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Meenakshi Wadhwa, Chair

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Elaine Denning, Executive Secretary

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Opening Remarks/Introduction of Members

Ms. Elaine Denning, Executive Secretary of the NASA Advisory Council (NAC) Science Committee (SC), opened the meeting and made administrative announcements. She introduced Dr. Meenakshi Wadhwa, Chair of the Science Committee, who brought the meeting to order. Members and meeting attendees introduced themselves around the room.

NASA Science Overview

Dr. Thomas Zurbuchen, Associate Administrator (AA) of the Science Mission Directorate (SMD), presented an overview of division activities, focused mostly on new developments that had occurred since the October teleconference: a recently announced Near Earth Objects (NEOs) mission; issues that relate to international collaborations; an update on CubeSats and SmallSats, which have proven useful for science; and education, training, and innovation.

SMD is very enthusiastic to be going forward to the Moon in 2021, where there is much new knowledge to be gained from upcoming missions including NOVA-C, Peregrine One, and the Volatiles Investigating Polar Exploration Rover (VIPER). Science highlights include the recent shipment of Solar Orbiter (SO) to the Kennedy Space Center (KSC), on schedule for launch in February 2020. Dr. Zurbuchen congratulated the European Space Agency (ESA) for finishing the vehicle on time, and also thanked Dr. Nicky Fox, Director of the Heliophysics Division (HPD). SO will launch on a United Launch Alliance (ULA) Atlas V. Dr. Zurbuchen noted that he had been on the Science and Technology Definition Team (STDT) for the mission, and while at the University of Michigan had proposed one of the instruments that was subsequently developed by the university. Dr. Zurbuchen said that SO has breakthrough potential in three areas. Although it will not fly as closely to the Sun as the Parker Solar Probe (PSP), it will orbit in the region of the inner planets with the best in-situ instruments ever flown in space. SO will use an ion electric propulsion engine that will enable a Venus fly-by. Also, SO will be able to see the constraints of the magnetic dynamo as it re-emerges from the polar regions of the Sun. The in-situ science makes for a unique mission, in complement with PSP and the Daniel K. Inouye Solar Telescope (DKIST), a ground-based component operated by the National Science Foundation (NSF). Together these missions and instruments will open a new era of transformative research of the most important star, said Dr. Zurbuchen. SO is set to launch on the same pad as a planned launch of the Boeing Commercial Crew vehicle, which creates a potential conflict if the Boeing mission is delayed; thus we are engaging in communication at all levels to clear the path to launch.

The ICESat-2 (Ice, Cloud, and land Elevation Satellite-2) satellite has been delivering science data on polar ice elevation that is unprecedented in accuracy, and has provided complementarity with the Operation IceBridge data sets. Operation IceBridge was conceived as an airborne mission to bridge the period between the launches of ICESat-1 and ICESat-2, and took off on October 18 from Tazmania for its final flight. The mission now is being phased out, but has contributed some overlapping data sets, demonstrating a successful and innovative way of connecting airborne and space missions.

The Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission to Mars has been in the news, Dr. Zurbuchen said, and is an example of what he calls "learning through science." The self-hammering heat probe, or mole, has backed about halfway out of the hole and will not go all the way down. The mole has encountered issues of unexpected soil consistency and compactness. The team has been incredibly innovative in trying many ways to overcome the issue and is committed to making the instrument successful, but it has been a setback.

The Transiting Exoplanet Survey Satellite (TESS) has imaged a mosaic of the southern sky during its first year of science operations completed in July 2019, during which time it has discovered 29 new exoplanets

and over 1,000 candidates. Through a survey of 13 sectors of the night sky, TESS already has captured 130,000 images and acquired 20 terabytes of Southern sky data. Dr. Zurbuchen congratulated the TESS mission team on its progress thus far.

The James Webb Space Telescope (JWST) cleared its critical sunshield deployment testing on October 21. Dr. Zurbuchen invited SC members to view the telescope if they were to travel to the West Coast in the near future. JWST is undergoing more testing to close out approximately a dozen issues that are being worked, not unusual for this time period prior to launch. The Mars 2020 rover, by comparison, has about five issues, but it is considerably closer to launch. Out of the 12 issues, only one would have led to some reduction on science return were it not resolved. Dr. Zurbuchen reported being nervous every day over the progression of this very complex mission, but had been heartened by observing the team deliberately moving forward and cohesively. The main worry is schedule; March 2021 is the current target for launch that is being assessed at an Agency level for fidelity. Dr. Vinton Cerf expressed concern that JWST testing was limited to a 1-G gravitational field, when it was to operate in a zero gravity environment. Dr. Zurbuchen acknowledged the fact, and explained that the mission was inferring some tests through models, and some through more direct means such as using weights to off-load certain components to simulate loads in zero gravity. He acknowledged that we *should* be nervous given what is at stake. Dr. Thomas Herring asked about the potential for damage to the sunshield materials if JWST stays on Earth longer than anticipated. Dr. Zurbuchen said that testing has obviated this concern.

Dr. Zurbuchen noted that NASA would announce more task orders later that afternoon for the Commercial Lunar Payload Service (CLPS) program. Some of these new tasks will be for heavier payloads such as the lunar rover, VIPER. NASA will be paying for the services rather than the landers, and the companies could have other customers go to the surface of the Moon alongside NASA. Newly selected companies will join the nine that were selected in 2018.

The new infrared Near Earth Object Surveillance Mission (NEOSM) is in planning to meet a Congressional directive to find 90% of NEOs of sizes down to 140m. The mission will proceed should funding be made available through the appropriations process. Congress has asked NASA to continue with a NEOSM mission study that will benefit from previous Extended Phase A study on NEOCam, which passed its systems requirements review (SRR)/mission definition review (MDR) in February 2018. If included in future Presidential Budget Requests (PBRs,) the mission concept is designed to be consistent with NASA's Planetary Defense strategy and to be handled in a similar way as a space weather mission. The cost of NEOSM is expected to be in the $500-600M range with a launch readiness date no earlier than 2025. Uncertainties with Congress and budget remain, but all stakeholders are working to align strategy. Dr. Zurbuchen's sense was that support for NEO surveillance had continually rematerialized on the Hill, based on observations from the last several years. The only questions regarding funding relate to what level and when. Dr. Feryal Ozel asked how difficult it would be to modify NEOSM for orbital debris monitoring. Dr. Paul Hertz, Director of the Astrophysics Division (APD), noted that Earth would not be in NEOSM's field of view, and therefore not suitable to the purpose. Dr. Cerf asked if there were other space agencies interested in supporting the mission, as NEOs are a planet-wide concern. Dr. Zurbuchen said there was some interest in ESA, and he was trying to determine how this could materialize. There is an ESA ministerial meeting later this month, thus, NASA would have to determine timing and role distribution before a discussion could take place. Dr. Cerf said he understood that a second European space agency was being proposed in the event that Brexit happens. Dr. Zurbuchen noted that ESA predates the European Union by many years, and said he had been assured by ESA colleagues that disruptions would be minimal. Dr. Pat Patterson asked why the 140m size was of such significance. Dr. Zurbuchen said that studies of NEO size vs. the damage they inflict created the bounding case; the size relates to the energy emitted by an impact. Dr. Michael New noted that a 1km NEO impact would be globally catastrophic, while a 140m-object would cause more localized/regional damage. The 2013

Chelyabinsk object, by comparison, was thought to be about 20m in size. Dr. Zurbuchen concluded that there is a good rationale for why the 140m threshold became law.

SMD continues to pursue international collaborations based on established principles, and had a productive experience at the International Astronautical Congress (IAC) in October 2019. International agreements have been protected often at the expense of other things. Principles of international cooperation include the peaceful use of space and the continuous effort to keep data open and deliver it to the public. While it is hard work for data centers, making data open and available to the public is what leads to the best science. While NASA has not fully implemented fully open models, it is working hard to do this, as has been recommended by the National Academies. Physics-based models increasingly are part of NASA's analysis of its science. The Agency is interested in sharing these models and also is striving to be responsive to Academy recommendations in a timely manner. Dr. Zurbuchen noted that SMD is exploring and developing an increasing set of international collaborations. He had just finished a visit to Israel, where he held discussions with Isreal about lunar and astrophysics collaborations; he also visited the United Arab Emirates (UAE), where he had similar discussions. NASA is working past politics and transcending differences. The NASA/Russia collaboration in space continues to go well.

The Council on Space Research (COSPAR) has made a series of recommendations for SmallSats, underscoring new ways to provide opportunities in space and assist international players in working together to create long-term roadmaps. Dr. Herring noted that there seemed to be a lot of new players in low-Earth orbit and beyond, and wondered if there was an issue of them being unaware of appropriate protocols. Dr. Zurbuchen said he believed NASA's value system should serve as an example in space and his sense was that concerns about orbital debris, for instance, are shared. This is the reason NASA talks to new agencies, so that all participants can adopt common standards going forward. Dr. Ozel asked if new mission-class requirements from COSPAR would trickle down to every participant in space. Dr. Zurbuchen said that many of the COSPAR recommendations are actions NASA already has implemented, but he noted that not all policy changes work. For instance, NASA took steps to reduce the reporting burden on Class D missions, but the vast majority of missions have not eased their own burden and seem to be sticking to the accustomed bureaucratic load. Dr. Zurbuchen thought NASA needed to have more discussions openly, because agency culture makes it difficult to dial back the bureaucracy. He was puzzled as to why this has been so difficult, and thought change could require stronger interventions. Dr. Cerf raised a concern about tracking the large number of satellites being launched into low-Earth orbit (LEO). Dr. Zurbuchen said he also was worried about LEO remaining a valuable place to do science, but that another launch approval agency tracks these launches. His sense was that for the present, the more significant issue was in ground-based astrophysics radiofrequency missions, but for the moment he did not have urgent worries and still supported commercial movement into space. He noted that COSPAR is planning to hold capacity-building workshops, which SMD intends to support with participating U.S. scientists and engineers.

CubeSat and SmallSat initiatives are progressing. A student project, HyperAngular Rainbow Polarimeter (HARP), was launched from Wallops on November 1. HARP is an Earth-observing spectroscopy-based instrument that was first pioneered as part of an airborne platform. The instrument will look at ocean color and aerosols. NASA also has entered a CubeSat partnership with Brazil named the Scintillation Prediction Observations Research Task (SPORT) to better understand what drives nighttime bubbles in the ionosphere. Final data is coming in from NASA's commercial data pilot study, in which NASA is buying data from commercial SmallSat data constellations with the goal of learning how to purchase data and combine it with NASA data for science purposes. Companies included in the effort are Planet, Digital Globe, and Spire Corporation and NASA expects to talk to more companies about participating. The incoming data strengthen U.S. space leadership and align NASA's interests with that of the commercial sector. The goal is to make these data openly available, as well. Commercially, data value decays rapidly; for science, not so much. NASA is trying to figure out what the right pricing and data policies should be

in order to get these data into the public domain, for example, at what cost and under what data principles. NASA is trying to learn about the value of these data, as the price will need to be negotiated with provider companies. This December, the American Geophysical Union (AGU) Fall Meeting is fielding over 60 submissions on planetary data alone. These data are leading to new science, and the continued interest assures NASA that it is moving in the right direction. Dr. Zurbuchen credited the Earth Science Division's (ESD's) former Director, Dr. Michael Freilich, for starting this satellite data buy initiative, and felt that over time, SMD should get to a place where it can support the use of commercial data for research. It is important, however, that SMD does not get to a place where it is outright owning the commercial data companies, because if these are not independently viable then this is back to the old contract model. Right now, the focus is on data that already exists or is being produced, but it is clear that these data are evolving and that NASA can take advantage of this evolution going forward.

Dr. Wadhwa asked if Dr. Zurbuchen had any thoughts about, or conversations with, the incoming Human Exploration and Operations Mission Directorate (HEOMD) AA, Mr. Douglas Loverro, with regard to the Moon. Dr. Zurbuchen said he had taken an active role in the search for the new AA, and reported having spent much time with Mr. Loverro and could not be more excited to be working with him. He looked forward to building a productive relationship and thought Mr. Loverro would be able to provide a briefing at the next SC meeting. Dr. Wadhwa asked if there were any new developments on the Mars 2020 rover. Dr. Zurbuchen said nothing had changed since the last meeting and that Mars 2020 is still on track for a July 2020 launch. He said that the thermal vacuum testing of the rover was complete, and that next up "dirty" testing of the sample handling system would be carried out. The issue list is not zero, but he said that the mission is moving forward very well. The most important priority is mission success, with the second most important being making the launch window, and after that making NASA's cost commitments. Dr. Hoffman asked if there were any plans to move forward on in-space assembly of telescopes. Dr. Zurbuchen agreed that telescopes larger than JWST would have to be built differently, including being able to service these in space and extend their lifetimes. He said that he was very interested in exploring new ways to do this, including through the next astrophysics decadal survey, calling it one of the potential game changer technologies. Dr. Anne Verbiscer asked a follow-up question on NEO surveillance, if any details were known on how the NEOCam science team would be incorporated into NEOSM. Dr. Zurbuchen said that the issue is being addressed at the Planetary Science Division (PSD) level.

Goals of the Meeting

Dr. Wadhwa reviewed the goals of the meeting.

Research and Analysis Innovations

Dr. Michael New, Deputy Associate Administrator (DAA) for Research, reported on his recent activities on behalf of Research and Analysis (R&A). New metrics have been collected on some of the latest division solicitations. Selection rates are holding between 25-30%, and half of proposals have their status announced within 150 days; in addition, it has been found that between 1/3 and 2/3 of selected Principal Investigators (PIs) are new to the solicitation for which they have been selected (new meaning not selected in the last 5 years). PSD has the lowest selection rate of 21%. The fraction of selectees who are new by division is increasing; turnover is much better than expected. In time from submission to selection, the Astrophysics Division (APD) is doing best. The speed is definitely driven by the number of Guest Observer (GO) proposals in APD, which are generally rapid. Mr. Marc Weiser asked if research had been done to understand how new PIs might have an overall effect on future proposals. Dr. New said he didn't know the significance of this change yet. Some changes do reflect the arrival of new programs, and some reflect the influx of new people. There doesn't appear to be a correlation of time-to-announce with due dates, but it does look like it could be useful to spread R&A due dates out over the calendar year. The current Continuing Resolution (CR) also has had an effect on this distribution of funds. Dr. Herring asked if the CR had been interfering with time to announcements. Dr. New said the correlation

was weak, and that time to announcement seemed to be more a function of overloading program managers with work.

Two pilot studies will be conducted for the next ROSES announcement in February 2020. SMD will be piloting a dual anonymous peer review process, and a new process for selecting high-risk, high-impact (HRHI) proposals. In the dual anonymous review, the information about the identity of proposers and their institutions is kept from the reviewers. Historically, the Space Telescope Science Institute (STScI) Hubble Space Telescope (HST) proposal success rate had been imbalanced by gender. In 2018, this imbalance disappeared thanks to the adoption of the dual anonymous review process. In this process, the panel review is split into two parts. In the first part, the panel evaluates the merit of proposals without knowing the proposer names or institutions. Second, after all the proposals were graded, identities are revealed, and the panel is asked if the teams were qualified to perform the work. In all cases at STScI, the panels agreed the teams were qualified. The idea of the dual anonymous review is based in part on a well-known bias study that showed gender-neutral outcomes of anonymous first chair violin auditions. All APD GO programs will be adopting this approach for ROSES 2020. Dr. Wadhwa asked if any proposals had been deemed not qualified in this latest round. Dr. Hertz said it had been found that people who are able to write a cogent proposal are generally qualified.

ROSES 2020 will conduct a pilot on four ROSES elements using dual anonymous peer review. Dr. Wadhwa asked, in the cases where dual anonymous reviews are utilized, whether there still would be concerns regarding conflicts of interest (COI). Dr. New said that yes, the concern would remain as COI are more about an individual's financial interest rather than a personal bias toward a given project. Dr. Verbiscer asked if there were historical data for other SMD divisions. Dr. New said there was no exhaustive evidence that there has been a strong gender bias issue in NASA proposals, historically. The goal is not to make it impossible to discern the identities, but to make it difficult enough so that this does not distract the panel from assessing science merit. Dr. Cerf thought it would be valuable to do a post-hoc review on how selected proposals were executed. Dr. New confirmed that this would be part of the review. Dr. Hoffman asked if Dr. New had had any discussions with NSF, which typically asks for exhaustive information in its proposals. Dr. New said he had talked with NSF and was not sure they were interested in NASA's approach. Dr. Liemohn thought the four elements selected for the pilots were good. Dr. Ozel noted that there will be some instances wherein it will be very obvious who is proposing. Dr. New reiterated that the point is to remove the distraction, but he did recognize that some communities are very small.

To assess the acceptance of HRHI proposals, SMD asked reviewers in 2018 to identify proposals with significant intellectual or reputational risk. As an example of such research, Dr. New cited Stanley Prusiner's discovery that prions constituted a new route of infectious pathology for diseases such as kuru and Creutzfeldt-Jacob dementia; the prion concept took decades to become accepted. In the 2018 SMD exercise, reviewers identified approximately 10% of proposals that met this criteria, and it turned out that this subgroup actually was selected more often than non-HRHI proposals (34% vs. 24%, respectively). The belief persists, however, that NASA is hostile to such proposals, thus SMD will be adding two text boxes to NSPIRES cover pages that will include a short description of HRHI proposals. Ultimately, the SMD AA will have a chance to select a few. The real concern is how to flush out proposers who may have been hindered by the erroneous perception that HRHI proposals are not widely selected. Dr. Wadhwa noted that self-declaring also may introduce some unexpected consequences. Dr. Herring commented that the downside might be that HRHI proposals could drive the overall selection rate down, however, it is also possible that such acceptance rates will go above 34%. Dr. Liemohn liked the idea of an HRHI pilot, and thought NASA needed to carry out an informational campaign to get the message across of what HRHI really means (i.e., intellectual risk). Dr. New said that SMD was planning to hold town halls and other fora to socialize the concept. Dr. Cerf suggested collecting information on what fraction of proposals would have been funded had there been sufficient funding.

The first "PI Launchpad" workshop is being held this month (November 18-20) in Tucson, AZ in response to the outcome of a 2018 diversity workshop on identifying barriers to becoming a PI. Dr. Zurbuchen held a two-hour livestream event to address the results, which led to this first 2.5 day interactive workshop. Forty participants were selected, mostly on the basis of leadership qualities, and all costs were covered by a grant from the Heising-Simons Foundation. SMD is targeting Spring of next year for the next workshop. SMD is very excited about these workshops. Over half of the attendees were women, however, outreach to historically black colleges and universities (HBCUs) was not as successful as hoped. Dr. New said he planned to make of a more grassroots effort in the future, having learned that NASA has to get beyond the gateway institutions to explain its jargon (e.g., *Phase A* and *cost caps*). Dr. Wadhwa noted that there is usually a degree of institutional commitment that affects mission selection, and that typically HBCUs have not had the opportunity to create a history. Dr. New said future plans in this arena are to feed forward to a PI-incubator or accelerator model.

Discussion on Research and Analysis

Dr. Cerf complimented Dr. Zurbuchen on his candid and open style that he thought deserved commendation. Mr. Weiser commented that making programs more inclusive is difficult, but he thought the direction had been very positive, and congratulated Dr. New on his efforts. He was excited to see the outcome on all fronts, and thought that it deserved a finding. Dr. Michelle Larson noted that it was worth emphasizing that NASA and the science community needs to find more ways to reach out to persons of color, and thought it's still worth working with the community organizations and institutions to help figure out how to communicate with the population. Dr. New agreed with Dr. Larson, and said he was going to reach out to faculty and see what they would like NASA to do to help it succeed in reaching out. Dr. Ozel said of her experience reaching out to minority communities, on a smaller scale at the University of Arizona, that a one-time effort almost never works. There is a lot of self-censoring that prevents success, thus any outreach must be done multiple times through multiple means, and no fewer than five times. Dr. Wadhwa said that NASA also should not lose sight of the fact that even for named programs, the number of proposals from women is still lower than those from men. This is not necessarily NASA's problem, it's more of a community issue. Dr. New said that SMD is undertaking an effort to go to conferences to teach proposal writing, and returning often to encourage early career people. Dr. Wadhwa noted that those types of activities do matter.

Dr. Cerf noted that NSF has a program called INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science), aimed at underrepresented populations, which may be worthwhile to consult. NASA needs to figure out where to aim capacity-building challenges to make these proposals happen, and to look for places that might benefit from engagement. Can there be joint agency outreach? An obvious place to start might be the Office of Science and Technology Policy (OSTP) that might be able to organize a White House event in this area. Dr. New commented that the astrobiology graduate student research science conferences have been a good source for NASA leaders; and that NASA should encourage these soft skills. The astrobiology community used to do a proposal-writing practicum that often gave people horizontal networking opportunities. In a similar vein, the marine biology community hosts the Diversity Initiative for the Southern California Ocean (DISCO), which has provided opportunities for early career people as well. These are good ways to cast the net broadly. Dr. Patterson said he appreciated the push in SmallSats, particularly with respect to their value to research and education, technology demonstrations, mission demonstrations, and as precursors to larger programs; the effort seems a natural fit, and at the right time. Dr. Liemohn noted that grants administration support staff is also important for proposers, and that smaller universities may not have these offices. Online tutorials for administrative staff could be useful here, to increase capacity. Dr. Cerf noted that many nonprofits that are looking for grants often use companies created for this purpose; it might be good to investigate such resources for these smaller institutions.

Technology Update

Mr. Michael Seablom, Chief Technologist for the SMD, reported that he was following up on a new initiative to increase early-stage, start-up companies in the technology portfolio. The thinking is that the portfolio could benefit from more such companies, as they tend to be passionate about problem-solving and can bring fresh looks at old problems. Elon Musk has been quoted as saying that "Ford cannot produce a Tesla." Breaking the mold requires someone who is not enmeshed in standard bureaucracy. SMD is looking to carve out some funding for these companies, using as a model a U.S. Air Force (USAF) "Pitch Day." During a recent Pitch Day, the USAF offered participating companies a credit card with a $100K line of credit, and issued $22M in awards in one day. The goal at SMD is to do the same thing through a pilot event. A previous plan had been to bring together SMD program scientists and venture capitalists to listen to pitches, but without the funding. Dr. Zurbuchen took this further and now the plan is to do this at the National Academies building in late winter, with a focus on three areas – Earth observations, autonomy, and small space platforms – and with the funding in place for it. SMD is consulting with the USAF for this event. Mr. Weiser noted that on the autonomy side, a shift toward alternate applications is occurring, which is good timing for NASA.

Lunch Presentation: *Study of a Near-Term Interstellar Probe: Current Status*

Dr. Ralph McNutt, Applied Physics Lab (APL), presented the historical beginnings of and present effort for an interstellar mission to fly through the outer heliosphere to the nearby Very Local Interstellar Medium (VLISM). Dr. McNutt outlined the compelling case for science that would span NASA SMD science disciplines. The primary science goal would be to investigate the global nature of the heliosphere and the nearby interstellar medium. Additional science goals could be to a) investigate the formation and evolution of planetary systems, including dwarf planets/KBOs (Kuiper belt objects) and the large-scale structure of the circum-solar debris disk, and b) uncover early galaxy and star formation, including investigation of the diffuse extragalactic background light (EBL). Dr. McNutt expounded upon potential targets and trajectories, sample instruments and payloads, and architecture constraints and trade-offs. The project will deliver to a final report to NASA HPD in April 2022 to inform the next heliophysics decadal survey.

SMD Science Activation Program NASEM Assessment

Ms. Kristen Erickson, Director of Science Engagement and Partnerships, introduced an overview of a National Academies of Science, Education, and Medicine (NASEM) assessment of the NASA Science Activation Program. She began with a history of Education at NASA. In 1993, SMD AA Dr. Edward Weiler set aside 1% of each mission funding pot for education and public outreach. Because SMD has over 100 missions in operation at any given time, there arose a concern over duplication of effort, followed by a call for more coherence and rigor in the education program at NASA. In 2013, the NASA SMD had a budget reduction of $42M, and the NASA Education Office was reduced by $119M. SMD AA Dr. John Grunsfeld sought to fix the problem and tasked Ms. Erickson with a restructuring of the education effort. At this time, NASA also began to work with the Office of Management and Budget (OMB) more closely, and consulted with both Congress and with the Executive Director of the Board on Science Education at NASEM. The Every Student Succeeds Act was passed in 2015. NASA came up with a science activation model, and when Dr. Zurbuchen, a former educator, came to SMD in 2016, he became instrumental in pushing the concept forward. The desired outcome of the Science Activation Program is to bring NASA experts, content, and experience into the learning ecosystem, to learners of all ages. NASA then created an open competition which led to a network of 27 awardees, all of whom were geared toward learning objectives. The effort involved new players such as community colleges in underserved areas, and the Public Broadcasting System (PBS), with every award independently evaluated. NASA also started leveraging efforts with groups such as GLOBE to avoid duplication effort. Currently, there are 24 competitively selected awardees that have grown a "network of networks," funded annually by SMD. Funding of $45M is set aside for Science Activation Program activities balanced across NASA science disciplines. In 2017, NASA had a one-off competition to leverage the total solar eclipse event of

August 2017. The competition was won by three groups, but it led to activation of the entire collective in the eclipse event. NASA helped to supply 6,100 libraries with materials, subject matter experts (SMEs), and eclipse-viewing glasses. The event was a tremendous success, resulting in 88% of the U.S. adult population witnessing the eclipse.

Science activation across the nation is being carried out through a network of 200 partnerships. The program has developed 350 hands-on toolkits, designed to be universally accessible. One example is a low-tech peg system that replicates a remote sensing activity, and another more high-tech example is touch tables. Many of the toolkits can be downloaded from Internet (https://science.nasa.gov/learners). Materials are in English and Spanish. The Science Activation Program is now preparing for JWST, Mars 2020, another total solar eclipse in April 2024, and Artemis in 2024. Dr. Cerf thought the website was a bit overwhelming, as a first impression. Ms. Erickson agreed, and said that the navigation aspects of the Learner page were being re-tooled. Dr. Herring asked: how do you make yourself known as the definitive source? Ms. Erickson said that the information was required to be accurate, to be linked strongly to NASA science, and was supported by iterative review.

In 2018, NASA re-assessed the linkages between the remaining 24 Science Activation Program awardees and the top four objectives of the program, and evaluated the lessons learned. NASA found that improving scientific literacy in a statistically significant way had not occurred. Therefore in year four of a ten-year program, NASA felt it was the perfect time to carry out an assessment. Subsequently, the NASEM undertook an evaluation of the program.

Dr. Margaret Honey, Chair of the NASEM study *NASA's Science Activation Program: Achievements and Opportunities*, presented the results of the assessment. Dr. Kenne Dibner, Study Director, prefaced the briefing with a review of the study charge.

Dr. Honey reviewed key conclusions and recommendations of the Committee to Assess Science Activation. The committee found that NASA has a unique role to play in the STEM (science, technology, engineering and math) education landscape, and that the current four science activation objectives create a useful vision, but they are too broad to be used in identifying actionable targets and desired outcomes. A concrete example of a desired outcome is improving science literacy; however, this term does not have an agreed upon definition.

The committee's first recommendation is that the NASA Science Activation Program undertake a visioning process that would bring the portfolio up to date with current research on learning and design, the new federal STEM plan, and evidence-based approaches to broadening participation. This process should also consider how science activation fits within and contributes to the larger STEM education ecosystem, and should provide the foundation for developing actionable and measurable portfolio goals. The committee also concluded that NASA has developed a portfolio of diverse projects; and has enabled partnerships that leverage and enhance the reach and value of the Science Activation Program. Another issue related to this conclusion is that it has been a sea change that elevates the quality of work. One challenge is that not all missions feel adequately represented, and the committee therefore recommends that the Science Activation Program build ongoing opportunities for dialogue with SMD missions and scientists.

The committee concludes that evaluation in the Science Activation Program currently focuses on individual projects, and not the entire portfolio. Among the evaluators, there is interest in contributing to a broader understanding of what is working well, what can be improved and where there are opportunities that can be further leveraged across the portfolio. Given the current design and program resources, there are limits to how much this is possible. The committee recommends that the program create an

independent mechanism to obtain ongoing, real time advice to inform a visioning process, drawing upon the following expertise:

- learning and design,
- the policy context of STEM education,
- partnering with local communities, and,
- broadening participation in STEM.

In addition, using input from outside experts, the Science Activation Program should consider whether and how a portfolio-level evaluation could strengthen the focus of the program and ensure that projects in the portfolio are effectively meeting overall goals and objectives.

The committee concludes that current research on learning emphasizes the importance of learner-centered and community-centered instructional design and practices. Science Activation Program awardees have had uneven success at mobilizing NASA assets while also being responsive to the needs of learners and communities. In addition, the portfolio lacks a coordinated effort to incorporate evidence-based practices in translating the expertise of SMEs in developing and implementing educational materials and learning experiences. The committee recommends therefore that the program should articulate 1) how it expects that the portfolio will leverage NASA assets, 2) how partnerships and networks will be built, and 3) an associated theory of change that hypothesizes how these actions will lead to desired, measurable outcomes.

The committee concluded that because broadening participation is a stated intention of the Science Activation Program, the recommendation is that the program should identify ways that the portfolio as a whole could draw on and implement evidence-based strategies for broadening participation. Broadening participation should be clearly defined so that grantees can have greater and more uniform impact in this area. The program should deepen its commitment by using metrics that go beyond numbers of participants.

Projects within the Science Activation Program's portfolio use a variety of design strategies to translate NASA's assets (e.g., SMEs, media assets, scientific instruments, and datasets) to support learning in STEM. Currently, there are limited mechanisms for gathering, synthesizing, and sharing these innovations across the portfolio or for learning from cases of success or failure. The committee therefore concludes that the program must consider whether the development of a coordinated learning network of awardees across its portfolio is a priority. At a minimum, the program should develop more systematic mechanisms for projects to share best practices and to learn from successes and failure. If a coordinated network is prioritized, the committee recommends that the program must provide the necessary infrastructure to support the work.

Finally, the committee concluded that as the Science Activation Program moves into Phase 2, it should take advantage of the opportunity for iterative improvement and refocusing in both the individual project level and the portfolio as a whole. The transition into Phase 2 is also an opportunity to bring in new grantees to ensure that the program remains robust and dynamic. The program should adopt a new vision and set of goals, based on a new logic mode, and should critically review and guide existing projects so they can grow. The program also should ensure a more consistent focus on underserved communities.

Dr. Cerf said he felt there were too many moving parts in the Science Activation Program, and the potential for excessive bureaucracy in the evaluation of the program. NASA might want to facilitate others to allow them access to the content NASA has available; he thought that NASA pushing too close to the education process could narrow the reach. The image of children directly interacting with a scientist doesn't scale up very well. A scientist can't talk to 30 million children and get any science done. Dr. Honey thought that one of the strengths of the program was in its partnerships, such as with the public

television station WGBH, where education experts are working on how to translate resources. A question the program could consider is the importance of scaling up. Education is not monolithic, and cannot build an everything-for-everyone model. Dr. Wadhwa asked how the recommended visioning process might be carried out: Internally? In the broader community? Dr. Honey said that there are a number of people who had been in the PI pool who could be tapped effectively. Complex data visualization expertise could also be brought in. The program knows they have something good, and wants to know what it can do better. Dr. Honey thought that it was a brave move to have this assessment at this time.

Ms. Erickson expressed appreciation for the very thoughtful work of Dr. Honey, et al. She noted that the Science Activation Program plans to meet with the PIs at the December AGU meeting to start the visioning process, which also segues with Dr. New's efforts for reaching the workforce pipeline. NASA will be able to bring in new actors through the 2020 call for proposals. Ms. Erickson welcomed the observations of the SC at a watershed moment in the program, as NASA wants to get into the strongest possible place. Dr. Herring asked: how do you handle uncertainty in education? Dr. Dibner reiterated that one of the strengths of the program's portfolio is the access to NASA scientists doing real work. With careful thought and training, SMEs can assist educators in introducing STEM subjects. Dr. Patterson asked about what happens at year 10. Ms. Erickson said that the program has a 2024 milestone to do actions such as effectively address the "flat Earth" issue that has grown in the public consciousness, by drawing on the power of the collective. The nature of science is to have debate, thus, the program seeks to document the questions around these discussions. Dr. Honey commented that NASA should push on goals that are defined, using a logic model. Dr. Liemohn noted that some NASA missions are not feeling adequately represented in the STEM initiatives, and asked how these PIs might become more involved. Ms. Erickson said that it is the larger scientific responsibility to strengthen ties with the community, to get a tighter fit in the future. She recognized that the program has some catching up to do in translating new missions and syncing up with the portfolio, now that the top line has grown. Mr. Weiser suggested that there are two things to measure: activating the audience, and measuring impact of the partnerships. Dr. Patterson commented that the program's 2017 eclipse coverage was excellent, and asked if there were any other plans for highly engaging events. Ms. Erickson said that the program was planning activities around the "first light" of JWST in 2021; the first flight of a supersonic test aircraft (Low-Boom Demonstrator); Mars 2020; the Artemis program; and the February 2020 launch of Solar Orbiter. She recommended that SC members have a look at the program's web features such as Infiniscope, which allows a user to crawl around the red rocks of Arizona. She added that now is the perfect time, on many levels, to re-assess and re-plan the Science Activation Program. Dr. Honey agreed that NASA has a unique capacity to inspire, and the question is how the Agency can build on amazing efforts such as the total eclipse; it may be that other, new grantees can lead the way. Dr. Wadhwa said she would like to hear a follow-up briefing. Ms. Erickson said she likely could report out some results by the time of the Spring meeting.

Planetary Science Advisory Committee (PAC) Report

Dr. Verbiscer, Chair of the Planetary Science Advisory Committee (PAC), provided an update. The committee had a face-to-face meeting in September, which had been re-scheduled from June for a variety of reasons. The meeting kicked off with the announcement of the NEOSM. The PAC then discussed the PSD Senior Review, the Lunar Discovery and Exploration Program (LDEP), and the Mars Exploration Program (MEP). The PAC heard a report on Mercury science and exploration that included a call for a new Analysis Group (AG) for Mercury. The PAC also carried out its annual Government Performance and Results Modernization Act (GPRAMA) evaluation, for which all objectives were unanimously voted Green. Finally, the PAC heard reports from all the AGs, mostly focused on preparing for the next Planetary Science Decadal Survey.

Dr. Verbiscer discussed a few details about the NEOSM, a high-heritage space telescope that also will draw from the Discovery Program's NEOCam mission Pre-Phase A studies. The current planetary mission to identify and characterize near-Earth objects, the NEO Wide-field Infrared Survey Explorer

(NEOWISE), is expected to exceed its useful temperature by summer 2020, indicating that it is a good time to start a surveillance mission. She presented some science highlights. The Earth now has a second interstellar visitor, which was imaged by HST in early October. STScI has just approved 5 (out of 17) mid-cycle proposals to observe this new object, named 2I/Borisov, with multiple HST instruments. Twenty new moons have been discovered at Saturn; its total moon count is now 82, surpassing Jupiter, at 79. The moons were discovered by Dr. Scott Sheppard et al. using the Suburu telescope on Mauna Kea in Hawaii. Dr. Verbiscer noted that artificial constellations, such as the recently launched Starlink satellites, greatly obscure the night sky and will affect future ground-based support of NASA flight missions and surveys such as the LSST (the Legacy Survey of Space and Time, formerly the Large Synoptic Survey Telescope survey. The International Astronomical Union (IAU) has bestowed an official name, Arrokoth, on the New Horizons flyby target, Kuiper Belt object (KBO) MU69, discovered by HST. Arrokoth is the Powhatan/Algonquian word for sky, in homage to the location of HST's operations at STScI and the New Horizons team in Maryland. A recent attempt to observe an occultation of one of the Lucy Discovery mission targets, the Trojan asteroid Orus, was clouded out, but the observing team was able to give 11 talks at schools and libraries in Darwin, Australia, and was overall a great success.

The PAC issued a number of findings commending the fine work of the comprehensive senior review. PAC accepted the recommendations of the review for the most part, but did find that there was insufficient scientific justification for the continuation of the Mars Explorer (MEX), an ESA orbital mission. PAC therefore recommended re-assessment of MEX. PAC also found that NASA should consider an unallocated future expenses (UFE) pool. PAC issued a finding on Mars Sample Return (MSR), suggesting that MEP engage the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) while planning any future sampling activity at Mars. PAC also issued a finding that suggested re-evaluate NASA travel restrictions on mission-funded contractors. PAC issued a finding on NEOSM, stating that the role and expertise of the NEOCam team should be preserved, and requesting a detailed explanation of the new leadership plan and structure for NEOSM, when it becomes available.

Dr. Wadhwa felt the PAC finding on MSR regarding CAPTEM could be cast as a SC recommendation. Dr. Cerf asked a question about the Double Asteroid Redirection Test (DART) mission, as to the amount of damage the impactor could inflict. Dr. Lori Glaze, Director of PSD, said the DART mission would use a 300-500kg spacecraft to impact the small moon of a binary asteroid system, Didymos. The mission is designed to have negligible influence on the total momentum and trajectory of the system; the purpose is to change the orbital period of one of the objects (on the order of minutes), and to measure momentum transfer.

Astrophysics Advisory Committee (APAC) Report

Dr. Feryal Ozel, Chair of the Astrophysics Advisory Committee (APAC) provided an update, noting that the bottom line is that things are going well. JWST work is proceeding according to the re-plan; the Wide Field Infrared Survey Telescope (WFIRST), a mission in development, passed its preliminary design review (PDR). A balloon mission of opportunity (MOO), Galactic/Extragalactic ULDB Spectroscopic Terahertz (THz) Observatory (GUSTO), has passed its critical design review (CDR), as has the Imaging X-ray Polarimetry Explorer (IXPE). GUSTO is an ultra-long duration balloon (ULDB) THz observatory that will look at the life cycle of the Interstellar Medium (ISM), and is described as representing the equivalent of 300 Stratospheric Observatory for Infrared Astronomy (SOFIA) flights. IXPE, selected two years ago and set to launch in 2021, will be the first mission of its kind to have detectors that are sensitive to the direction of the photoelectron; better than anything APD has had before. NASA's contribution to the JAXA mission X-Ray Imaging and Spectroscopy Mission (XRISM), a rebuild of the Hitomi mission, has completed its pre-ship review; and NASA's hardware contribution to the ESA mission Euclid has been delivered. One caveat that APAC has noted is that with respect to JWST, 70% of the schedule reserve has been used up 50% of the way into the completion of the items in the re-plan.

In the APD Balloon Program, a problem with a series of balloon leaks has been resolved after a study pinpointed the cause. The latest FY19 Fort Sumner campaign was extremely successful as a result, and the program also will be looking at alternative launch sites for future experiments. For implementation of the dual anonymous proposal review process, the first pilot study will be NuStar Cycle 6, with a proposal due date of January 24, 2020. For the Chandra, the pilot will begin in March 2021, but the remainder of APD R&A topic areas will use the dual anonymous approach in 2020.

Dr. Ozel offered some science highlights. The Spitzer Space Telescope has afforded a rare look at a rocky exoplanet that was discovered by TESS. A study has shown that the exoplanet LHS 3844b is "tidally locked" orbit around its M dwarf star; the planet has a surface that may resemble the Moon or Mercury, and likely little to no atmosphere. Another science result that was released in September involved a supermassive black hole that has "three hot meals a day." The black hole was observed by ESA's X-ray Multi-Mirror Mission (XMM)-Newton and NASA's Chandra as going through extremely regular, bright outbursts, marking the first time such behavior has been observed.

Public Comment Period

Mr. Jason Harris, describing himself as a veteran business owner, said that he greatly appreciated the ability to listen to the Committee proceedings.

Discussion

The SC reviewed draft findings and recommendations. Dr. Cerf, remarking on the Science Activation Program assessment, thought that NASA should not be focusing on infrastructure, but rather teaching the teachers, and letting teachers teach the kids. Dr. Liemohn said he had similar concerns about increasing the bureaucratic burden, but noted that it is beneficial to have the recommended visioning process be broad-based. Dr. Cerf said he hadn't heard any statistics on how many students have been reached, adding that it is difficult to track success, as one does not see results until the individual is of career age. Dr. Liemohn felt that the key point for intervention is in middle school, where STEM students tend to get lost. Dr. Cerf cited an annual Science and Engineering Indicators Report as one endpoint to watch. Dr. Wadhwa deferred the discussion until SC member Dr. Michelle Larson could join, but supported an eventual finding, adding that she thought NASA was missing a strategic opportunity to help the public fall in love with the mystery of science. Part of the appeal of science is the teamwork that is required to pull together to learn hard things—science is not all about facts, but rather about the process.

The SC discussed findings on R&A, including on innovations, on the balance within the program of the incoming pool of proposers, and on applauding the creation of the PI Launchpad, which is clearly meeting a need, given the robust response. The SC formulated a finding on technology focus areas. Mr. Weiser thought that the effort to reach start-ups was evolving, and saw an opportunity to emulate other grant-making organizations' abilities to bring companies into the sphere; actually having a budget to offer would change things drastically. The main thing he would recommend would be for NASA to adopt the strategy the USAF is using in its Pitch Day approach. Mr. Weiser also felt it might be too early to expand beyond the three focus areas enumerated by Mr. Seablom. Dr. Herring was concerned about the failure rate of start-ups. Mr. Weiser noted that NASA would be leveraging such efforts, and not funding them completely. He added that a small amount of funding to a start-up could be worth a large amount to traditional companies – it is a balance and there is no perfect model.

Dr. Wadhwa asked the SC to consider a full recommendation on the engagement of CAPTEM within MSR planning, and Dr. Verbiscer agreed to draft text. Dr. Wadhwa also aired a recommendation supporting the formation of an SC subcommittee on lunar science, noting that it would be helpful to press on this, especially given the accelerated schedule for Artemis. A recommendation would assist in ensuring that science is part of the equation going forward with lunar exploration.

Dr. Herring requested guidance on future budget levels from Dr. Zurbuchen, as the subject of a briefing for a future meeting.

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Dr. Wadhwa opened the second day of the meeting, and introduced Mr. Michael Gold, the departing NASA Advisory Council (NAC) Regulation and Policy Committee (RPC) Chair. Mr. Gold had been appointed as Special Advisor to the Administrator on International Affairs. Ms. Denning made some administrative announcements.

Planetary Protection Independent Review Board

Dr. Alan Stern, the PI for the New Horizons mission to Pluto, presented the final report of the Planetary Protection Independent Review Board (PPIRB), a board that had been charged with revisiting planetary protection policy at NASA, given that there have been vast changes in the scientific understanding of places that might support life in the solar system. It is now known that Earth is not the only planet in the solar system with an ocean, but that there other bodies that have subsurface oceans. In addition, much has been learned about prebiotic chemistry over the last several decades. The emergence of both commercial and other small space agencies that can field missions to space has also given a fresh impetus to a review of planetary protection. As a result, the NAC recommended that NASA take a fresh look at the discipline, which originated in the 1960s.

SMD AA Zurbuchen chartered the PPIRB to freshly assess how to treat the forward and backward contamination risks that are inherent to space exploration. This was a quick study of 90 days that concluded at the end of September; the report was released on October 18, 2019. The Board's 12 members represented a broad cross-section of expertise: planetary scientists, biologists, and representatives from the industry such as SpaceX, Blue Origin, and Lockheed Martin. The board met four times, and heard close to 100 in-person briefings. The report was reviewed internally for its pedagogy. The PPIRB was chartered as a non-consensus board, but in reality the group reached consensus on the entirety of the report.

The report has about 80 findings and recommendations on planetary protection that are aimed at clarifying and streamlining processes within NASA, advancing protocols with more modern technologies, reducing burdens on missions, and advancing policies for private sector missions. The report is divided into specific topics: Categorization (Categories I-V, increasing in stringency with number), Human Spaceflight, Robotic Mars Sample Return (MSR), Ocean Worlds, and Private Sector Initiatives and Missions.

Dr. Stern highlighted key findings, beginning with a finding that recognized the evolution of planetary protection techniques as a discipline. The PPIRB finds that because the space landscape is rapidly changing in terms of both science and access, the discipline should be re-assessed regularly, at least twice per decade. In addition, the board recommends that NASA establish a new standing forum for the discussion of planetary protection issues, and that the forum have all the necessary participants, including international players and private sector representatives. Dr. Stern noted that the report of the PPIRB really is merely a snapshot in time, and this should be emphasized.

Regarding the Planetary Protection Office (PPO) at NASA, there have been changes in staff, and the new Planetary Protection Officer has taken a much more modern viewpoint. PPO was housed in SMD for decades. Moving the PPO from SMD to the Office of Safety and Mission Assurance (OSMA) was a long overdue and positive decision, given that the former location in the SMD was thought to present a conflict of interest that created unnecessary tension. Accordingly, the PPIRB additionally recommended that

NASA adopt an explicit process, such as an ongoing independent review as well as an internal review process, to ensure that planetary protection policies and processes are applied consistently, regardless of specific PPO personnel. This would be something analogous to a standing review board that allows outside input from a very broad access community to the PPO, on a regular basis (several times per year).

Regarding NASA control over planetary protection, the board felt that the Agency can exert a degree of control over the behavior of emerging space actors that are not signatories to the Outer Space Treaty (OST), or members of COSPAR, particularly in regard to sample return. Because most of these entities want to do business with NASA, the PPIRB feels that NASA should link good planetary protection practices to future business, while recognizing that such a linkage could backfire if done in too heavy-handed a way. Dr. Hoffman noted that the Federal Aviation Administration (FAA) would be the regulatory body most relevant to planetary protection issues: shouldn't NASA be talking with FAA on such concerns? Dr. Stern said that there are regulatory points that companies have to pay attention to such as the FAA, the Federal Communications Commission (FCC) and the National Oceanic and Atmospheric Administration (NOAA). In some cases, these agencies have come to NASA for opinions. The PPIRB believes that NASA, over the longer term, should work to find a suitable home for planetary protection within the federal government as a one-stop regulatory shop, rather than relying on scattered efforts. Mr. Gold cited the payload review process, wherein the FAA's Office of Commercial Space Transportation (OST) is the decision maker, but NASA has input. He added that the only issue missing seemed to be the Article VI procedure of the OST, which does not have a "home" at present. Dr. Cerf saw a potential problem in that the U.S. is not the only launching authority in the world, and cannot solve the problem by itself. The other is problem is the commercialization of space, which has the potential for conflict with scientific research; and what if private entities bring back something harmful? These tensions will become worse over time. Dr. Stern commented that these problems are not unique to planetary protection, and that there also is tension between radio astronomers and the radio satellite industry.

The board recommends that NASA modernize its planetary protection methods to be more in line with modern biological practices, noting that the current practice of using spore counts to assess contamination are 1970s-era biology, leading to anachronistic and unrealistic requirements. PPIRB further recommends that NASA conduct research so as to adopt more modern (molecular) methods, allowing missions to address their planetary protection needs flexibly and individually. These techniques should also be reviewed every 3-5 years. The board noted that the PPO would need additional resources to support this modernization.

The board recommends that NASA re-evaluate its planetary protection categorizations for the Moon (I vs. II), and Mars (II vs. IV), because science has come to understand much more about the habitable and diverse regions on bodies in the solar system. This new information suggests NASA should take a more nuanced approach to these bodies. The consensus view on the Moon is that it has generally has no astrobiological potential, thus its planetary protection category could be relaxed from Category II to Category I. Permanently shadowed regions on the Moon that perhaps could preserve astrobiological materials could have a Category II rating. In the case of Mars, some areas of the surface and subsurface could be recategorized as Category II, rather than as Category IV. NASA should study and reconsider these categorizations on an ongoing basis, in order to remove burdensome planetary protection requirements.

The PPIRB issued a major finding and recommendation on Ocean Worlds, given that a preponderance of knowledge has been gained with regard to the Outer Planet moons Enceladus, Titan and Europa. The board recommends that these icy moons be assessed individually, case by case, with respect to planetary protection needs. The planetary protection requirements for Ocean Worlds exploration should be re-assessed in the light of these discoveries, as the radiation, chemical, and temperature environments of some of these bodies are prohibitive to the maintenance of known life forms.

The PPIRB put forth a major recommendation to accelerate a plan, in the very near term, to develop a Mars Sample Return Facility (MSRF) without jeopardizing the cost or schedule of the MSR program. The MSR mission could be delayed or sidetracked if an MSRF plan is not accomplished quickly. Public concerns could also unduly drive the requirements for an MSRF.

The PPIRB had major findings on human missions to Mars. Human exploration of Mars will assuredly introduce orders-of-magnitude more terrestrial organisms than any robotic mission; this fact needs to be recognized and accepted. The board also found that evidence to date indicates that terrestrial biology brought to Mars would perish in an essentially poisonous environment, and was also not equivalent to contamination of an entire planet. The board took the stance that human missions to Mars will create new science opportunities that far outweigh any danger of global contamination. The PPIRB also found that requirements for a robotic Category V/Restricted Earth Return mission from Mars appear to be unachievable if applied to human missions from Mars. A human mission cannot be made to follow the "break the chain" technique for preventing backward contamination; the board recommended that NASA should invest in exploring this issue further.

NASA planetary protection planning for human missions to Mars, and the communication of those plans, at present are very immature. PPIRB recommends therefore that NASA, sooner rather than later, make proactive plans to communicate to the public all aspects of planetary protection planning for human missions to Mars, analogous to NASA's past proactive preparation for the launch of radioisotope power systems. The PPIRB feels that planetary protection science issues have not been well aired by NASA, such that court actions, injunctions, or other barriers might halt launches and prevent the return of Mars materials to Earth. Dr. Hoffman asked how valid the argument was that Mars materials are actually sterile. Dr. Stern said the issue is a double-edged sword; radiation and the re-entry process would sterilize the surface of returning samples, but the deep interior could be preserved. Mars materials, in the form of meteoroids, have been raining on Earth for millennia; however, a mission sample is returned in a more controlled way. Dr. Hoffman noted that there are no restrictions on slicing open Martian meteorites. Dr. Stern agreed that this point exactly highlights why the conversation needs to take place; the public needs a more sophisticated understanding of sample return.

For dealings with international partners, Dr. Stern noted that the PPIRB's recommended standing board should also include international participation, and that the PPIRB report will be briefed to COSPAR, as well. Mr. Gold noted that the Outer Space Treaty (OST) delineates provisions for the prevention of harmful contamination, but that NASA should probably consult the United Nation's Committee on the Peaceful Uses of Outer Space (UNCOPUOS), which has a legal subcommittee that deals with planetary protection issues. He agreed that NASA needs to be proactive to avoid a future with conflicts, and that the Agency needs to work with others in an ongoing dialogue. Dr. Hoffman said he was glad to see a finding supporting genetic analyses of vehicle bioburden, and that future Mars missions ought to be genetically analyzed. Dr. Stern noted that Dr. Lisa Pratt, the new PPO, is already on it, preparing genetic inventories on vehicles before they leave Earth. Mr. Gold commented that Dr. Stern had been uniquely suited to head the PPIRB, given his background in both science and commercial arenas. Dr. Stern extended kudos to Dr. T. Jens Feeley for staffing the PPIRB. Dr. Patterson asked for Dr. Stern's opinion on the treatment of OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer) asteroid sample returns. Dr. Stern noted that the OSIRIS-REx mission, as well as the two Japanese asteroid return missions, are not viewed in the same way as for MSR that needs to consider forward and backward contamination. In the case of asteroids, the PPIRB report does address the categorization issues. Dr. Wadhwa asked if the Board considered a "national park" status of some places in the Solar System: are there places that will be considered permanently off-limits? Dr. Stern said that historically, the period of performance of spacecraft was set at 50 years. Re-evaluating the time frame could be done, but it would be a lot of work, and he was not sure it was necessary given the current understanding of the Solar

System. He added that the National Academies would be reviewing the board's report, and commended Dr. Zurbuchen and Administrator Bridenstine for initiating the study.

Discussion on PPIRB Report

Dr. Cerf said that the SC might want to mention to Dr. Zurbuchen the potential for conflict between science and commercial interests in space. SMD does not want to prevent commercialization, but ideally it also does not want to be inhibited by commercial exploitation of and civilian access to space. This is a long-lead issue that SMD should recognize, underscoring the importance of maintaining high-quality science results. Dr. Wadhwa asked if the board had any recommendations on the identification of resources for the PPO, and the scope of work required to modernize techniques. Dr. Stern said that the PPIRB did not speak to this specifically, and simply stated that modernizing techniques will require resources for research. Dr. Wadhwa noted that the need for resources also plays into the urgency for a MSRF, with both long- and short-term implications. Dr. Liemohn said he had been hearing that SMD really drives planetary protection to preserve remote locations of scientific value. Now that the PPO is no longer part of SMD, how does this help SMD argue for planetary protection? Dr. Stern said that the relocation of PPO in OSMA does not mean that the PPO is disconnected from SMD. Dr. Glaze commented, from the PSD perspective, that she thought the PPO was better situated in OSMA, particularly because of the new Agency emphasis on human exploration. Dr. Wadhwa said that the SC has an interest in keeping the lines of communication open between PPO and SMD. Dr. Cerf commented that there will need to be some international agreement in support of a successful MSR mission, and to protect the planet.

Heliophysics Advisory Committee (HPAC)

Dr. Liemohn, Chair of the Heliophysics Advisory Committee (HPAC), presented an update. The HPAC last met in October, after a ten-month hiatus. The HPAC received a report from the Science and Technology Definition Team (STDT) for the Geodynamics Constellation (GDC), the next of the large strategic missions for heliophysics. GDC will examine energy inputs, from above and below, into the ionosphere, focusing on the lower latitudes. The mission is focused on ten objectives under two separate goals. This particular STDT was organized under Federal Advisory Committee Act (FACA) rules as a subcommittee reporting to the HPAC, hence the team was prohibited from discussing specific instrumentation, or from doing a full cost estimate of the mission concept. As the STDT was forced to focus on goals and objectives leading to the actual physical measurements, this was considered a positive "side effect" of ignoring implementation. The negative side of this approach was that the team had to guess at cost, which could have produced a very expensive mission. To work around this problem, the STDT prioritized the ten science objectives to come up a wide range of options to address the goals. The core goal of GDC is to determine how high plasma convection and auroral precipitation drives thermospheric neutral winds.

Dr. Liemohn and HPAC commended HPD on the progress of its overall program. The PSP mission is going very well. The Global-scale Observations of the Limb and Disk Missions (GOLD) mission has completed a full year of operation, with papers based on GOLD data due to come out soon. The Ionospheric Connection Explorer (ICON) also is doing well. Two Small Explorer (SMEX) selections have been made: Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites (TRACERS) and Polarimeter to Unify the Corona and Heliosphere (PUNCH). HPAC is pleased with all the activity, and with newly simplified and modified options for the senior review process, but did express concern with new language surrounding a senior review requirement for open-source code. As there is a lot of legacy code in proprietary language, the HPAC is concerned that the requirement not be interpreted too broadly. Dr. Wadhwa offered that the SC could produce a finding on this latter point.

Earth Science Advisory Committee (ESAC)

Dr. Herring provided an overview of the newly reappointed Earth Science Advisory Committee (ESAC), now down to ten members, and which has not had a face-to-face meeting since March 2018. The Committee was able to hold its annual GPRAMA exercise via teleconference for 2018 and 2019, both of which resulted in uniformly Green grades. He noted that the program managers had prepared drafts for the teleconferences, and that the reports had been made more uniform across the six GPRAMA focus areas.

Regarding the Earth Science focus area Weather and Atmospheric Dynamics, the sense of ESAC was that the missions that have been in operation for several years are now generating excellent results. In the area of Climate Variability and Change, with its focus on ice sheet dynamics and sea-level change, ESAC thought that the new results which tend to emerge at the end of a fiscal year need to be better incorporated into the GPRAMA exercise. In the Atmospheric Composition Focus Area, ESAC noted that the global drop in chlorofluorocarbons (CFCs) had been a great success, and that satellites now can identify countries that are not in compliance with the CFC ban. The ESAC had praise for the Earth Surface and Interior (ESI) focus area, and complimented the CORE (Challenges and Opportunities for Research in ESI) report that traces the way managers are running the program back to the goals of the report. ESI also held a team meeting in November that was beneficial for allowing interaction between community members. Dr. Cerf asked if it were possible to detect the tectonic side effects of polar cap melting. Dr. Herring said that to some degree it was possible; e.g., there are strong correlations between seismicity and the drought in California. With sea level rise and the loss of ice sheets, it can be seen that with the Alaskan coast line rising, there is a drop in the normal stress on faults.

The ESAC felt that in the case of the Water and Energy Cycle focus area, NASA needed to publicize these missions more. In the Carbon Cycle and Ecosystems focus area, ESAC looks to data that ICESat-2 will provide on vegetation and carbon budget, and also anticipates new data from ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS), launched to the International Space Station (ISS) in June 2018.

Dr. Cerf asked if NASA has been able to leverage European weather forecast models for needs such as hurricane tracking. Dr. Herring acknowledged that the European models incorporate GPS (global positioning system) into their forecasting, leading to generally superior results. The U.S. has been experimenting with similar modeling techniques, but still has a way to go.

Moon to Mars

Mr. Steve Clark, Deputy Associate Administrator for Exploration (DAAX), presented a report on the Moon to Mars initiative. Staffing level has grown, and now includes Drs. Ben Bussey, Brad Bailey, and Sarah Noble. Ms. Angela Melito is the new program executive (PE), and Ms. Jean Wolfe is the PE in the Joint Agency Satellite Division (JASD), where she is focused on the VIPER reviews.

A total of 25 instruments are set to fly on CLPS. NASA conducted two calls, one internal that resulted in the selection of 13 instruments, followed by an external call to commercial makers that resulted in 12 instruments. All instruments now are either developed or in development. Future calls, both internal and external, are planned on an approximately annual basis. There also will be opportunities for international agencies to provide payloads. The Astrobotics Lander and Intuitive Machines Lander, awarded in May, each will carry a number of NASA instruments; planning is for a 2021 launch. Astrobotics will fly an additional dozen instruments from non-NASA (commercial customer) sources. The DAAX office is having good conversations with PIs, and all is going well. Five additional CLPS awards have been made very recently to Blue Origin, Ceres Robotics, Sierra Nevada, Space X, and Tyvak Nano-Satellite Systems.

A payload workshop meeting is under way with the VIPER team. There now are 14 CLPS providers who will bid to fly VIPER; there should be an award by January/February 2020. The VIPER is targeted for landing at the southern lunar pole in late 2022. There it will obtain ground truth on the horizontal and vertical distribution of lunar volatiles on a long-duration (months), long-traverse (tens of kilometers) trip in order to gather multiple data points. There are four key instruments: Neutron Spectrometer System (NSS), Near InfraRed Volatiles Spectrometer System (NIRVSS), Mass Spectrometer Observing Lunar Operations (MSolo), and The Regolith and Ice Drill for Exploring New Terrain (TRIDENT). An independent VIPER Review Team (VRT) has been established to ensure mission success, and is chaired by Mr. Geoff Yoder. For this multi-center project, management is done at Ames Research Center (ARC), rover development at Johnson Space Center, and instrument development at ARC. Kennedy Space Center (KSC) is handling the drill procurement, and the Jet Propulsion Laboratory (JPL) is contributing rover expertise. Both Mr. Clarke and Dr. Zurbuchen are regularly receiving "snapshot reviews," in advance of an April 2020 PDR.

Twelve Lunar Surface Instrument and Technology Payload (LSITP) payloads were selected in July of this year; all instruments are ready or near-to-ready. Possible scenarios for the first seven small CLPS deliveries include one payload to a polar region and one to a nonpolar region, for 2021. Two deliveries in 2022 are anticipated, also to polar and nonpolar regions. Dr. Wadhwa asked if there was any instrument duplication between the nonpolar and polar payloads. Mr. Clarke said the PIs are being engaged to hold a workshop to discuss this. NASA research announcements will state the locations for each Task Order (TO). Selected instruments would feed the manifests from TO 20B and beyond, building a pipeline of instruments and technology demonstrations that could be flown twice per year. NASA is moving more toward PI-driven instruments, with future instrument calls planned to support a good cadence.

In the Apollo Next Generation Sample Analysis (ANGSA) call, nine teams were selected to analyze pristine Apollo 15 and 17 samples with techniques that were not available in the 1970s. Beyond VIPER, SMD wants to do additional rover missions. A request for information (RFI) is due to be released to industry to provide new ideas, including solicitation of ideas from terrestrial mobility providers. Subjects include polar landers and rovers, non-polar landers and rovers, orbital assets, and in-situ research utilization (ISRU) research to answer questions on regolith composition and the potential ability to use lunar ice to produce fuel and oxygen. Mr. Clarke said that far-side exploration is on the table, but that more input is needed from the community. NASA has been talking about orbital communications and data relay both internally and with international agencies. NASA's Space Communications and Navigation (SCaN) and U.S. commercial services also are interested in providing communications infrastructure. All current rovers and landers are planned for the near-side, but that could change.

Mr. Clarke said he appreciated SC comments on the Science Strategy of the Moon, and that Dr. Bussey has incorporated them and refined the document. He said he would be pleased to share the next version, and that the DAAX office intends to keep refining it as a living document. He wanted to reemphasize that the DAAX office is working closely with HEOMD on the science that crews will carry out, to complement the robotic missions. In April 2020, there will be a joint workshop with SMD, STMD, and HEOMD to discuss crew-enabled science at the south polar region.

A cross-directorate, federated board structure has been stood up for lunar exploration and is working well. Mr. Clarke is an ad-hoc, voting member on the Gateway Program Control Board. A DAAX office staff member is on the Gateway Utilization Control Panel. Dr. Bailey is on the board reviewing Human Landing System (HLS) proposals, focusing on the science. There is ongoing discussion on human pressurized and unpressurized rover concepts, aimed at ensuring science investigation opportunities. For Mobility Services, SMD and HEOMD have been sharing draft language to prevent confusion in their separate RFIs.

Dr. Cerf asked if there already were standardized operability protocols for communication and data processes in the CLPS program, such as APIs (application programming interfaces) for the landers and rovers. Mr. Clarke said that those discussions are under way with the initial providers. Dr. Cerf urged Mr. Clarke to look into the bundle protocols on the ISS, and prototypes being used at Mars, as Gateway will also need relay capability. Mr. Clarke said he had been talking to the Mars teams about how they communicate with rovers. NASA is also looking at the Gateway's Power Propulsion Element (PPE) as a communications relay asset. Asked if he had read the PPIRB report, Mr. Clarke said that he had, and was open to additional ideas. Mr. Weiser asked: on the RFI for Mobility Services, how did you figure out who to engage with? Mr. Clarke said he had reached out to many organizations, including those with a terrestrial focus, as mentioned, and several companies are interested. Mr. Clarke said he had done some pre-socialization before releasing the RFI, and based on the feedback, had decided to issue it.

Dr. Wadhwa said she was glad to see the emphasis on cross-directorate collaboration, and asked Mr. Clarke if he could speak to the communication between the SMD divisions for instruments, beyond PSD. Mr. Clarke noted that there has been interest from HPD for solar wind data, and also from HEOMD on radiation measurements at Gateway. The DAAX office has reached out to other divisions for interest in flying on PPE; it was ascertained that APD and ESD have limited interest on flying early on PPE. As Gateway evolves, Mr. Clarke expected to continue to collaborate across the SMD divisions, looking at all the different aspects of the configuration. From a CLPS standpoint, the instruments are open to the entire community, not just planetary science. There is interest from APD to conducting future missions on the far side; the DAAX office is working with them on deciding when to put out a call. In response to a question about Astrobotics and Intuitive Machines, Mr. Clarke confirmed that there are commercial payloads being shared with the NASA payloads, and that both providers have evolved capabilities planned. Astrobotics has a larger lander called the Griffin lander that can carry heavier payloads, and also have plans for a commercial Polaris rover. There also are orbital providers that could launch CubeSats. Dr. Cerf asked if anyone was thinking through the potential for orbital debris around the Moon. Mr. Clarke agreed that NASA needs to plan around this matter sooner rather than later, with international discussions as well.

Discussion

Dr. Wadhwa asked for impressions from around the room. Mr. Weiser felt that a lot has to be accomplished for the next set of CLPS calls; participants will need collaboration to achieve results within the rapid timelines. Dr. Hoffman thought that the PPIRB report deserved an SC endorsement. As far as the lunar science went, he thought that this still was in the formative stage, and all that the SC could ask is to be kept updated once plans are established. Dr. Verbiscer echoed the endorsement of the PPIRB, and Dr. Ozel agreed. Dr. Liemohn said he was amazed and impressed that the Moon to Mars effort has moved so fast, and commended the DAAX office on its progress. Dr. Cerf commented first that the meeting had been well organized with an appropriate scope, within which members could react and converge on ideas. He then noted that given the rapid pace of commercialization and increased activity of other space agencies that there will be a greater need to coordinate and agree on how to behave on a global scale. He added that the NEOSM is another important effort, especially as we could be surprised again with regard to interstellar visitors. Dr. Patterson noted that space is changing fast, as is the Moon; small satellites for international collaboration could prove to be a beneficial platform for the future. Dr. Herring said he had been impressed with the briefing on R&A innovations, and looked forward to the results. Dr. Larson thought that NASA was making great progress in stepping up its alignment with commercial activity, but still was concerned about the budget; she thought an overarching budgetary narrative should be developed for NASA's long-term planning in such an ambitious program. Dr. Wadhwa agreed, adding that the SC should state that the existing science program should not suffer in the current atmosphere. In addition, she reiterated that the SC formally should recommend the formation of a lunar science committee, specifically regarding science of and from the Moon.

The SC discussed several draft findings:

1) Planetary protection – endorsement of report,
2) Planetary protection –science and commercial endeavors,
3) Planetary protection –timeliness of action on modernizing the understanding of disciplines, techniques and addressing MSRF in a timely way,
4) Planetary protection – NASA SMD coordination,
5) Open source code for mission software,
6) R&A innovations commendation of efforts aimed at eliminating potential bias, and the HIHR proposal pilot,
7) Technology focus areas,
8) NASEM Assessment of SMD Science Activation, and the
9) Science of the Moon Subcommittee.

The SC also discussed one recommendation: MSR ground element coordination and the engagement of CAPTEM.

Dr. Cerf said that he was alarmed by the tangled bureaucracy that surrounds education. Dr. Ozel commented that there are many intangibles that should not be lost as the Science Activation Program responds to the NASEM report. Dr. Larson felt that the program's response should emphasize evidence-based results.

Outbrief for SMD AA

Dr. Wadhwa presented the SC draft findings and one recommendation to Dr. Zurbuchen.

Dr. Zurbuchen thanked the Committee for its comments, and asked if there was something SMD was missing, or if there were other things on which it should be focusing. Dr. Herring said he was worried about the government's budget deficit and the potential consequences to NASA and NASA Science. Dr. Wadhwa noted that because the Artemis program is moving quickly and might impact SMD, she asked that the SC be kept apprised of any potential impacts. Dr. Patterson thought there seemed to be an obstacle to working with international players in space, and that there did not seem to be concrete plan. The same problem exists with regard to space traffic management in the global commons. Dr. Cerf commented that Internet governance has a similar problem. Mr. Weiser, referring to the discussion on planetary protection, noted that NASA is not a regulatory agency, but does play a role and that the only real leverage the Agency has is business leverage. He asked: At what level does this need to be tackled? Dr. Liemohn commented on commercialization in LEO and its contribution to orbital debris, weighed against the positive outcome in that increased satellite activity could also afford more opportunities for science. Dr. Verbiscer said that the ground-based telescope and astrophysics communities were especially concerned about orbital debris and its impact on celestial observations; a recent observation shows the interference of 19 Starlink satellites in one image. Dr. Wadhwa said she was eager to hear about the path of young proposers (via the PI Launchpad) and their impact on the community. Dr. Ozel commented that the APAC had looked at falling selection rates, and recommended that APD double its funds allocation for R&A.

Dr. Zurbuchen offered the SC the opportunity to hold future meetings at various NASA Centers, so that members could have a glimpse of new NASA hardware.

Dr. Wadhwa adjourned the meeting at 12:45pm.

Appendix A
Attendees

Science Committee Members

Dr. Meenakshi Wadhwa, **Chair,** Arizona State University
Vinton G. Cerf, Google
Thomas Herring, Massachusetts Institute of Technology *(ESAC Chair designee)*
Jeffrey A. Hoffman, Massachusetts Institute of Technology
Michelle Larson, Adler Planetarium *(via telecon/Webex)*
Michael W. Liemohn, University of Michigan
Feryal Ozel, University of Arizona
Pat Patterson, Space Dynamics Laboratory
Anne Verbiscer, University of Virginia
Marc Weiser, RPM Ventures
Elaine Denning, **Executive Secretary,** NASA Headquarters

NASA Attendees
Veronica Bindi, NASA HQ
Paula Bontempi, NASA HQ
Lin Chambers, NASA HQ/LaRC
Kristen Erickson, NASA HQ
T. Jens Feeley, NASA HQ
Nicky Fox, NASA HQ
Lori Glaze, NASA HQ
Mike Gold, NASA HQ
Mike Henry, NASA HQ
Paul Hertz, NASA HQ
Michael Kincaid, NASA HQ
William Knopf, NASA HQ
Christy Layton, NASA HQ
Peg Luce, NASA HQ
Amanda Moore, NASA HQ
Michael New, NASA HQ
Marian Norris, NASA HQ
Ursula Rick, NASA HQ
Michael Seablom, NASA HQ
Lucia Tsaoussi, NASA HQ
Dan Woods, NASA HQ
Thomas Zurbuchen, NASA HQ

Non-NASA Attendees
Pontus Brandt, APL
Tammy Dickinson, Science Matters Consulting
Kenne Dibner, NASEM
Mary Floyd, Electrosoft, Inc.
Margaret Honey, NYSCI
Ralph McNutt, JHU/APL
Heidi Schweingruber, NASEM
Alan Stern, SWRI

Joan Zimmermann, Zantech Inc.

Telecon/Webex Attendees
David Adler
Larry Bell, Museum of Science
Linda Billings, NIA
Mia Brown, NAS
Brendan Byrne, WMFE
Victoria Carter
Steven Clarke, NASA HQ
Bradford Davey, TFWA
David Eisenman, NASA JPL
Jeff Foust, SpaceNews
Richard Gilmore, NASA
Beverly Girten, NASA
Jim Green, NASA
Mary Gunther
Jason Harris, veteran business owner
Tina Harte, World Mission Earth
Brian Harvey, BAN Associates
Joan Higginbotham, Collins Aerospace
Tupper Hyde
Christopher Johnson, Secure World Foundation
Jennifer Kearns, NASA HQ
Ken Keiter
Gilbert Kirkham, NASA HQ
Dave Kirtman, NASA
Janet Kozyra, NASA HQ
Rob Landis, NASA
Robert LaSalvia, NASA HQ
Carey Lisse, APL
James Lochner, USRA
Paul Mahaffy, NASA GSFC
Erin Mahoney, NASA
Catherine McCarthy, Science Museum of Minnesota
Jeff Morrill, NASA HQ
Jeffrey Newmark, NASA
Stefanie Payne, NASA HEOMD
Margaret Pippin, LaRC
Daryl Porcello
Corrie Roe, AMNH
Gabe Rogers, APL
John Rummel, SETI Institute
Abigail Rymer, APL
Rita Sambruna, NASA HQ
Evan Scannapieco, NASA
Andrew Schurr, NASA
Mary Sladek, NASA HQ
Denise Smith, STScI
Marcia Smith, Spacepolicyonline.com
Jessica Taylor, NASA LaRC

Paul Voosen, AAAS
Nicholas White, Space Science Solutions
Ashlee Wilkins, House of Representatives
Lisa Wood, Ball Aerospace

Appendix B
Science Committee Membership

Dr. Meenakshi Wadhwa (Chair)
Arizona State University

Dr. Vinton Cerf
Google, Inc.

Dr. Jeffrey Hoffman
Massachusetts Institute of Technology

Dr. Michelle Larson
Adler Planetarium

Dr. Michael Liemohn
University of Michigan

Dr. Feryal Ozel
University of Arizona

Dr. Pat Patterson
Space Dynamics Laboratory

Dr. Anne Verbiscer
University of Virginia

Mr. Marc Weiser
RPM Ventures

Appendix C
Presentations

1. NASA Science Overview; *Thomas Zurbuchen*
2. Goals of the Meeting; *Meenakshi Wadhwa*
3. Research and Analysis Innovations; *Michael New*
4. Study of a Near-Term Interstellar Probe: Current Status; *Ralph McNutt*
5. SMD Science Activation Program National Academies of Science Assessment; *Kristen Erickson, Margaret Honey*
6. Planetary Science Advisory Committee Report; *Anne Verbiscer*
7. Astrophysics Advisory Committee Report; *Feryal Ozel*
8. Planetary Protection Independent Review Board; *Alan Stern*
9. Heliophysics Advisory Committee Report; *Michael Liemohn*
10. Earth Science Advisory Committee Report; *Michael Herring*
11. Moon to Mars; *Steven Clarke*

Appendix D
Agenda

Dial-In (audio) & WebEx (view presentations online) information is located on page 2.

NASA Advisory Council
Science Committee

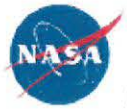
November 18-19, 2019

NASA Headquarters
Room 9H40

Agenda
(Eastern Time)

Monday, November 18

8:30 – 8:40	Opening Remarks / Introduction of Members	Ms. Elaine Denning Dr. Meenakshi Wadhwa
8:40 – 9:45	NASA Science Overview	Dr. Thomas Zurbuchen
9:45 – 10:00	Goals of the Meeting	Dr. Meenakshi Wadhwa
10:00 – 10:15	***Break***	
10:15 – 11:30	Research & Analysis Innovations Discussion	Dr. Michael New All
11:30 – 11:45	Technology Update	Mr. Michael Seablom
11:45 – 1:00	***Lunch:*** **Presentation** "Study of a Near-Term Interstellar Probe: Current Status"	Dr. Ralph McNutt John Hopkins University Applied Physics Laboratory
1:00 – 2:30	SMD Science Activation Program National Academy of Sciences (NAS) Assessment Discussion	Ms. Kristen Erickson Dr. Margaret Honey New York Hall of Science All
2:30 – 3:00	DAC Chair Reports Planetary Science Advisory Committee Astrophysics Advisory Committee	 Dr. Anne Verbiscer Dr. Feryal Ozel
3:00 – 3:15	***Break***	



Dial-In (audio) & WebEx (view presentations online) information is located on page 2.

3:15 – 3:25	Public Comments	
3:25 – 4:15	Discussion	All
4:15	***Adjourn for Day***	

Tuesday, November 19

8:30 – 8:35	Re-Open Meeting	Ms. Elaine Denning Dr. Meenakshi Wadhwa
8:35 – 9:45	Planetary Protection Independent Review Board (PPIRB)	Dr. Alan Stern Southwest Research Institute
9:45 – 10:15	DAC Chair Reports (continued) Heliophysics Advisory Committee Earth Science Advisory Committee	 Dr. Michael Liemohn Dr. Thomas Herring
10:15 – 10:30	***Break***	
10:30 – 11:15	Moon to Mars	Mr. Steven Clarke *(via telecon)*
11:15 – 12:15	Discussion, Findings and Recommendations	All
12:15 – 12:45	Outbrief for SMD AA	Dr. Meenakshi Wadhwa Dr. Thomas Zurbuchen
12:45	***Adjourn***	

Dial-In and WebEx Information

For entire meeting

Dial-In (audio): Dial the USA toll free number 1-888-469-1762 or toll number 1-212-287-1653 and then enter the numeric participant passcode: 8281293. You must use a touch-tone phone to participate in this meeting.

WebEx (view presentations online): The web link is https://nasaenterprise.webex.com, the meeting number is 906 106 313 and the password is SC@Nov2019 (case sensitive).

** All times are Eastern Time **