of Step-1 decisions: Encouraged to submit a Step-2 proposal, Discouraged with a redirect to another NASA SMD R&A program, and Discouraged without a

suggested redirect. Of the total number of Step-1 proposals received thus far, 1563 were encouraged, 96 were redirected, and 26 were discouraged altogether. Some of the latter did not involve science at all or were not addressing planetary science. These Step-1 decisions were not binding and if any Discouraged proposals can be submitted, they would be reviewed by a panel unaware of the Step-1 decision. A Step-2 proposal that the review panel evaluated as being not relevant to the program that was submitted would have its panel evaluation sent to the appropriate program for funding consideration. Between the Step-1 and Step-2 submissions, there has been an attrition rate of 20-25 percent. The review panels are set up based on Step-1, which is why PSD needs to know if funded team members are added; this might affect panel composition. For those programs that maintain the Two-Step proposal process, the PSD R&A group is discussing strengthening this requirement.

SSW is the largest program, and Dr. Rall used it as an example: An analysis found that 78 percent of the PIs submitted only a single Step 1 proposal, and 83 percent submitted a single Step 2 proposal. Less than 1 percent submitted four proposals, the most any PIs sent in. About 15 percent submitted two proposals on both steps. An analysis of the number of proposals by institution shows that the majority submitted five or fewer. PDART is a new, consolidated program that received three times what its predecessor, the Planetary Mission Data Analysis Program (PMDAP), had gotten. The time between the Step-1 deadline and the Step-1 decisions had generated some complaints but, beyond that, PSD has received little feedback.

Dr. Michael New discussed a survey conducted with the XRP, EW, and SSO panels at the end of their review panels. PSD hopes to survey the community eventually, but this was the starting point on gathering information. There were 16 questions and a 65 percent response rate, with respondents remaining anonymous.

There were seven questions in the area of documentation, instructions, and conflicts of interest (COIs). The majority of respondents gave positive answers to these questions. Regarding workload, the survey asked about the time involved, compared to previous years, both at the panel and beforehand. About half of the panelists had not served before and over 40 percent thought they had worked the same amount. Three questions addressed the subject matter expertise of the panelists: most panelists felt that they had been matched well to the proposals they reviewed. There were also questions about the panel management and instructions and whether the presence of the program officers enhanced the process: both received positive responses. The program officers helped shape the recommendations going into sign-off and allowed the program to get involved earlier when issues did occur.

Regarding the selection letters, Dr. Rall said that since the budgets are not yet decided and we're facing a Continuing Resolution in FY15, one option would be to just fund those proposals rated Excellent and decline the rest. NASA has the right to "undecline" any rejected proposals if and when more funding becomes available. The Programs could also keep a smaller batch of selectables in the running. The proposers will receive timely notification that the review has occurred.

Joint Session with the Committee on Astrobiology and Planetary Science (CAPS)

PSD Status Update

Dr. James Green, Director of PSD, provided a Division status update. In reviewing a list of upcoming mission events, he noted that MAVEN was about to be inserted into Mars orbit, Comet Siding Spring (CSS) will encounter Mars in October, Curiosity arrives soon at Mt. Sharp, ESA's Rosetta mission lands on Comet Churyumov-Gerasimenko this fall, and NASA will be participating in the launch of Hayabusa-2 to asteroid 1999 JU₃. Events in 2015 include MESSENGER running out of fuel and impacting Mercury, Dawn going into orbit around the dwarf planet Ceres, New Horizons flying through the Pluto system, and work continuing on other missions.

PSD released a draft Discovery Announcement of Opportunity (AO) over the summer and received more than 100 comments. There is a need to replace some Discovery mission infrastructure in order to go forward. A 3-year hiatus in generating plutonium pellets will affect the Discovery schedule, however. Proposals in response to the Europa instrument AO are due in October; this was a Decadal Survey (DS) priority. The Senior Review was completed, as PSS had just heard, but it is only one element of a decision on moving forward with these missions. Other factors include the eventual budget, programmatic concerns, and possible Congressional direction.

More than a dozen responses were received for a Request for Information (RFI) for a commercial buy of Mars communications. This will help determine whether there is a viable business case for commercial companies to provide infrastructure support in relaying data from Mars.

NASA is a partner on ESA's Rosetta mission, which will drop the Philae lander onto Comet Churyumov-Gerasimenko in November. The comet appears different from what was expected. NASA has three instruments, a large portion of the electronics package, and three PIs and 40 co-investigators (Co-Is) providing modeling and other support.

The Asteroid Redirect Mission (ARM) is now under study. PSD's role is to identify an appropriate near-Earth object (NEO) for a mission that will then redirect and explore the object. Dr. Green described the capture approaches under consideration. PSD has enhanced its NEO program as a result, and reactivated the Wide-field Infrared Survey Explorer (WISE).

Dr. Green next discussed planetary technologies, some of which are benefitting from collaboration with NASA's Space Technology Mission Directorate (STMD). A number of instrument development success stories are the result of major investments and will go onto the Mars 2020 mission. The Department of Energy (DOE) is continuing its NASA-funded Pu-238 supply project. The goal is to have 1.5 kilo plutonium oxide by 2021, which can be blended with older plutonium that would otherwise not be viable. This fuel will enable Mars 2020 and Europa, as well as other missions going to the far reaches of the solar system. This Radioisotope Power System (RPS) project has considerable "mission pull" and is a critical technology.

NASA's Astrophysics Division (APD) has approved two Hubble Space Telescope (HST) surveys related to PSD. One is to try to find a New Horizons Kuiper Belt Object (KBO), and the other looks at the Europa plumes. With Spitzer mission operations extended for the next 2 years, both APD and PSD have requested observing time for FY15. PSD strongly encourages the planetary community to submit planetary proposals for time on HST, Spitzer, and Keck.

Another astrophysics mission, the James Webb Space Telescope (JWST), will have capabilities of interest to planetary science, including detecting important molecules, gathering information about Kuiper Belt Objects (KBOs), and monitoring planetary weather. The baseline mission is 5 years, and the hope is to extend the mission long past that. The call for proposals will be 1 year prior to launch and will be highly competitive. Proposing early will allow planetary science to participate early in Cycle 1. Many of the Cycle-2 proposals will follow up Cycle-1 projects.

Discussion

Dr. Gerald Schubert of CAPS asked about the Akatzuki mission with the Japanese Space Agency (JAXA). Dr. Green explained that this will take place in 2015, and the hope is to have guest investigators involved. Dr. McSween said that he was pleased to hear confirmation that ARM is not a PSD mission, but he wondered if, should the mission go to completion with a return sample, there will be a PSD role. Dr. Green said that that had been discussed. Once the Human Exploration and Operations Mission Directorate (HEOMD) decides what to visit, PSD might have varying levels of interest. The Division has the infrastructure to curate and manage any material that returns. That would be on the other end of the mission. Dr. McSween added that the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) and Small Bodies Assessment Group (SBAG) were asked to provide information to help maximize the science, but the scenario seems to have moved away from that. Dr. Green replied that PSD does want to seek advice from the community eventually. Re-engaging CAPTEM would be especially important if the designated object is a rubble pile.

Regarding a CAPS question about plutonium, Dr. Green said that NASA considerations include the fact that plutonium provides heat and needs the appropriate casing, especially in the event of an accident upon launch. The generation of new plutonium will allow safe packaging of a blend of new and old plutonium. Congress has approved DOE moving forward on this. The preference is to use solar where it is feasible, as with Mercury, for example. Jupiter is at the edge of the current range for solar operations, and a discussion would be necessary for any mission headed there. Some New Frontiers missions will require plutonium.

PSD is soliciting planetary proposals with the Astrophysics Division (APD), which will allow the Division to use APD assets for monitoring. All proposals must go through peer review for selection and be compelling; these opportunities must be won, and it is now a possibility. Dr. Luhmann suggested having a briefing on how to do this. Dr. Green agreed, noting that this is already being done for JWST. He promised to look into the options. PSD is co-invested with APD on an exoplanet call that helps both communities conduct significant research in that area together. Dr. Rall noted that the Division for Planetary Science (DPS) conference in November will have a workshop on JWST discussing synergies with other facilities.

Dr. Luhmann asked about foreign collaboration and the next New Frontiers mission. Dr. Green said that NASA is being as aggressive as possible in working with international partners. The current political environment has put collaboration with Russia on hold, however. The next opportunity is working with the Indian Space Research Organization (ISRO), which is interested in a joint working group on Mars. There are also regular conversations with ESA and JAXA. The next New Frontiers mission will follow the launch of the Origins Spectral Interpretation Resource Identification Security Regolith Explorer (OSIRIS-REx) and the call will reflect the Decadal Survey (DS). For ESA's M4 call, NASA will provide guidance to the community as teams form and expertise comes together. This will be similar to what was done on the M3 call.

As the teams form, ESA will talk to NASA, and PSD will determine if the mission supports the Division's science priorities.

Dr. Nancy Chabot noted that ARM does involve the planetary science community heavily, since they have the knowledge of the near-Earth asteroids (NEAs) and small bodies. SBAG just determined that the current knowledge and uncertainties contribute to mission risk. NAC looked at it, too, and their finding is to do a separate cost analysis, which seems incompatible with a December down-select. Dr. Green pointed out that SBAG has been jointly chartered by PSD and HEOMD. Unfortunately, HEOMD's position of Chief Exploration Scientist has been vacant since Dr. Mike Wargo passed away. Dr. Wargo had encouraged HEOMD to deal with SBAG more formally.

Dr. Lori Glaze asked whether the next New Frontiers call would be affected by funding of a Europa flagship mission. Dr. Green said that PSD has the greatest fluctuations in the Science Mission Directorate (SMD) budget, so he could only speculate. PSD will execute the budget that Congress passes. He hopes for a budget that satisfies many of the Decadal Survey (DS) objectives. It is only another year or two before it will be clear how the New Frontiers program shapes up.

Mars Exploration Program Update

Dr. Green next discussed the Mars Exploration Program. Soon after MAVEN is inserted into Mars orbit, India's Mars Orbiter Mission (MOM) will arrive, and Comet Siding Spring (CSS) will encounter Mars. Other upcoming activities are ESA's Trace Gas Orbiter and the ExoMars Rover in 2018. During orbit insertion, MAVEN will be in contact with Earth during its entire burn sequence. The Mars Commercial Telecomm RFI is seeking business models for data-relay services. The bandwidth will be crucial for human exploration.

The Rovers have been doing great. Opportunity has gone further than the lunar rovers did including the Soviet Lunakhod rovers. Interior Structure from Seismic Investigations, Geodesy and Heat Transport (InSight) is a Discovery mission for a stationary long-duration geophysical lander using a Phoenix heritage spacecraft. It will have one Mars year of surface operations. Science goals include understanding the formation and evolution of terrestrial planets through investigation of the interior structure and processes of Mars, and determining the present tectonic activity and meteorite impact rate.

The 2020 Rover will conduct rigorous *in situ* science and go to a geologically diverse site of ancient habitability. It will select places from which to analyze the core, demonstrate future technology, and create a returnable cache of samples. PSD is working closely on this with HEOMD and STMD, which are jointly funding some of the technologies. Dr. Green presented a high-level graphic indicating the many instruments. In addition to the U.S. contributions, there will be one each from Norway, Spain, and France.

CSS is an Oort cloud comet, also known as C/2013 A1. It probably took millions of years to come this far from the Oort cloud. On October 19, Mars will be in the tail of the comet and will let us see how it works. A number of Mars assets will be used for observations, and there will be additional help from APD assets. Oort cloud comets are very fast. The perihelion is on October 25, after which CSS will head back to the Oort cloud. All Mars orbiters and Rovers will observe CSS. Opportunity will observe it close to local dawn, and Curiosity will observe it close to local dusk. They will also observe the Mars response. In addition to a conference at the Applied

Physics Lab (APL), the comet community has come together, as they did with Comet ISON, through the Coordinated Investigations of Comets (CIOC) group. The comet is brighter than the Jet Propulsion Lab (JPL) estimate by a range of 0.5 to 0.75. For CSS dust modeling, a call for proposals resulted in two groups being selected to perform dust analysis and predictions. Information presented at the APL conference indicated that the dust environment is not as severe as first thought. CSS encounter goals for Mars assets start with having the missions survive the encounter. The orbiters can hide behind Mars at the closest approach. Rovers are protected by the Mars atmosphere.

The High Resolution Imaging Science Experiment (HiRISE) will provide resolution of the nucleus of an Oort cloud comet and will characterize the CSS coma and tail in terms of particle size, gas composition, and surface activity. The Mars spacecraft instruments were not designed for this event, but the mission teams will do whatever they can. MAVEN will be best for this. The hope is to observe the impact of gas and dust on the Mars atmosphere, and how that is processed. Initial expectations are ionospheric enhancement, upper atmospheric heating, possible cloud seeding that results in warmer mid latitudes, and colder polar regions with increased winds. There will likely be fewer effects in the lower atmosphere.

Dr. Green presented a graphic showing preliminary science observations. Comets are notorious for not behaving as predicted. This could be a bust, or it could be spectacular. NASA will do as much as possible to enable maximum down-linkage by the Deep Space Network (DSN), which is well prepared for this. Phasing maneuvers are completed, and observation sequences are being finalized. A mid-September CIOC workshop will be held to discuss calibration and determine if any additional tweaks are needed.

Discussion

Dr. Neal asked if the ISRO letter of cooperation also includes lunar projects. Dr. Green said that at this point, it is just Mars. ISRO wants to consider its next step on Mars, and he would like to help them get their creative juices flowing. He will always be looking for lunar opportunities, however.

Dr. Green also explained that the deep space optical communications system is a partnership. NASA may pay for integration. PSD has talked to DSN and has almost exclusive tracking of the comet. Dr. Mark Saunders of CAPS asked if the Mars program has a strategy for potential cost growth in Mars 2020. Dr. Green replied that the mission is in Phase A, which defines Level-1 requirements. The instruments are in the cost cap, and this is something PSD will continue to monitor, as this is a cost-constrained mission.

Dr. Luhmann asked if there will be public awareness website for CSS. Dr. Green replied that the CIOC website has the latest material, and all of the workshops have been open to the public via WebEx. The outreach plan is still in development, but the effort to tell the public what NASA is doing began when he spoke to House staff the previous day. They were excited and wanted NASA to relay this to the public. There will also be communications with the science community.

A CAPS member asked if a barometric pressure measurement is possible, and if so, how it will be coordinated for a better weather map of Mars. Dr. Green replied that there is some coordination. The Mars climate modeling at the Ames Research Center (ARC) is engaged. Dr.

Michael Meyer added that Curiosity has a pressure sensor going at all times. Dr. Green said that it would be great to have lower atmosphere measurements, but the lower atmosphere is unlikely to be affected. Dr. Mihaly Horanyi pointed out that some of the dust will linger for a long time. Dr. Green agreed, and added that the MOM and MAVEN mission will be in orbit, providing an excellent opportunity to see the dust impacts.

Mars 2020 Status Report

Mr. George Tahu, Mars 2020 Program Executive, explained that the Mars 2020 mission responds to the DS recommendation to address top priority science and to cache samples for possible future return. It will provide opportunities for HEOMD and STMD to participate with science instruments.

Objectives fall into four categories: geologic history; astrobiology; selection, collection, and storage of samples; and facilitation of future human exploration. The mission is implementing the “high heritage” approach, using what worked from Curiosity, for example, as well as other missions. The mission concept involves a launch similar to that of MSL. The mission will cruise for 7.5 months, then use an entry, descent, and landing (EDL) approach like MSL’s. More complete information is available at <http://mars.jpl.nasa.gov/mars2020/>.

The spacecraft design approach leverages prior success and experience. The mission will procure heritage items early in order to reduce risk. This includes using spares worth about \$200 million from Curiosity and other missions. The sampling system will require a new arm, however. The MSL Entry, Descent, and Landing Instrument (MEDLI) will fly again; SMD will collaborate with HEOMD and STMD on this. There will be new sensors and possibly a camera trained on the parachute.

Earlier this year, NASA held a workshop to looking at landing sites and the selection process. Current Mars assets are being used to obtain additional information necessary for assessment of potential sites. The team is also looking at what science and technologies are needed for these sites. There have been proposals on both new and prior sites. Mr. Tahu presented a list of significant events, including an Environmental Impact Statement (EIS) that will be required due to the assumed use of plutonium, though solar has not yet been ruled out. The previous week, NASA had the first project science meeting with the selected PIs. The Agency is pulling the instruments into a suite and the PIs into a team.

Dr. Mitch Schulte, Mars 2020 Program Scientist, presented findings from the science definition team (SDT). The SDT envisions a mission that would conduct rigorous in situ science, enable the future, and respect current financial realities. Proposed measurement options include threshold measurements for each objective, plus baseline and enhanced options. The AO was sent out last September, based largely on the standard SMD PI-led mission AO, but also addressing the unique requirements of instrument investigations. Proposers had to address constraints on volume, mass, and power, and could propose for Mars instrument science investigation, Mars exploration technology investigation, or both. While the AO had no set cost cap per instrument, budget resources were about \$100 million for Phase A.

Dr. Schulte listed the selected instruments. The Mastcam-Z does context imagery and mineralogy, while the SuperCam conducts context mineralogy; fine-scale imagery, mineralogy, and chemistry; and organic detection. The robotic arm turret will include PIXL, which does fine-

scale imagery and chemistry. For example, it will enable small-scale chemistry of a vein of mineral through a rock. Sherloc will do fine-scale imagery and mineralogy, as well as organic detection. The Rover body will include three instruments. MOXIE will do solid oxide electrolysis for producing O₂; MEDA is from Spain and will detect temperature, pressure, wind speed, and wind direction, while also doing dust characterization. RIMFAX, the Norwegian instrument, will do subsurface sensing and use ground penetrating radar for subsurface structure.

A comparison of the selected instruments to the SDT's recommendations for science functionality shows that there are several instruments capable of making multiple types of measurements. The threshold payload came in at about \$100 million, which was important. The baseline mission is met with this suite of instruments.

Discussion

Dr. McSween said that MSL has an instrument suite that the team views as fiendishly complex, and the team considers the work exhausting. He wanted to know how Mars 2020 will compare. Dr. Schulte said that it will be tight, but the points Dr. McSween made were considered. The instrument PIs are talking together about how to make it go more smoothly. They have MSL experience and know the issues. At the very least, the mission will not repeat the same wheel issues.

Dr. Philip Christensen said that he was struck by the fact that caching received little discussion despite being a DS priority. CAPS will pay close attention to this mission. Dr. Green explained that the first step in designing a caching system begins with the instruments. The team can now look at caching, what will and will not be cached, and how that is decided. Mr. Tahu added that the Phase A focus was on solicitation and evaluation of instruments. The team also looked at heritage instruments. Caching has been the third emphasis, but it is a huge focus nonetheless. This will be a very integrated system, and Mars 2020 is not going to just grab things and put them in a can. Dr. Meyer noted that the issue is how to ensure that the sampling system collects a cache that they actually want to bring back, and which samples warrant caching, as opposed to those that are simply interesting.

Dr. Candice Hansen-Koharchek asked how many of the landing sites will be ruled out because they are in special regions. Dr. Meyer said it was too early to tell, and more information is being collected. A CAPS member was concerned about instruments getting in the way of each other and the growth of some instruments descopeing the others. He does not want to see the science displaced. Dr. Meyer replied that the AO stated that instruments cannot interfere with other science instruments. The nature of the volume is constrained, so instruments that grow larger will not be able to go. Dr. Green added that the O₂ instrument is not meant to generate sufficient oxygen for humans to breathe, but just to test the capability.

Dr. Luhmann wanted to know more about the participating scientist program. Mr. Tahu said that there will be a call for a participating scientist eventually. Dr. Meyer added that that is an important part of the program. Instruments often present new and unanticipated opportunities.

Outer Planets Program Update

Dr. Curt Niebur, NASA's Outer Planets Program Scientist, noted that the outer planets budget reflects an agglomeration of related activities, not an official program.

Juno is healthy and operating nominally; the team is currently resolving a side swap issue. The Earth flyby was last October but there was an incident requiring safe mode. This was a learning experience. Deep space encounters provide an opportunity to learn to fly the spacecraft. While this saves money, the teams need to consider that most missions have limited time at their final destinations. Juno has covered 80 percent of its trajectory.

New Horizons is in excellent health and operating nominally. The team has been working to address the Pluto dust hazard, and the mission is now ready for the encounter. It will start collecting data in January, and will begin getting resolution better than the Hubble Space Telescope (HST) does in May, then encountering Pluto in July. There will be fuel left after the Pluto encounter. The mission is trying to find a KBO, which has been surprisingly challenging. Since ground-based telescopes have not succeeded, the only option left is the HST, which has a narrower field of view. Odds are against flying by a KBO without having a target, and that target needs to be found within the next 4 to 6 months. This will not affect the Pluto flyby, as that is the prime mission. New Horizons crossed the orbit of Neptune 25 years to the day after Voyager 2 did.

Cassini is in excellent health and operating nominally. The team is lowering the inclination to enable more icy moon flybys and is doing intense planning for a proximal orbit mission. For ESA's Jupiter Icy Moons Explorer (JUICE) mission, NASA is contributing an Ultraviolet Spectrometer (UVS), as well as portions of the Particle Environment Package (PEP) and the RIME radar sounder. The next major milestones are a systems requirements review in the fall and formal mission adoption in November. The latter is similar to NASA confirmation. The mission focus is on Ganymede.

The past 7 months have been very intense for the Europa mission. Europa Clipper preformulation and technology development work continue. NASA released an RFI to collect ideas on a mission of less than \$1 billion. Six of the resulting concepts have gone through evaluation. Launch vehicle options are being studied and include the SLS. The Europa Plume HST campaign has also been selected. This will affect how the plume is explored, but this is not changing the mission concept. Scientists do not yet understand Europa that well, so it is important to avoid focusing on something that they might not find. The AO was written to allow NASA to decide later on how to approach this: flyby or orbit, level of investment, etc. There is also a need to be responsive to Congress, which is very interested in Europa. The Planetary Society sponsored an event on Capitol Hill that was incredibly well attended. Bill Nye was a big draw, but so was Europa.

Discussion

Regarding the possibility of cubesats that might ride along, Dr. Niebur explained that there are various options, according to the launch vehicle and the speed of travel. If there is mass available, the mission could take a university-built suite of cubesats that will deploy in the Jupiter environment, for example. There are no restrictions on who can respond. The cost of a mission should affect the number of AO selections, not the quality of science.

GPRAMA Review and Discussions Session with the Committee

Ms. Jennifer Kearns of SMD described the Government Performance and Results Act Modernization Act (GPRAMA), which used to be called GPRMA. GPRMA was passed in 1993, with an update in 2010. GPRAMA requires each Federal entity to provide a strategic plan, an

annual performance plan, and an annual performance report. This Act was geared more to other types of agencies, not those with an R&D orientation, but NASA has adapted. The Agency measures mission milestones that are objectively verifiable, and also looks at science results through the SMD advisory subcommittees.

The Agency needed PSS to provide a recorded vote on each PSD science objective, then include supporting text. The items need only include key results to support the rating. The text will be the Chief Financial Officer's (CFO) starting point, Representative items will be selected, but not everything. The document's target audience is the public, specifically the intelligent layperson with a college degree that is not in science. If there were a critical item that must be included, PSS was to flag it. The introductory text will be written elsewhere to include non-science elements.

Dr. Rall explained that the PSS job was to score PSD progress against the objectives, which come from the 2014 Science Plan and which PSS had vetted. Dr. David Draper asked for more time next year for advance review of the PSD document with examples of highlights, and Dr. Rall noted that, adding that PSD wanted to make sure there were no gaps or major highlights. Citations from late 2013 were allowed.

PSS was required to give a color rating of Green, Yellow, or Red.

- A rating of Green meant that the expectations of the research program were fully met in context of the budget;
- Yellow meant that there were some shortfalls but some science was achieved; and
- Red meant that there were major disappointments or shortfalls in scientific outcomes in context of resources invested, uncompensated by any positive results.

Ms. Kearns added that the budget elements are supported by other metrics, and that there would be no science from missions in formulation and development.

After some discussion about overlap among the objectives, Dr. Luhmann reminded the group that they would choose three or four items for each objective, making sure that they were of interest to non-specialists. There was also disagreement about when to vote on the color ratings. Dr. Rall recommended that they identify three high-profile results for each objective. Dr. Christopher House added that PSS was to evaluate whether PSD did its job, not the program balance. They were to vote on the body of research from the past 12 months. It was not their job to prepare the document, they were just giving input on what should be included. Dr. Luhmann said that there had to be enough to make the case for readers who do not have a scientific background. She asked the Subcommittee members to send examples to Dr. Rall in time for the next day's meeting.

Other Discussion

Dr. Glaze suggested having a finding in support of the Senior Review. Dr. McSween agreed, recommending that the finding note that NASA has selected exciting missions that continue to bring good results. Dr. Chabot added that they should note that the Review did a good job in developing a range of scores. Dr. Luhmann suggested that since there is no feedback system for the Senior Review, PSS should suggest that there be a way for proposers to receive that input. It

should be content that is useful for young people in the community, and possibly made available on the NASA website.

Dr. McSween said that it was news to him that the planetary community could use the APD telescopes. This needs to be communicated more broadly. Dr. Gaddis said that this has always been an option, but it is now receiving a higher profile with JWST coming up. On the other hand, it was not clear what Dr. Green meant in referring to a new arrangement with APD. Dr. Rall said that Dr. Green and the APD Director, Dr. Paul Hertz, talk a lot. The agreement for PSD to use Spitzer is new.

Dr. Verbiscer noted that the time allocation reflects the ratio of proposals. This struck Dr. Hansen-Koharcheck as odd, and possibly encouraging “junk proposals.” Dr. Chabot was not sure that this should be a priority for planetary, and Dr. Neal added that the planetary community should be careful about supporting APD projects. Dr. Rall pointed out that PSD has part of JWST regardless, so the planetary community should get involved by proposing the kinds of activities that planetary science would support.

Doris Daou said that she had been previously involved with Spitzer while at the Infrared Processing and Analysis Center (IPAC). Normally, there is a planetary panel when reviewing proposal, so planetary scientists compete with their peers. The Spitzer team does plan to interact more with the planetary community and talk about opportunities. Dr. Rall explained that while PSD has a good relationship with APD, there ought to be more planetary observers, so getting word out is important. APD expects more planetary proposals.

Dr. Luhmann summarized by saying that the planetary community has a piece of the pie and does not know how much, but it is a resource. She recommended that there be an informational finding that this should be communicated better.

Adjourn

The meeting was adjourned for the day at 5:07 p.m.

Thursday, September 4, 2014

Agenda Updates and Announcements

Dr. Luhmann opened the meeting. She had drafted some findings to discuss later on the Senior Review process and the R&A program. Dr. McSween was to do an ARM finding because it was felt that PSS should comment, even if it was just to reiterate what Dr. Green said.

For the next meeting, Dr. Luhmann thought it would be a good idea to discuss the changes being made by the Planetary Data System (PDS). It would be helpful for PSS to have some insight into the subnodes and user satisfaction. Dr. Glaze added that by the next meeting, the SSW review process would be done and they should be close to making announcements. PSS could then discuss how the new process is working and start getting community feedback. Dr. Rall explained that programmatic balance is hard to define and achieve. A single program officer running a single program can balance as he or she sees fit. The caucus idea which gathers expertise from across the R&A program offices was meant to help achieve a better balance. He expects some vigorous discussions as a result of the new situation. Dr. Glaze said that while she

agreed in principle, she felt that for SSW there is not always a caucus member with intimate knowledge of that area. So there is still a concern that there is not really a strong advocate for that work. This is something people are watching. Dr. Rall said that there are still caucus expertise needs and vacancies. The goal is to have a full caucus that spans breadth of the program.

Dr. Draper advised discussing facilities at the next meeting. He also felt that the meetings do not always include sufficient discussion time, especially when presentations run over. Dr. Horanyi asked if it would be possible to receive information to read in advance in order to facilitate discussion. Dr. Rall said that, in regard to facilities, the question is how much science they produce. PSD needs to examine why it keeps these investments going. This will require possible outside expertise and site visits. Dr. Luhmann asked Dr. Draper to draft a finding that PSD should have a Senior Review of the facilities and tell PSS what would be involved in that.

Dr. Chabot seconded the recommendation for more discussion time, noting that the AG reports are on the last day, then the members leave. Dr. McSween asked if it was necessary to have full AG reports each time. After Dr. Luhmann said that they contain what the AGs want to share, Dr. McSween said that PSS might prefer to have a block of time to focus on issues the AGs bring up, with less time for reports and more for discussion. He recommended having an annual report from each AG, with discussion at the other meetings. Dr. Luhmann noted that the AG reports have typically been rich with discussion. Dr. Neal wondered if the AGs could send material in advance so that PSS can know what issues to discuss. Dr. Rall said that while FACA requires that discussion be in an open forum, the reports can be distributed early. He liked that idea. Dr. Luhmann said that the AG chairs can decide what they want to include in their reports; the reports could go into an appendix in the minutes. She thought the AG chairs could coordinate offline to decide how they would like to revise the timing and content.

CAPTEM Discussion

Dr. McSween explained that CAPTEM makes findings in regard to requests for samples for scientific research, plus education and outreach. The allocations are made by NASA Headquarters. There are seven subcommittees dealing with lunar samples, Stardust, Genesis, cosmic dust, asteroids (formerly Hayabusa), facilities, and informatics, along with a working group on meteorites that will be included in CAPTEM's revised charter.

Recent activities include a review of the Johnson Space Center (JSC) astromaterials curation plan for annual inventories of allocated samples. JSC is responding to CAPTEM informatics findings about consolidating curation databases. The lunar curation task force conducted a site inspection of lunar sample curation and will complete a report soon. Education and public outreach (E/PO) efforts continue. The ARM task force completed a requested study for the ARM design team. CAPTEM recommended that JSC make acquiring a Micro-CT scanning facility a high priority in order to improve subsampling. Finally, CAPTEM cosponsored a successful workshop called "Vesta in the Light of Dawn."

JSC has reduced the number of lunar samples out in the community from 11,000 to 7,000. This is a positive development, as there were too many samples in circulation, but bringing them back in is taking time. The Meteorite Working Group (MWG) reported that 335 Antarctic meteorites collected last year were unable to be returned on time. The Cosmic Dust Subcommittee has done a preliminary analysis on 2012 Draconid particles collected opportunistically from Comet

Giacobini-Zinner. The group is also getting dust from high altitude aircraft wings. Some cosmic dust collected on the ground contains sea salt, so the collectors are being moved to Mona Kea, Hawaii.

The Stardust Subcommittee will cosponsor a meeting in Berkeley with the Meteoritical Society (METSOC) in 2015. The topic had 48 peer reviewed publications in the last year. Hayabusa now has 25 grains at JSC. JAXA curation has been slow, affecting transfer. NASA would like to get uncharacterized samples without going through this process. The CAPTEM's Asteroid Returned Sample Committee is also advising on OSIRIS-REx sample curation. Genesis (solar wind) data show that the solar wind photosphere is fractionated in the low first-ionization-potential elements.

Science highlights include the use of new analytical technologies on old Apollo samples, including those from the Apollo 17 site. Data show the two kinds of rocks have the same chemical fingerprint. Hayabusa has allowed the first direct sampling of an asteroid's regolith. A finding on the origin of water in solar system bodies shows that water can be formed in inner/interplanetary space.

CAPTEM is concerned about the delayed return of the Antarctic samples, as well as the consequences of a new JSC astromaterials policy on science collections, as mandated by the Office of Science and Technology Policy (OSTP). The three original supporting agencies – NASA, the National Science Foundation (NSF), and the Smithsonian – have all agreed that MWG should be integrated into CAPTEM. There should be a regular cadence of Discovery missions. CAPTEM is also determining if the new R&A reorganization affects astromaterials curation. Finally, the group is apprehensive about the JSC reorganization and is monitoring that, too.

Discussion

Regarding the OSTP mandate, Dr. McSween explained that the directives are known and apply to biology, geology, and all other collections. They center on the need to maintain security and provide information and access to the general public. It is a lot of work, but it will not change how JSC handles samples. Dr. Schulte added that NASA's policy is mature, but there will be a draft policy reflecting the OSTP requirements.

Regarding the R&A balance, Dr. McSween explained that astromaterials research is fundamentally different from all other NASA research, in that it requires laboratories with experience and expensive instrumentation. The concern is that some of the R&A restructured programs might not understand that. It is useful to have two or three labs that can confirm results, and that capability might be missing with a single, consolidated lab. NASA lab facilities often drive analytical development. The samples are small and precious – investigators cannot retrieve additional samples like they might on Earth. Dr. Nittler agreed. Anecdotally, he hears that the Stardust facility is not filling requests adequately in terms of time or preparation. There is concern that JSC lacks the needed expertise. Dr. Rall added that Dr. Gale Allen, NASA's Deputy Chief Scientist, said that the collections policy was not mandated by OSTP, but it is being made consistent across the agencies.

NAI

Dr. Mary Voytek described the operations of the NASA Astrobiology Institute (NAI). The NAI mission statement reflects the NASA mandate to look for life and includes five elements: collaborative, interdisciplinary research; training the next generation of astrobiologists; education and outreach; providing leadership for NASA space missions; and information technology for research. NAI is a virtual institute with 15 competitively selected science teams and about 770 members at approximately 130 institutions. NAI is affiliated with astrobiology institutes worldwide, and there is a tremendous amount of collaboration, especially with Europe.

Dr. Voytek next gave an overview of the results of the 2008 NRC Review of NAI, listing four review questions and their associated findings. In the area of interdisciplinary research, NRC found NAI to be successful, with many achievements and supported programs. The recommendations were to implement better measurements of performance and progress to improve accountability of NAI nodes in promoting astrobiology as a field. In response to this, NAI funded a related postdoc position.

NRC also found that NAI should improve the tracking and assessment of its publications. Dr. Voytek agrees that this area needs improvement, as NAI has an overreliance on self-reporting. The Institute is working on this. NRC recommended that NAI encourage and cultivate interactions with non-NAI astrobiology teams and organizations. Dr. Voytek agreed that the Institute is too clubby and that there is good astrobiological science that happens outside NAI. A publications metric reflected fluctuations in funding. All of the research published in the most common journals was analyzed for interconnectedness. Dr. Voytek also analyzed topic connections to show the interdisciplinary element.

The second NAI goal is training the next generation of astrobiologists. Trained graduates are now employed in academic and other positions, and NAI has promoted the establishment of new astrobiology programs and faculty positions at several universities. However, the Institute has not been sufficiently proactive in countering the negative effects on training and programs caused by budget cuts. Recommendations were for more consistent education and training opportunities, and more stable support for students and postdoc researchers. Dr. Voytek thinks NAI does this well, especially since the Institute keeps the student/postdoc funding steady even in the face of budget cuts.

Regarding the third NAI goal, to provide leadership for current and future space missions, NRC said that NAI should be more proactive in identifying future astrobiology missions. This is an area in which Dr. Voytek sees room for improvement. Nor does she think the Institute has been particularly strong in partnering with engineers to help define future NASA missions. In selecting new nodes, NRC said that NAI should - and Dr. Voytek thinks it does - give more weight to the potential contribution of the proposed research to future NASA missions.

NRC also addressed the Institute's use of information technology. NAI has made successful central efforts to improve communications among members, but has been less successful in promoting collaborative work tools. The Committee therefore recommended new approaches in this area. Dr. Voytek sees this as an area for continuing improvement.

Finally, in the area of education and outreach, NRC saw NAI as having successfully promoted astrobiology as a field with broad-based public appeal, and with effective outreach programs. The Committee also praised the Institute's minority education activities, but recommended a

more strategic approach in reaching younger and minority students. NRC also wanted NAI to set specific requirements for teaching astrobiology at the undergraduate level. Dr. Voytek sees this as an area of strength for NAI. For example, the Minority Institution Research Support Program reaches out to underserved communities. She would like to give it more emphasis. She also offered the example of an award-winning biogeochemist who works with the Institute.

Discussion

Dr. Hansen-Koharcheck said that the day will come when scientists want to bring samples back that they hope have some astrobiological activity occurring. She wondered if NAI was communicating with CAPTEM to brainstorm how to handle these things. Dr. Voytek said that NAI had not, though there have been workshops in this area involving NASA's Planetary Protection Officer. JSC is not yet able to handle samples with life. Dr. McSween said that CAPTEM is looking at protocols for lunar sample handling, and part of that involves organics. The materials community is interested in communication with NAI. Dr. Voytek said that this is where astrobiology could learn from geologists. There must be several different protocols for handling samples with organics. Every couple of years, the instrumentation changes.

NAI has talked to the ocean drilling community, with which Dr. Voytek has some experience. The current NAI call requires a better definition of interdisciplinary plans and research, including broader engagement on the part of investigators, and data sharing to prevent overlapping projects. NAI is really a model for making research awards. Among the missions that have astrobiology elements are Kepler, MESSENGER, MSL, Mars 2020, and JWST. The Institute is involved in formulations for any missions involving Europa, and for missions done with JAXA. NAI is interested in Spitzer, TESS, and OSIRIS-REx as well.

Dr. Luhmann asked how NAI meshed within the R&A structure. Dr. Voytek said that NAI is hard to compare. Other programs in PSD involve one to four people. NAI teams start at 30 people. What she picks for NAI is often informed by related areas that are not sufficiently moving forward elsewhere. She looks for people who would be a good fit, and makes them aware of opportunities. By same token, she also talks with her PSD colleagues about issues the NAI teams raise and where the R&A program needs more emphasis. She supports the Habitable Worlds area in R&A, which mainstreams astrobiology.

Dr. Luhmann was impressed by what Dr. Voytek described and wanted to know what other areas might benefit. She was also curious about how the discipline is managed to prevent double dipping. Dr. New said that NAI is very large and requires interdisciplinary approaches, so there is little overlap with normal PI work. There are also qualitative differences in the kinds of science proposed. While PSD lacks the personnel to check every grant proposal for overlap, proposers do have to list current and pending support. Dr. Voytek added that she and Dr. New work together on any program with astrobiology. The reorganized R&A program enables that even more.

GPRAMA

After explaining that Dr. Nittler had created a spreadsheet with the objectives and the potential supporting items (see Appendix E), Dr. Rall suggested taking the required vote.

PS-14-4: Demonstrate planned progress in exploring and observing the objects in the solar system to understand how they formed and evolve.

The vote for a rating of Green was unanimous.

PS-14-1: Demonstrate planned progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact, and evolve.

The vote for a rating of Green was unanimous.

PS-14-5: Demonstrate planned progress in exploring and finding locations where life could have existed or could exist today.

The vote for a rating of Green was unanimous.

PS-14-8: Demonstrate planned progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.

The vote was 12 for Green and 2 for Yellow. Dr. Rall asked for further discussion. Dr. Draper felt like there was not much substance in this area. Dr. Hansen-Koharcheck wanted more material from NAI, which Dr. Voytek promised to send. Dr. House observed that there had been more material in previous years. Dr. Rall pointed out that the idea was to demonstrate quality. Since there was a super-majority for Green, he declared that to be the rating. Ms. Kearns agreed.

PS-14-12: Demonstrate planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.

There was discussion as to whether the resources element of this objective had been met. Dr. Mainzer said that there was substantial supporting material that had not been provided, and she committed to adding it.

The vote for a rating of Green was unanimous.

LEAG Discussion

Dr. Neal described the activities of the Lunar Exploration Analysis Group (LEAG). The annual meeting will be in October and will be at APL for three days, with more than 70 abstracts. LEAG is offering student travel grants.

There is now a project team for the Resource Prospector Mission Science Analysis Team (RPM-SAT); a draft report has been delivered. The Volatiles SAT is looking at what we learn from orbit and determining the best sites for exploration. The Roadmap Update executive summary is now available and is being integrated with the international global exploration roadmap. In response to a request for a technology plan roadmap, LEAG is putting together a team and clarifying the request.

Initiatives include an international lunar workshop in 2015 to re-evaluate the state of the field. Scientific Context for Exploration of the Moon (SCEM) is an international document that will include evaluation of strategic knowledge gaps. A workshop to update the 2006 Next New Views of the Moon document will be held in 2015.

Some sample analyses are resulting in age dates that seem too young. There are also curation issues. LRO offers new opportunities. Other issues focus on facilities and cartography. The latter needs to be solidified in the new R&A structure. Cartography, photogrammetry, and image processing software are all important for future missions. Facilities also need support.

Discussion

Dr. Gaddis said that cartography lacks long-term planning, which is worth considering. Dr. Neal suggested that the Senior Review of the facilities include cartography. At the moment, PSS did not have a representative from that community, and he thought that should be addressed as well.

Dr. Norman Sleep of CAPS said that what has fallen through the cracks is the chronology of the nodes like the South Pole, and there is no program addressing that. Dr. Neal added that there are questions about impact chronology, especially at the large basin-forming impacts. Planetary cartography will have an issue in dealing with this. Dr. Rall read a statement from PSD's Dr. Michael Kelley noting that the planetary and cartography working group used to provide priorities to NASA and the United States Geological Survey (USGS). That has changed, but there is an effort to resume it.

Dr. Luhmann advised having a PSS action on cartography, with Drs. Neal and Chanover working on it together. Dr. Neal asked about where cartography fits in the R&A scheme. Dr. New replied that USGS has a planetary cartography program for 5-year grants. NASA adds some funding to that.

NEOO Update

Mr. Lindley Johnson, Chief Scientist for NASA's Near Earth Object Observations (NEOO) Program, explained that over time, the Program's mandate has changed from discovering all objects larger than 1km to discovering all objects larger than 140 meters. The latter is very difficult, and it will be hard to achieve the 90 percent completion target by 2020. There have been budget increases, however, and ARM has been a factor.

The program involves a loose collection of missions, with NEO-WISE, the Linear/ Space Surveillance Telescope (SST), the Catalina Sky Survey, and Pan-STARRS as mainstays. JPL hosts a NEO office to help determine any threat of impact, not just on Earth but also on Mars and other bodies. Catalina has been the most productive. Linear is prolific but being revamped right now. Pan-STARRS is relatively new. NEO-WISE, which does characterization, is the only spacecraft; the others are ground based.

Discovery of an object with potential for impact results in alerts sent out to NASA and the rest of the world. A recently discovered Near-Earth Asteroid (NEA) was soon to approach, though it would be far away from the planet and its orbiting satellites and spacecraft. For larger objects, the discovery rate has fallen off as discoveries have been made. However, there has been a robust discovery rate increase overall. The estimates of the NEO population are based on statistical work done on the known population and how it relates to size, brightness, impact energy, and frequency.

Mr. Johnson presented a graphic showing the known NEA population by size. Physical characterization of NEAs involves radar, infrared (IR), light curves, and long-arc high-precision astrometry. Mass is estimated from size and shape using IR or assumed density. Composition can

only be roughly assessed via analogy. At this point, Goldstone and Arecibo are the only observatories doing radar observation of NEOs, but OSIRIS-REx will be available eventually. IR characterization increasingly relies on Spitzer and the IR Telescope Facility (IRTF). A new characterization process was used for 2013 EC20, which was initially seen as an ARM candidate, though it was ultimately determined to be too small.

A pie chart showed the NEOO project allocations, with search projects accounting for 40 percent and allocations to infrastructure and radar being 15 and 17 percent, respectively. Funding for the 59 projects in FY14 went almost entirely to institutions outside of NASA, as very few NASA personnel do this work. More direct NASA involvement occurs in mitigation studies and related efforts, which are highly collaborative. These studies include NASA Innovative Advanced Concepts Program study awards and Kinetic Impactor demonstration mission studies. The latter looks promising and could be launched as a secondary capability. NASA and ESA are working on an asteroid impact and deflection effort in which a spacecraft would rendezvous with an asteroid for an interception. Interagency efforts involve DOE and the national labs to look at impact effects and possible actions. One question is how to deal with a rubble pile.

The Federal Emergency Management Agency (FEMA) is conducting impact emergency response exercises. NASA is giving that agency information on what we can know and do, and with what precision. This is helping FEMA to understand its disaster response options. These might be analogous to hurricane evacuations, for example, and FEMA has plans for space vehicles re-entering with hazardous materials. The UN Office of Outer Space Affairs (OOSA) within the Committee on Peaceful Uses of Outer Space (COPUOS) has a role in the international NEO threat response. The “Grand Challenge” is to find all asteroid threats to human populations and to know what to do about them.

Mr. Johnson next showed the three components of ARM: identification, redirection, and exploration. Identification is the NEO element; NASA is already characterizing asteroids, so this is an extension of that effort. Only about 10 percent of NEOs are in the candidate category, however, and in 2013, there were only about 20. Radar observations of Asteroid Redirect Robotic Mission (ARRM) candidates indicate a mere handful of candidates, though there are others awaiting validation. Radar characterization of boulders on asteroids currently comes from ground radar. ARM will have its mission concept review in February 2015.

Discussion

Dr. McSween said that having NEO samples would be useful for hazard mitigation, but he did not see how ARM technologies can do that. Mr. Johnson explained that ARM’s primary objective is technology development for human exploration. ARM then has science and planetary defense as secondary objectives. Dr. Luhmann said that some in the community feel that more observing should be done because needed information is missing. Mr. Johnson agreed. He would like NASA to go to space and conduct IR detection of these objects. There is no science justification for ARM, but he would like the Agency to get whatever science it can from the mission.

Dr. Sleep of CAPS said that a space-based asset would be necessary to detect all of the 140-meter objects, and that would take a couple of decades. Mr. Johnson said that NASA is pursuing the capability, but lacks the funding. Dr. Chabot added that while the community does not often agree on everything, there is agreement on the need for this survey. She asked if the NAC

finding asking for an independent assessment of ARM would affect the projected schedule. Mr. Johnson said that it would.

Working Lunch

Over a somewhat informal working lunch, discussion began with whether there should be a finding on ARM. Dr. Chabot perceived a larger problem of possible overlap with planetary defense. Dr. Rall said it was important to note that the ramp-up for the NEO Program does not come from the rest of PSD. This is not a PSD issue, it is an Agency/Federal government issue. He thought it was a good example of what the Federal government should do, but also thought it was important that PSD not become the “NEO Division.” Dr. McSween wanted to have a finding stating that ARM is not a science mission.

MEPAG Discussion

Dr. Lisa Pratt updated the activities of the Mars Exploration Program Analysis Group (MEPAG). The May face-to-face meeting included four major segments. First was a discussion with Dr. John Grunsfeld, Associate Administrator of SMD, and others from NASA Headquarters. There was also an overview of Mars missions and a landing sites discussion, along with special reports addressing Mars special regions and sample return quality.

The 8th International Conference on Mars, held in July at CalTech, was a great success and had 650 participants. A single-track program allowed everyone to hear all of the same talks and facilitated conversation while also reinforcing the interdisciplinary element. Emphasis was on increasing knowledge of the mineral diversity and indicators of wet environments on early Mars; climate cycle variations on orbital time scales; and dynamic processes on Mars today. Other outstanding questions concern whether early Mars was inhabited, and the persistence of water and how it moved and interacted with the surface.

The Mars 2020 payload selection had some surprises, but there is now an active conversation about how the payloads will change what we know and how to use them best. More international missions to Mars are in the pipeline; Dr. Pratt updated their status. The Senior Review has generated a lot of discussion. Curiosity Rover is moving along to Mt. Sharp to study the layered sedimentary unit. The rocks have caused some turnarounds and redirections, and there are wheel issues that have resulted in mitigation activities. The teams are now deciding Opportunity Rover’s path on the Endeavour Crater Rim, and scientists have come up with some clever responses to the evolving degeneration of some instruments.

A big activity for MEPAG was the Special Regions Special Analysis Group (SR-SAG2), which included microbiologists and updates the 2006 report with major recent discoveries. The report has been accepted by MEPAG and will be published in *Astrobiology*. Among the findings are the low water activity limit for terrestrial life and a proposed classification of Martian environments.

Looking ahead, MEPAG is glad to see more conference travel options and is waiting to see the impact of PSD’s reorganized R&A program. It would also be good to see E/PO come back to the program. Future MEPAG thrusts include how to best harvest exciting ideas beyond Mars 2020, which would involve a stronger relationship with HEOMD. This has led to discussion of updating the MEPAG goals document. MEPAG is looking forward to the report from the Organic Contamination Panel as well.

OPAG Discussion

Dr. Hansen-Koharcheck presented the report from the Outer Planets Assessment Group (OPAG), which evaluates outer solar system goals and investments. The most recent OPAG meeting was a face-to-face meeting July. OPAG is very concerned about the looming gap in missions to the outer solar system (OSS). While there are some promising near-term missions, the longer-term future involves only limited participation in JUICE and the possible New Horizons KBO flyby. With both Juno and Cassini expected to end their missions around 2017, this is a problem. One issue for outer bodies is the time it takes to reach the destination.

This raises the question of why explore the outer solar system. Dr. Hansen-Koharcheck presented six key study areas: atmospheric circulation, weather, atmospheric chemistry and astrobiology, magnetospheres, materials behavior, and exoplanets. To get OSS research back on track, the first step is to maintain support for Cassini, as was shown by the recent Senior Review. It is also important to have a new start for a DS-responsive Europa mission, make sure that OSS missions have a home in Discovery and New Frontiers, and invest in the right power sources. The launch pace was good from 2003 to 2012, but the upcoming decade has very little OSS exploration planned. A mission to Europa is the highest priority mission destination for the outer planets community and should be addressed. Europa Clipper is scientifically compelling and technically and financially feasible. OPAG is pleased with NASA for the progress that has been made and is glad to see Europa in the FY15 budget. But there have been many studies, and it is now time to build and launch a spacecraft.

It is also important to have a home for OSS missions in the Discovery and New Frontiers programs. Dr. New changed the Discovery AO to be more appropriate for OSS work, but the schedule for fueling the RPSes will still prohibit OSS from being on a Discovery mission. In addition, there is concern about the New Frontiers program, which has supported OSS investigations; OPAG urges PSD to restore it.

While the SLS launch vehicle has intriguing potential to decrease travel time, NASA has yet to develop a cost model that works for PSD. This leads to the issue of the limitations of solar power in space. It is hard to imagine a solar mission at Neptune, for example. Non-solar-powered spaceflight should be made operational, with the appropriate technology development. Restarting production of PU-238 is a good start in this direction. OPAG also wants to support Earth-based observations for missions. There is concern about proposal selection in the revamped R&A program, and OPAG would like to see a programmatic funding breakdown, particularly for SSW.

In other business, OPAG is working on a new science goals document, updating the 2006 document that was supplemented by a 2009 white paper and technology recommendations to the DS. This should be a living document that can be adjusted as discoveries are made, with a focus on science rather than missions and science goals that can go into Discovery. This will also help prepare for the next DS. The approach has been to stick with science, not mission concepts, using recent studies and augmenting them. The current work is on overarching themes, such as how the outer planets molded the solar system. From there, OPAG will come up with specific science questions. The initial draft is posted on OPAG website for feedback.

Recent events include Juno's flyby of Earth last October. A YouTube video of the approach has generated almost 1.5 million views, along with a video of ham radio operators sending messages to Juno. Cassini has done a lot; Dr. Hansen-Koharcheck reviewed some of the science highlights.

Discussion

Dr. McSween observed that every AG presentation mentioned concern about the reorganized R&A program, with the subtext that NASA should fund as it did previously. However, there is no way to disentangle any changes in the program that might reflect bad oversight versus bad proposals. There will be some changes, and they will average out over time.

Dr. Saunders of CAPS noted the need for an SLS lunch vehicle cost model for outer planets missions planning. Dr. Hansen-Koharcheck explained that this dialogue has just begun, and the concern relates to the budget. Dr. Sushil Atreya praised Dr. Hansen-Koharcheck for making such a strong case for bringing OSS research off the back burner. He asked about collaboration options with ESA. Dr. Hansen-Koharcheck replied that such partnerships are important and OPAG would be eager for the opportunity to work with ESA.

Dr. Chabot stated that SBAG agrees that the New Frontiers program is important and noted that they have been assured that there will be a funding wedge when OSIRIS-REx is out of the development phase. Dr. Hansen-Koharcheck was less confident of that. Dr. Green pointed out that the President's budget is notional for the out-years, with placeholder funds in the projections and greater ability to plan closer in. Now the intent is to have more frequent Discovery missions than the previous budget allowed. The next New Frontiers call will follow the DS on five objectives, two of which reflect OSS research. It will be competitive, however.

SBAG Discussion

Dr. Chabot began the SBAG presentation by noting that there had been a meeting in July. The reactivation of NEO-WISE in December 2013 was a positive development, and the mission is doing well. Dawn prepares to encounter Ceres in March 2015, and there will be a Guest Investigator program. There will be an encounter with Pluto in 2015, and HST has now found a promising KBO candidate.

At the July meeting, SBAG developed the following two findings:

- SBAG approves of having a Discovery AO in 2014, and supports maintaining a regular cadence of Discovery AOs at the DS recommendation of at least every 24 months.
- For the New Frontiers Program, the DS emphasized the importance of having two such missions in the decade to achieve a balanced exploration portfolio. Therefore, SBAG encourages an AO for the fourth mission selection in the near future as OSIRIS-REx development work is completed.

The Balloon Observation Platform for Planetary Science (BOPPS) will launch later this year. The Rosetta mission with ESA will reach its primary target Comet C-G later this year and the Hayabusa-2 with JAXA will launch later this year.

In another finding, SBAG expressed concern about the future stability of funding for key planetary radar facilities. The Group further addressed the need for a NEO survey. A dedicated, space-based survey telescope would achieve the detection goal in the shortest period of time.

SBAG found that for the B612 Sentinel Project, NASA entered into Space Act Agreement (SAA), but B612 has not met its milestones. The concern is that this effort is important, and NASA was relying on the Agreement.

Another SBAG finding stated the need for a Planetary Defense Coordination Office. The Group found that the ARM work is limited and not compelling from a science perspective. Furthermore, the information is limited.

Discussion

Dr. Mainzer recused herself from this discussion.

Dr. Pace of CAPS asked if anything is being done with Ceres and astrobiology. Dr. Chabot replied that there are those who feel that what is found at Ceres could be very compelling, possibly leading to a flagship or New Frontiers mission. Dr. Saunders of CAPS asked if SBAG had thought about packaging a space-based telescope to fit the Discovery program. Dr. Chabot thought that the price point is in the realm of possibilities. Dr. Johnson said that such a mission has been proposed and he would like to see such a proposal again. The science must be compelling.

Dr. Richard Binzel of CAPS said that HEOMD is struggling to have meaningful NEO targets. He also doubted that NASA would meet the requirement for the detection target. Dr. Green admitted that this will be difficult. Congress has not given funding or direction for this, and competitive efforts have not always worked. Dr. Chabot wished that this were not a PSD issue. She thought it should be a NASA issue beyond just PSD and asked if there might be another avenue to pursue. Dr. Green explained that each organization within NASA follows the law to the extent possible, given the funding. This is true throughout NASA. So unless the community is willing to give up other missions and go outside the DS, this cannot go further. The only open competition is through Discovery, and the agreement with B612, the next best step, did not work out. Dr. James Kasting of CAPS agreed that this should not be a PSD decision and advised that CAPS make a recommendation that this should be studied at the NASA level.

Dr. Luhmann pointed out that the official avenue for PSS is a report of findings. She was uncertain the extent to which the NAC Science Committee would agree to forward this to the NAC, but PSS would develop a finding. Dr. Michael Moloney of NRC explained that CAPS cannot make findings or recommendations, nor could the Committee make a statement of consensus. Dr. Neal proposed that PSS support the SBAG finding on science and planetary defense as they relate to ARM. He noted that SBAG had spent a lot of time on this, and he thought that PSS should have on the record that it recognizes the lack of science in this mission. Mr. Johnson explained that these findings have been discussed a lot, and reassured PSS that they were being heard. There are many constraints and considerations in this mission.

Dr. McSween noted that ARM has a possible science implication that CAPTEM would weigh in on, which is the value of the sample return. This is not the way to plan a sample return.

VEXAG Discussion

Dr. Glaze reviewed recent activities of the Venus Exploration Analysis Group (VEXAG). The Group meets annually, so there were no new findings since the last PSS meeting. However, members have finalized three documents that are now posted on the VEXAG website: Goals,

Objectives, and Investigations; Roadmap for Venus Exploration; and, Technology Plan. Over the summer, VEXAG held a Venus Exploration Targets workshop, members attended a Venus Seismology Workshop, sponsored by the Keck Institute for Space Studies, and a task group assessed the Research Opportunities in Space and Earth Sciences (ROSES) AO. Ongoing activities include a centennial challenge.

Regarding whether or not to seek PSS recognition of the roadmap document, Dr. Glaze noted that it is consistent with the DS but has much more detail. Approval was tabled for the next meeting, at which time PSS will discuss the AG process in general. The exploration-targets workshop, held at LPI with 54 attendees, built on the documents. Dr. Glaze reported that it was very vibrant, and much thought was given to how to achieve the measurements needed to meet the objectives. The seismology workshop focused on three different scenarios for measuring waves, ranging from being on the surface to having a balloon in orbit.

The Venus Express, an ESA mission, has been orbiting Venus for over 8 years now, and while VEXAG hopes to get an extension, it is nearing the end of its fuel. An aerobraking campaign is helping to extend the mission, along with reduced orbit time. Venus Express found that atmospheric pressure is more variable than expected. The Akatsuki mission may go into orbit in 2015, and the intent is for NASA to reinstate the participating scientist program. The potential Russian mission has been terminated due to politics, and it is not clear if the Russians are still pursuing it.

A January workshop will focus on instrument needs and measurements. There will also be a town hall at the Lunar and Planetary Science Conference (LPSC) next spring. VEXAG hopes to have another workshop at Keck Center in May, and is planning a comparative climate of the terrestrial planets event in September 2015, to be held at NASA Ames.

While there were no new findings, the topical analysis group is requesting that there be an assessment of PSD's reorganized R&A program. Science nuggets include the discovery that lightning generated extremely low frequency (ELF) waves, similar to what is seen on Earth. There was also confirmation of a likely ferroelectric substance, which suggests different types of materials. The M4 call is out in Europe, which could be a Venus mission. Finally, there is a great deal of excitement about Discovery.

Discussion

Dr. Luhmann asked if a VEXAG subgroup might be available to compare ground-based versus space-based observatories. Dr. Glaze said that this is something to consider. JWST will not be able to look at Venus, and ground-based radar is still used for this purpose.

SSERVI

Dr. Yvonne Pendleton presented an overview of the Solar System Exploration Research Virtual Institute (SSERVI), which she directs. The Institute takes no funds from the R&A Program, where it is listed only for bookkeeping purposes. SSERVI is a joint project of SMD and HEOMD. As a virtual institute, there are no geographical constraints, allowing teams to be put together regardless of location.

The Cooperative Agreement Notices (CANs) go out every 2 to 3 years, and each PI's institution must provide in-kind contributions. The structure allows rapid integration of multidisciplinary

topics, cross-team sharing of students, long-term funding, collaborative teams, and real-time science discussion. SSERVI's mission is to advance basic and applied lunar and planetary science research in support of human exploration of the solar system. Collaboration is a big part of SSERVI. SSERVI provides flexible support by using cooperative agreements to redirect efforts in response to new knowledge and/or changing NASA requirements. It is flexible enough to encourage researchers to go in a new direction regardless of what was in the proposal.

At the end of 2013, SSERVI selected 9 new teams out of 32 proposals. Reviewers looked at how proposals addressed strategic knowledge gaps. There are also international partners, both individual and institutional. SSERVI offers shared facilities that are open to the community; Dr. Pendleton presented several examples, such as the University of Colorado at Boulder's dual accelerator and the Stony Brook vibrational spectroscopy lab. There is also a sample library being developed. Next generation support is another focus.

The SSERVI central office is at Ames. SSERVI has instituted new tracking mechanisms for papers in order to determine the role of the Institute in publication. There are community engagement initiatives that seek to bring together the science and exploration communities. While some meetings are virtual, there is a strong preference for in-person meetings. A virtual lunar science forum in 2013 used cutting edge virtual technologies, but denied scientists (especially the younger scientists) the opportunities to network. SSERVI manages a lunar mapping and modeling portal. Commercial partnerships include Google.

Dr. Victoria Friedensen from HEOMD said that SSERVI hopes to strengthen ties between HEOMD and SMD. Dr. Luhmann advised that SSERVI develop liaisons with the AGs. She asked how PSS might best and more regularly get a sense of what the institutes are doing. Dr. Pendleton explained that the institutes are structured differently, and it would not make sense to do this through the R&A report.

Dr. Chabot asked how the funding works, given that teams go for 5 years and there are selections every other year. Dr. Rall explained that the funding profiles were front-loaded to avoid having to do wholesale replacement. Dr. Pendleton added that the CAN was built to have a funding wedge. There will be fewer teams selected in the next round.

JSC Organizational Update

Dr. Eileen Stansbery described the reorganization at JSC. The goals were to advance human exploration with a structure and governance that is more lean, agile, and adaptive to change; enhance collaboration and reduce stove-piping; engage leadership on a more strategic level; coordinate exploration activities and resources; respond quickly to changes in NASA priorities and programmatic direction; and operate more efficiently. One of the issues the reorganization addresses is the large number of personnel reporting directly to the Center Director. This number has been reduced and the structure has been changed in a way to facilitate decision-making.

Dr. Stansbery showed the previous organizational chart and compared it to the new one. There is a leaner senior staff, with the CFO and procurement organizations working together in an integrated business office. Two new technology organizations consist of a flight operations group and an exploration, integration, and science unit. The reorganization is not intended to change or eliminate any current work.

Dr. Neal was concerned that the astromaterials research and curation unit is being demoted; PSS needs to watch this. He would like an update at the next PSS meeting, as this could affect planetary science. Specifically, he wants to know the future of astromaterials curation. Dr. Stansbery agreed to provide an update, adding that it is important to have a voice at the highest level to make sure these elements do not get lost. It is still unclear how it will all work out or what impact it will have.

General Q&A Session with the Committee

Dr. Luhmann said Dr. Voytek wanted to make an announcement about SSW in order to avoid anything coming as a surprise. Dr. Voytek explained that there had been discussion about having two deadlines for SSW, and the staff had an idea she wanted to run past PSS.

For SSW 2015, the idea is to have a single Step 1 that would feed two Step-2 deadlines. The Step-1 proposals will be divided between the two deadlines, and there would be a space in the Step-1 proposal to indicate a preference and the reason for that preference. It is possible that some preferences might not be accommodated, however. A sample schedule showed how the deadlines could be staggered.

In this scenario, when PSD sends out the encourage responses to the Step-1 proposals, the Program will designate the Step-2 group to which the proposers are to respond. It is not yet clear how PSD would handle the discouraged responses. Proposers would not be able to submit to the other Step-2 group. Funding would be about one-third awarded to Step 2.1, about one-third awarded to Step 2.2, and the rest held to be divided between second tiered selections, which would essentially be delayed notification. That group would have a longer wait, as they would be fill-ins. This will help solve a burgeoning problem.

The advantages are that this addresses community concern that proposals are all due at once or too close to other deadlines, and program caucus issues of having to do too much, too quickly. It minimizes gaming the system, so that no proposers unfairly benefit from review feedback for a second submission within a ROSES year. Some members of the caucus would have to attend all reviews, but some might be able to attend fewer. There could also be more total proposals. Dr. Voytek asked that comments be sent to her.

Findings

Dr. Rall put together a PSS findings summary that could be fleshed out off-line. Following are the findings topics that PSS agreed to, with selected details and assignments:

1. PSS recognition of the recently completed Planetary Mission Senior Review. (Luhmann)
2. PSS interest in regular updates of the ongoing restructuring of the R&A Program. (Luhmann, Horanyi, House)
3. PSS request for updates on the Senior Review of various planetary science facilities. (Draper)
4. PSS concerns regarding Planetary Cartography and Geological Mapping representation. This item gave rise to the following draft finding PSS recognizes the importance of Planetary Cartography and Geological Mapping as an integral part of planetary science. We find that the Cartography program at USGS would benefit greatly from additional long-term monitoring and planning activities by the planetary science community. Such an activity would recognize cross-disciplinary nature of the cartography program and its

importance and value to planetary science. This activity should be carried out by an Analysis Group, with membership from the:

- USGS Cartography program, Planetary Cartography, and Geologic Mapping Working Group (PCGMWG – a review panel that meets annually to review the USGS cartography program), Geologic Mapping Subcommittee of the PCGMWG, and
 - Members of the national science community who are engaged in cartographic research and development using planetary science data. The interdisciplinary CRAG (Cartography Research & Analysis Group) should meet several times annually and should report regularly to the PSS, as do the other PSD AGs.
5. PSS perspective on the Asteroid Redirect Mission: PSS agrees with and supports the PSD's position that the ARM is not a science mission, and the SBAG finding that states: *“The portion of the ARM concept that involves a robotic mission to capture and redirect an asteroid sample to cis-lunar space is not designed as an asteroid science mission and its benefits for advancing the knowledge of asteroids and furthering planetary defense strategies are limited and not compelling.”*
- PSS also recognizes that it is PSD's task to find and characterize appropriate target NEOs, and we find that the NEOO program is making good progress in this effort. Our appropriate subgroups (SBAG and CAPTEM) stand ready to provide additional findings, as needed to inform mission design.
6. PSS concerns regarding the urgent need for a space-based telescope for an NEO survey, recognizing that this is an Agency matter that is bigger than PSD. (Chabot)
7. PSS grateful acknowledgment that the Dawn @ Ceres Guest Investigator Program has been amended into ROSES 2014, and expression of support for a Hayabusa-2 PSP. (Chabot)
8. PSS concern about new mission starts/needs in Discovery, NF, Europa, including collaborations with foreign countries on new missions. (Hansen-Koharcheck, Glaze)

Dr. Luhmann asked that the Subcommittee members write their pieces and send them to the entire group. Dr. Chabot would edit and collate them.

(Note: The final PSS Findings for this meeting are posted on the PSS website and appended in the following section.)

The next meeting date was still being confirmed, though the week of November 17, 2014, looked promising. Proposed agenda items included the following:

- Update on PDS (Knopf/New)
- Update on Planetary R&A restructuring
- Lessons learned from the LRO mission (ESMD/SMD partnering) – (Vondrak)
- JSC Reorganization update
- Invite directors or leadership of the Institutes
- Invite representatives from HEOMD and STMD

Adjourn

The meeting was adjourned at 5:13 p.m.

Findings from the Planetary Science Subcommittee Meeting of September 3-4, 2014

Finding: Asteroid Redirect Mission Assistance from PSD

Although the PSS agrees with the PSD's position that the Asteroid Redirect Mission (ARM) is not a science mission, it also recognizes that it is PSD's task to find and characterize appropriate target NEOs. While the NEOO program is making substantial progress in this effort, the PSS calls attention to the SBAG finding about ARM, which states:

"The portion of the ARM concept that involves a robotic mission to capture and redirect an asteroid sample to cis-lunar space is not designed as an asteroid science mission and its benefits for advancing the knowledge of asteroids and furthering planetary defense strategies are limited and not compelling. Limits in the current knowledge and large uncertainties in the properties of near-Earth asteroids contribute significantly to schedule and cost risk, and to the risk of mission failure....Current surveys, observing programs, and other projects are not positioned to sufficiently bridge this knowledge gap within the allotted schedule."

The SBAG ARM Special Action Team report

(http://www.lpi.usra.edu/sbag/documents/SBAG_ARM_SAT_Full_Report.pdf) provides detailed scientific and technical information about the current knowledge of properties of near-Earth asteroids, the limits of that knowledge, and the significant associated uncertainties. Relevant PSD assessment/analysis groups, SBAG and CAPTEM, stand ready to provide additional inputs to inform ARM mission planning. ***The PSS finds that further advantage can and should be taken of communication and knowledge transfer between the HEOMD and SMD at this critical time, using these PSD resources.***

Finding: Need for a Near-Earth Object Space-Based Survey

An advanced space-based survey optimized for finding and characterizing near-Earth objects (NEOs) would serve multiple Agency goals, consistent with NASA's Asteroid Grand Challenge. As stated in the 2011 Target NEO workshop report

(<http://targetneo.jhuapl.edu/archives/2011files/TargetNEOWorkshopReport.pdf>), such a survey would *"inform planning for a human mission to a NEO and assist the Agency in meeting other important goals for Human Space Flight, science, in situ resource utilization, and planetary defense communities at large... Such an asset can be a benefit to SMD, ESMD, and SOMD interests, and is the next step to provide a robust and sustainable exploration program."*

Such a mission is consistent with PSS's own assessment based in part on reports from the cognizant PSD assessment/analysis groups and community inputs. In particular, ***the PSS finds that the elevation of an NEO Space-Based Survey Mission to the level of an Agency priority, and the pursuit of its new start, are essential for the broadly needed advancement of NEO knowledge.***

Finding: Planetary Mission Senior Review Assessment

The process of the Senior Review allows PSD to objectively evaluate their portfolio. The PSS commends the Planetary Mission Senior Review Panel, program officers, project leaders, and members for contributing to the Senior Review Process. The involved missions as a whole were uniformly regarded as uniquely valuable assets for continuing to carry out high priority scientific investigations, often by altering operations and /or by focusing on new themes. We particularly applaud the Review Panel for their efforts to help identify further opportunities and to steer the goals of some of the extended missions to maximize science return. These Senior Review results again emphasize the importance of extended missions in achieving PSD science goals, while balancing the additional science to be harvested from them with new mission

opportunities. The need to take full, considered advantage of existing missions as resources and national investments, as part of the overall PSD mission strategy, cannot be overstated. ***PSS finds the recent Senior Review exemplary in demonstrating the associated decision making process.***

Finding: Status of the PSD Research and Analysis Program Reorganization

The PSD Research and Analysis Program is critically important to PSD goals. Given its importance and the recent reorganization, PSS finds that regular updates of the status of the PSD R&A Program are needed, both to the PSS and to the community at large. In particular, outcomes from the large Solar System Workings program will be important to report and evaluate. Reports from PSD assessment/analysis groups listed community concerns about ensuring that strategic balance is maintained within the programs. While these concerns remain, the PSS acknowledges the efforts of PSD program managers and all those involved in implementing the startup of the reorganized R&A Program proposal submission and review process. A special note of appreciation is warranted for the initiative taken to obtain panel reviewer reactions to the new process and quantitative information on proposal statistics for comparison to the prior system. From the survey it is apparent that for the first program elements through the new process, the panel experience has been similar to previous years and generally positive. ***The PSS finds additional efforts to track and report on the progress of the reorganized R&A Program are both desirable and necessary for informing both PSD and the community.***

Finding: Need for a Senior Review of PSD-Supported Facilities

Many of the projects supported within the PSD use facilities supported by the division as part of either research or technical development. These facilities are listed in ROSES 2014, Appendix C1, Planetary Science Research Program Overview, and include (but are not limited to): Regional Planetary Image Facilities, NASA Ames Vertical Gun Range, Planetary Aeolian Facility, NASA Venus In situ Chamber, and Reflectance Experiment Laboratory. As both the facilities and the need for their services evolve with time, it is necessary to periodically evaluate their physical status, operations, uses, and plans. ***The PSS finds that a Senior Review of PSD-supported facilities is needed at this time to assess the return on PSD investments and to ensure they are receiving the support needed to maintain critical capabilities.*** PSS also encourages PSD to begin collecting information on funding, personnel, and usage of facilities toward enabling this Senior Review, and to make the schedule for the completion of the review available.

Finding: Planetary Cartography and Geological Mapping Representation on PSS

The PSS recognizes the importance of planetary cartography and geological mapping as an integral part of planetary science. We find that the Cartography program at USGS would benefit greatly from additional long-term monitoring and planning activities by the planetary science community. Such an activity would recognize the cross-disciplinary nature of the cartography program and its importance and value to planetary science. ***The PSS finds that establishment of a dedicated Analysis Group is needed, with membership from the USGS Cartography program, the Planetary Cartography and Geologic Mapping Working Group (PCGMWG – a review panel that meets annually to review the USGS cartography program), the Geologic Mapping Subcommittee of the PCGMWG, and the science community engaged in cartographic research and development using planetary science data. This interdisciplinary***

CRAG (Cartography Research & Analysis Group) should meet several times annually and should report regularly to the PSS, as do the other PSD AGs.

Finding: Paths to New PSD Missions

Continued forward motion on missions on all possible fronts is essential to the health and survival of planetary science within NASA. The PSS commends NASA and PSD for the significant progress made on future planetary missions. In particular, the recent PEA for Europa Instrument Investigations, has provided needed progress toward fulfilling that Decadal Survey mission priority. The PSS also commends PSD for the release of the Discovery Draft Announcement of Opportunity (AO) with the current schedule of release for the final AO in late September or early October 2014. The lack of a target date for the next New Frontiers opportunity is a concern, though the PSS recognizes the agency directives and the funding challenges PSD has faced for the past few years. As an additional strategic mission option, the PSS encourages the use of international partnerships as an excellent, proven way of amplifying the scope and science results of a mission otherwise implemented by an individual space agency. For example, the combination of an ESA M-class mission with a New Frontiers level contribution from NASA would give ESA and NASA the equivalent of a small flagship.

Regarding next steps, the PSS finds that the PSD must soon settle on a Europa mission architecture that meets the preponderance of the Vision and Voyages goals and push forward with a plan to get the mission to the launchpad. In the case of Discovery- following the current competition, the PSS finds it is important to maintain a more regular cadence of opportunities in line with the original plan for these missions and Decadal Survey priorities. As for New Frontiers missions- the selection of two missions for flight within the decade 2013-2022 was recommended by Vision and Voyages. As such, we find PSD needs to initiate the next opportunity for this essential program as soon as is practical. In addition, ESA is in the process of defining M-class missions. PSD should quickly define the level of partnership NASA is willing to consider and move aggressively to take advantage of opportunities these may provide in fulfilling Decadal Survey goals.

Finding: Need for Participating Scientist and Guest Investigator Programs

The PSS recognizes and appreciates the PSD positive response to our previous meeting Finding regarding the need for a Dawn at Ceres Guest Investigator (GI) Program in ROSES 2014, which has now been realized. Both GI and Participating Scientist (PS) opportunities maximize the science return from planetary missions and provide valuable opportunities for increased involvement in planetary missions. ***PSS finds the planned establishment of GI and/or PS programs for other upcoming missions and mission special phases, such as Hayabusa-2, both strategically-targeted and scientifically advantageous uses of PSD science resources.***

Appendix A Attendees

Subcommittee members

Janet Luhmann, University of California, Berkeley, *Chair, Planetary Science Subcommittee*
Jonathan Rall, NASA, *Executive Secretary*
Nancy Chabot, The Johns Hopkins University
Nancy Chanover, New Mexico State University
David S. Draper, Johnson Space Center
Lisa Gaddis, U.S. Geological Survey
Lori Glaze, Goddard Space Flight Center
Candice Hansen-Koharcheck, Planetary Science Institute
Mihalyi Horanyi, University of Colorado
Christopher House, Penn State
Amanda Mainzer, JPL
Harry McSween, University of Tennessee
Clive Robert Neal, University of Notre Dame
Larry Nittler, Carnegie Institute
Anne Verbiscer, University of Virginia

CAPS Attendees (via videoconference)

Phillip Christensen, Arizona State University, *Co-Chair*
J. Gregory Ferry, Pennsylvania State University, *Co-Chair*
David H. Smith, The National Academies, *Study Director*
Michael Moloney, The National Academies, *Board Director*
Andrea Rebolz, The National Academies, *Program Coordinator*
Sushil Atreya, University of Michigan
Amy Barr, Brown University
Richard Binzel, MIT
Ronald Breaker, Yale University
John Clarke, Boston University
Geoffrey Collins, Wheaton College
Pascale Ehrenfreund, George Washington University
Linda Elkins-Tanton, Carnegie Institute
James Kasting, Pennsylvania State University
Laurie Leshin, Worcester Polytechnic Institute
Stephen Mackwell, Lunar and Planetary Institute
Norman Pace, University of Colorado, Boulder
Gary Ruvkun, Harvard University
Mark Saunders, NASA, Retired
Gerald Schubert, UCLA
Normal Sleep, Stanford University
Cristina Kakacs-Vesbach, University of New Mexico
Roger Yelle, University of Arizona

NASA attendees

James Green, NASA HQ, *Director, Planetary Science Division* (via videoconference)
Michael Amato, NASA
Max Bernstein, NASA
Doris Daou, NASA HQ
Kelly Fast, NASA
Jeff Grossman, NASA HQ
Jeffrey Hayes, NASA HQ
Jennifer Kearns, NASA HQ
John Keller, NASA GSFC
William Knopf, NASA HQ
Jared Leisner, NASA HQ
Michael Meyer, NASA HQ
Michael New, NASA HQ
Sarah Noble, NASA
Christina Richey, NASA HQ
Mitch Schulte, NASA HQ
David Schurr, NASA
George Tahu, NASA
Elsayed Talaat, NASA
Mary Voytek, NASA
Richard Zurek, NASA JPL

Non-NASA attendees

Linda Billings
Lamont DiBiasi, Southwest Research Institute
Eric Hand, Science
James Lochner, USRA
Richard Polidan, NGAS
Amy Reiser, Zantech
Larry Richardson, ULA
Tom Statler, University of Maryland
Elizabeth Sheley, Zantech

WebEx participants

Paul Abell
Gale Allen
Brent Archinal, U.S. Geological Survey
Louis Barbier
Darrell Branscome
Laura Broccoli
Ben Bussey
Jason Callahan
Julie Castillo
Richard-Duane Chambers
Kenneth Chang
Stephen Clark
Ryan Clegg

Jeff Collins
Dom Conti
Kate Craft
Katie Daud
Dwayne Day
James Dean
Brett Denevi, Johns Hopkins Physics Lab
Cynthia Dinwiddie, Southwest Research Institute
Estelle Dodson
Casey Dreier
Pascale Ehrenfreund
Carolyn Ernst
Caleb Fassett
Julie Fletcher
Jeff Foust, The Space Review
Victoria Friedensen
Marc Fries
James Gaier
Michael Gaunce
Daniel Glavin
Tim Glotch
Edward Goolish
Cesare Grava
Craig Hair
Jasper Halekas
M. Hedman
David Hinson
Jeffrey Hollingsworth
Andrea Holz
Briony Horgan
Dana Hurley
Doug Isbell
Jeffrey Johnson
Gordon Johnston
Van Kane
Michael Kelley
Melissa Kirven-Brooks
Kurt Klaus
Rachel Klima, NASA APL
Miriam Kramer
David Ladler
Rob Landis
Samuel Lawrence
Greg Lee
Jared Leisner
Dan Leone
Allan Li
James Lochner

Bill Mackey
Paul Mahaffey
Earl Maize
Jonathan Malay
Emily Martin
Tim McCoy
Stephanie Milam
Chase Million
Michele Minnitti
Curt Neibur
Bob Pappalardo
Wes Patterson
Yvonne Pendleton
Trent Perrotto
Noah Petro
Karl Pilcher
Jeff Plescia
Lisa Pratt
Betsy Pugel
Connor Radnovich
Julie Rathbun, PSI
Kurt Retherford
Christina Richey
James Roberts
Allison Rose-Sonnesyn, House Science Committee
John Rummel, East Carolina University
Nick Saab
Rita Sambruna
Daniela Scalice
Margaret Simon
Gerald Smith
Marcia Smith, spacepolicyonline.com
Eileen Stansbery
Paul Steffes
Richard Stelling
Melissa Stickle
Mike Skrutskie
Jessica Sunshine
Micheline Tabache
D. Vergano
Richard Vondrak
Mike Wall
Matt Wallace
Hal Weaver
Pamela Whitney
Alexandra Witze

Appendix B
Membership Roster

Janet Luhmann, Chair
Space Sciences Laboratory
University of California, Berkeley

Jonathan A. R. Rall, Executive Secretary
Planetary Science Division
Science Mission Directorate
NASA

Nancy Chabot
Applied Physics Laboratory
The Johns Hopkins University

Nancy Chanover
Astronomy Department
New Mexico State University

David S. Draper
Astromaterials Research and Exploration Science Directorate
NASA Johnson Space Center

Lisa Gaddis
Astrogeology Science Center
U.S. Geological Survey

Lori Glaze
Goddard Space Flight Center

Candice Hansen-Koharcheck
Planetary Science Institute

Mihalyi Horanyi
Laboratory for Atmospheric and Space Physics
and Department of Physics
University of Colorado

Christopher House
Department of Geosciences
Penn State

Amanda Mainzer
Jet Propulsion Laboratory

Harry McSween
Department of Earth and Planetary Sciences
University of Tennessee

Clive Robert Neal
University of Notre Dame

Larry Nittler
Carnegie Institution of Washington

Anne Verbiscer
University of Virginia

Appendix C Presentations

1. *Results of the 2014 Planetary Mission Senior Review (PMSR)*, William Knopf
2. *Planetary Science R&A Process and Status*, Jonathan A. R. Rall
3. *Planetary Science Division Status Report*, James Green
4. *Mars Program Update*, James Green
5. *Mars 2020 Project Update*, George Tahu, Mitch Schulte
6. *Outer Planets Program Status*, Curt Neibur
7. *CAPTEM Report to the Planetary Science Subcommittee*, Harry McSween
8. *NAI Briefing to the PSS*, Mary Voytek
9. *LEAG Report*, Clive Neal
10. *Finding Near Earth Objects: In the Context of an Agency Grand Challenge*, Lindley Johnson
11. *MEPAG Report to PSS / CAPS*, Lisa Pratt
12. *Outer Solar System Exploration*, Candice Hansen-Koharcheck
13. *SBAG*, Nancy Chabot
14. *VEXAG Update*, Lori Glaze
15. *SSERVI: A Virtual Institute*, Yvonne Pendleton
16. *JSC Reorganization*, Eileen Stansbery

Appendix D
Agenda

Planetary Science Subcommittee Meeting
September 3 and 4, 2014
NASA Headquarters
Washington D.C.

Wednesday, September 3, 8:30 a.m. – 5:00 p.m. (8Q40)

- 8:30 Welcome, Agenda, Announcements (Luhmann, Green, Rall)
- 8:45 Introductions (ALL)
- 9:00 Ethics Training (Spear)
- 10:00 PSD Senior Review Update..... (Knopf)
- 10:30 Break
- 10:45 PSD R&A Update (Rall)
- 11:45 PSD Status Update (Green)
- 1:00 (Working Lunch) Break
- 1:15 Mars Exploration Program Update (Green)
- 2:00 Mars 2020 Status Report (Tahu/Schulte)
- 2:45 Outer Planets Program Updated..... (Niebur)
- 3:30 Break
- 3:45 GPRA-MA Review + Discussions Session with the Committee (All)
- 5:00 Adjourn

Thursday, September 4, 8:30 a.m. - 5:00 p.m. (8Q40)

- 8:30 Agenda Updates & Announcements (Luhmann, Rall)
- 9:00 CAPTEM Discussion..... (McSween & All)
- 9:30 NAI (Voytek)
- 10:15 Break
- 10:30 GPRA-MA (All)
- 11:00 LEAG Discussion..... (Neal & All)
- 11:30 NEOO Update (Johnson)
- 12:00 Lunch (On own)

1:00	MEPAG Discussion	(Pratt & All)
1:30	OPAG Discussion	(Hansen & All)
2:00	SBAG Discussion	(Chabot & All)
2:30	VEXAG Discussion	(Glaze & All)
3:00	SSERVI	(Pendleton)
3:45	Break	
4:00	JSC Organizational Update	(Stansbery)
4:15	Q&A Session with the Committee	(All)
4:30	Findings	(All)
5:00	Adjourn	(All)

Appendix E

GPRAMA Objectives and Candidate Topics

PS-14-4: Demonstrate planned progress in exploring and observing the objects in the solar system to understand how they formed and evolve.

- NASA's Comet ISON Observing Campaign enabled new knowledge of a sun-grazing comet's properties and evolution through wide-ranging scientific measurements.
- Herschel Space Telescope Detects Water Vapor on Dwarf Planet Ceres.
- The timing of collisions in the main asteroid belt can now be measured with much greater precision using new measurements of asteroid sizes, reflectivities, and colors.
- Using a combination of newly measured sizes, reflectivities, and colors, the main asteroid belt has been shown to be much more compositionally diverse than previously thought, requiring violent mixing in the early Solar System.
- Ni isotopes constrain formation time of Mars.
- Accurate knowledge of Enceladus' heat flow provides a fundamental understanding on the likelihood of a subsurface ocean.
- New models of convection in Enceladus' ice shell provide a natural explanation for how the moon's heat flow localizes near the south pole.
- Cassini discovers a new molecule in Titan's upper atmosphere.
- Cassini finds Titan's smog begins with chemical reactions high in the atmosphere.
- Spring Rain on Saturn's Moon Titan.
- Water Vapor Plumes on Europa.
- Understanding the Plasma Field Around Jupiter by Looking at Auroras from its Moons.
- Io's Atmosphere Expands and Contracts,
- LADEE finds lunar "dust cloud".
- LRO Camera Identifies Recent Craters.
- Lunar interior properties from the GRAIL mission.
- Global assessment of pure crystalline plagioclase across the Moon and implications for the evolution of the primary crust.
- A young solidification age for the lunar magma ocean.
- Sulfuric Acid Rain In The Upper Haze Of Venus.
- Dwarf Planet Discovered with the Most Distant Known Orbit.

PS-14-1: Demonstrate planned progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact and evolve.

- Planetary building blocks incorporated water from chondrite impacts
- Igneous rock on Mars signals a different crustal composition
- MESSENGER observations reveal that Mercury has shrunk much more than previously believed
- Long-term acceleration observed in Venus Cloud top winds
- Evidence of Mantle Material in Martian Craters
- LADEE characterized the Lunar exosphere

PS-14-5: Demonstrate planned progress in exploring and finding locations where life could have existed or could exist today.

- NASA Space Assets Detect Ocean Inside Saturn Moon
- Paleoclimate Modeling on Mars Begins
- Bound Hydroxide Confirmed on Phobos & Deimos
- Signals for Early Atmospheric Escape from D/H ratios in Mudstones from Gale Crater
- Finding Glycine may be an indicator of past life
- Opportunity Identifies the Oldest Habitable Environment on Mars
- Curiosity Investigates Details About Water in Mars Soil

PS-14-8: Demonstrate planned progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.

- Evidence of Crusty Impacts on Early Earth
- Early Life Had Limited Raw Materials At Its Disposal
- Dining on Methane in the Cold, Dark Sea

PS-14-12: Demonstrate planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.

- NASA – Near-Earth Object Survey
- Spitzer Used to Characterize a Small Asteroid for the Asteroid Redirect Mission
- Radar Imagery of Near-Earth Asteroid (NEA) 2014 HQ124