NASA ADVISORY COUNCIL

SCIENCE COMMITTEE

March 12-13, 2020

Telecon Meeting

MEETING REPORT

May 27, 2020

Meenakshi Wadhwa, Chair

Elaine Denning, Executive Secretary

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Prepared by Joan M. Zimmermann
Zantech IT, Inc.

March 12, 2020

Opening Remarks

Ms. Elaine Denning, Executive Secretary of the NASA Advisory Council (NAC) Science Committee (SC), opened the meeting and made some administrative remarks. Ms. Denning introduced Dr. Meenakshi Wadhwa, Chair of the SC, and member introductions were made. Dr. Wadhwa briefly introduced the agenda.

NASA Science Overview and FY21 President's Budget Request

Dr. Thomas Zurbuchen, Associate Administrator (AA) of the Science Mission Directorate (SMD), provided an overview of the directorate. Due to the coronavirus outbreak, NASA Headquarters operations are being adjusted accordingly. Headquarters is working on a staged approach, focused on the evidence as it becomes available, and is standing ready to adapt to changing conditions. It is expected that ongoing work in hardware development and production might be impacted over time. Ames Research Center went to mandatory telework due to an exposure, and eventually hardware work could be delayed. Earlier that morning, there was a press conference with the European Space Agency (ESA) and Roscosmos on the subject of the ExoMars mission, announcing that the launch has been moved to 2022. After his conversations with ESA's David Parker, Dr. Zurbuchen's sense was that ESA made the right decision. NASA's contribution to the ExoMars mission, the Mars Organic Molecule Analyzer (MOMA) mass spectrometer instrument, at a value in the excess of $100 million, still will be part of the instrument suite. Dr. Zurbuchen said he received assurances from ESA that the delay will not affect Mars Sample Return (MSR). MSR still is going forward as planned, with its launch anticipated for 2026, and with ESA contributions.

Effective as of early March, there is a new Deputy Associate Administrator (DAA) at SMD, Ms. Sandra Connelly, who had been serving as Deputy Associate Administrator for Programs (DAAP). She has lots of experience, is a strong "process" person with an engineering background, and will complement SMD AA. Former SMD DAA Mr. Dennis Andrucyk has taken the position of Director of the Goddard Space Flight Center (GSFC), a win-win for both NASA and GSFC.

SMD will be announcing openings for Program Executives (PEs), and is planning to fill multiple GS-801-14/15 positions. There will be similar openings for Program Scientists (PSs) shortly after the PE announcement. In order to do the best job NASA Science can on behalf of the scientific community, SMD needs great talent, and the directorate puts a lot of effort into that.

Changes in the NASA Science fleet include the renaming of the ESA satellite Sentinel 6A, to Sentinel 6A Michael Freilich, to honor the retired Earth Science Division director. Sentinel 6A is a mostly European-funded mission. The renaming, initiated by European colleagues, demonstrates the depth of the collaborative ties between the U.S. and Europe in Earth science, and SMD deeply appreciates its ESA colleagues and is looking forward to continuing to work closely with them. Dr. Freilich presided over a significant expansion in NASA Earth Science missions and research in his 12 years as division director.

A NASA Town Hall meeting on the Fiscal Year 2021 President's Budget Request (PBR) is scheduled for March 20. Science highlights include a Transiting Exoplanet Survey Satellite (TESS) result. TESS found its first Earth-sized exoplanet in a habitable zone in the constellation Dorado. The mission continues to support amazing work thanks to both the team and the open data policy, the latter of which is helping the entire community. Parker Solar Probe (PSP) continues to reap milestones and make news, setting a record for both speed and proximity to the Sun. PSP's first results were published in Nature recently, describing one of the phenomena that has been ascertained by multiple sensors. The shape of the Sun's magnetic field is not just a microscope spiral but also appears to have "switchbacks" that can go back to the Sun, indicating a dynamic process in the solar atmosphere. There is much discussion occurring about the

nature of these processes and how these contribute to coronal heating. *The Astrophysical Journal* has issued a special supplement on PSP results.

The Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx) spacecraft continues to orbit the asteroid Bennu and is preparing to obtain a sample for return to Earth. The proposed sampling site is called Nightingale. The complex sampling touchdown maneuver will require much planning. A site named Osprey will be the backup sampling site. The Geostationary Operational Environmental Satellite (GOES-17) provided valuable imagery of the 2019 Australian bush fires, using its Advanced Baseline Imager (ABI). The James Webb Space Telescope (JWST) team is doing well. JWST is 41 weeks from delivery, scheduled for late December. The schedule is tight, and everything must go right to get to launch. During the last six months, all troublesome hardware has been replaced and the team has remained on schedule, within their reserves. If you look at the whole schedule assessment, what comes out is that the likelihood of JWST making the March 2021 launch isn't very high, but the performance has been on track for the last six months. The Mars 2020 rover mission (M2020), now known as Perseverance, has been shipped to the Kennedy Space Center (KSC) and is undergoing final work for launch vehicle (LV) integration, proceeding to launch in July of this year. COVID-19 probably is the biggest threat to this mission, but M2020 remains Green for schedule at present.

The FY21 PBR, more than $25 billion for NASA's future in space, is one of the strongest budgets in NASA history, representing an increase of approximately 12% over the FY 2020 level. The PBR supports Decadal Survey (DS) priorities MSR, Europa Clipper, and new Earth Observing (EO) missions, and keeps the Agency on track for the human landing on the Moon in 2024. If you look at history, when human exploration has received strong strategies, science has fallen to the wayside, and this has pitted organizations against each other; but that did not happen here. Dr. Zurbuchen congratulated the science team for their work in budget cycle development, and expressed his appreciation for Administrator Bridenstine regarding his strong support for SMD endeavors, and for exploration.

The FY21 budget supports the Artemis program with enhanced lunar science and technology demonstrations, and strengthens collaborations between science and exploration. For example, Artemis is enabling new heliophysics missions that look at space weather forecasting and the special line of Sun-Earth interactions at the Moon. Overall, Artemis supports the development of more than 15 missions, bolsters crucial lunar science with the Commercial Lunar Payload Service (CLPS), to deliver S&T payloads beginning in 2021 virtually anyone on the Moon, and initiates the search for polar ice via the Volatiles Investigating Polar Exploration Rover (VIPER), scheduled to launch in 2023. The new budget also will enable development of a more robust lunar rover (solar power), and help provide valuable precursor experience for human exploration of Mars with missions such as MSR and the newly announced Mars Ice Mapper. MSR is the highest priority from the 2013-2022 Planetary Science DS; Mars Ice Mapper, was not in the last Planetary DS, but not every mission SMD does has to be in the DS, and this actually was recommended in the 2017 DS mid-term report as a contribution to the communications relay infrastructure that is sorely needed at Mars. One of the mission instruments is already funded by the Canadian Space Agency; it will not be a large, costly mission for NASA.

The budget also supports a balanced and integrated program of over 40 missions in formulation and development, including MSR, Europa Clipper, the New Frontiers and Discovery programs and the Near-Earth Object Surveillance Mission (NEOSM) for planetary defense. It includes Earth Science implementation of the first Designated Observable (DO) mission, and full funding of the Earth Venture Class portfolio. SWOT and NISAR also are international partnership missions that are funded going forward. It also supports the Heliophysics Division (HPD) Interstellar Mapping and Acceleration Probe (IMAP), Explorers, and Geospace Dynamics Constellation (GDC). The budget advances compelling science with highest national priorities, including the Double Asteroid Redirection Test (DART);

prioritizes Astrophysics Division (APD) funding for competed small missions and research; and fully funds JWST for launch in 2021. SOFIA is not funded. Finally, the budget will support NASA in its ability to execute innovative partnerships, with over 400 SMD agreements.

Strategy and key highlights were addressed by Mr. Craig Tupper, who Dr. Zurbuchen noted would be retiring later this Spring. Dr. Zurbuchen expressed his appreciation for Mr. Tupper's excellent service and consistently high performance. Mr. Tupper provided some details of the budget, beginning with a slide describing the cost performance of recently launched missions. He noted that over the last 8-9 years, all of the missions in total have underrun the Phase C/D budget slightly, by about 4%. When M2020 comes along, the -4% figure will approach zero. When JWST comes in, the net overrun will be an additional $800M, for a total of a 5% overrun. Overall, Mr. Tupper felt that performance was satisfactory. SMD received approximately $7.1B from Congress in FY20. In FY21, the request is $6.3B, the difference being not requesting funding for the Wide Field Infrared Survey Telescope (WFIRST), the Plankton, Aerosol, Cloud and ocean Ecosystem (PACE) mission, the Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder, and the Stratospheric Observatory for Infrared Astronomy (SOFIA). These have been zeroed out during the last three budget cycles. Historically, back to 2013, Congress has enacted budgets that are much healthier than requested for NASA Science. Dr. Zurbuchen noted that the current $7.1 billion budget for SMD is a historically large number, and expressed appreciation for Congress' decision and taxpayer support for science. The intent is to continue to have SMD act as careful stewards of such funding.

Planetary Science Division (PSD) Director, Dr. Lori Glaze, addressed the planetary science budget for FY21. What has changed is the following: the budget proposes that the Europa Clipper launch in 2024 on a commercial vehicle, which would save $1.5B, and make the Space Launch System (SLS) available for an Orion launch to the Moon. The Dragonfly mission to Titan has been selected as the New Frontiers (NF) mission, with a launch readiness date (LRD) of 2026. The budget also supports CLPS based on awards to date; CLPS now has 14 commercial providers. The first two CLPS launches in 2021 will carry science instrumentation and tech demonstrations. The budget provides an increase to the small satellite SIMPLEX line. Dr. Glaze said she had been pleased with proposal quality, and hoped to increase SIMPLEX opportunities in the future. The budget also reflected an increase in the PSD Research and Analysis (R&A) program, as recommended by the DS, and begins studies on Mars Ice Mapper with international and commercial partners. What is the same is the following: the FY21 PBR enables an MSR launch in 2026; implements the M2020, Dragonfly, and Psyche and Lucy asteroid missions; supports NASA instrumentation for the international missions ExoMars, JUpiter ICy moons Explorer (JUICE) and Martian Moons eXploration (MMX); enables Discovery selections in 2021; and supports the NF 5 Announcement of Opportunity (AO). However, there is no funding for a Europa lander. Asked about the Mars Ice Mapper timeline, Dr. Glaze said the intent would be to have it launch with MSR (roughly an LRD in 2025/26). Dr. Zurbuchen said the launch could be as late as 2028, but his sense was that it was best to begin studies as soon as possible.

Astrophysics Division Director (APD) Dr. Paul Hertz addressed the astrophysics budget. What is the same is the following: JWST is fully funded; no funding for WFIRST; Spitzer mission was completed in January 2020; Hubble, Chandra, and other operating missions are continuing; Imaging X-ray Polarimetry Explorer (IXPE), Galactic/Extragalactic ULDB Spectroscopic Terahertz Observatory (GUSTO), X-ray Imaging and Spectroscopy Mission (XRISM), and Euclid development are on track and within budget. What has changed is the following: APD has a new initiative, the Astrophysics Pioneers Program, for small satellites, balloons, CubeSat constellations, and smaller International Space Station (ISS) payloads. The budget supports the newest medium-sized Explorer (MIDEX) selection, Spectro-Photometer for the History of the Universe, Epoch of Reionization, and Ices Explorer (SPHEREx); a new Mission of Opportunity (MOO), Contribution to ARIEL Spectroscopy of Exoplanets (CASE), for inclusion in ESA's ARIEL mission; and again proposes the termination of SOFIA. The budget also extends Fermi, Neutron

Star Interior Composition Explorer (NICER), Nuclear Spectroscopic Telescope Array (NUSTAR), Swift, TESS, and the X-ray Multi-Mirror Mission (XMM), per the results of the 2019 Senior Review.

Dr. Zurbuchen briefly covered the details of the HPD budget. Changes include the addition of the Heliophysics Explorer selections Polarimeter to Unify the Corona and Heliosphere (PUNCH), Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites (TRACERS), and Atmospheric Waves Experiment (AWE). The Space Weather Science and Applications (SWxSA) program budget enables the development of a sensor package on the Power Propulsion Element (PPE) of the Gateway, in support of the Artemis Program. In ESD, the FY21 budget continues to support commercial data buys, initiates the first DO mission in FY21, and provides for the first Earth Venture Continuity selection, an award that will go to the University of Colorado for a radiation budget instrument. In the Joint Agency Satellite Division (JASD), the budget proposes to extend the life of the Deep Space Climate Observatory (DSCOVR), which now is back online, by developing a gyro-less control system. The JASD budget also supports the release of a solicitation of instruments for the mission Space Weather Follow On L1 (SWFO-1), in coordination with NOAA.

Dr. Zurbuchen addressed some ongoing issues in planetary protection. In June 2019, NASA requested the creation of a Planetary Protection Independent Review Board (PPIRB), led by New Horizons PI, Dr. Alan Stern. Its final report has been released, and SMD is now focused on implementation of the PPIRB's recommendations. The response is being led by senior policy analyst Dr. Ursula Rick, who is doing amazing work. The resulting implementation effort has led to the drawing up of a NASA Interim Directive (NID) that will address planetary protection categories for robotic and crewed missions to the Moon. NASA also has asked the National Academies of Science, Engineering, and Medicine (NASEM) to review the PPIRB's conclusions, while the Agency utilizes PPIRB inputs to update policy requirements. A statement of task concerning lunar planetary protection is being submitted to NASEM. Other community work is going on in parallel with respect to developing new planetary protection policies at Mars. It is estimated that it will take about two years to carry out the entire response to PPIRB, including answering knowledge gaps. The next call planned for ROSES21 will put into place an annual cadence for planetary protection research on topics such as bioburden and microbial detection. PSD also is starting a discussion of scientific requirements for receiving and analyzing Mars samples. NASA facilities and the National Environmental Protection Act (NEPA) team are meeting to look at restricted Earth return and curation facilities. A plan is due at the end of March 2020, and a communication plan for MSR also is in process in the PSD, due at the end of March. Ursula Rick is the person to talk to if you need to know anything else in more detail.

Recent accomplishments in the Lunar Discovery and Exploration Program (LDEP) include five CLPS projects representing compelling science. For example, one of the CLPS landers will liberate materials from the regolith that scientists will be able to measure using a spectrometer. Another mission will look at the behavior of dust in electric fields. There also has been new activity in the Apollo Next Generation Sample Analysis Program (ANGSA), which is preparing to open a long-sealed Apollo core that will inform the curation of future moon samples. When we send humans back to the Moon, we will be able to bring more samples back.

Dr. Wadhwa asked Dr. Glaze to talk more about the budget for Artemis science. Dr. Glaze noted that there is funding in the FY21 budget not just for CLPS, but for the VIPER mission. The funding is directed to Ames Research Center. VIPER builds on the heritage of the former lunar Resource Prospector project. VIPER carries several instruments and will be designed to "survive the night." NASA also is looking at commercial options for rovers. In the Moon to Mars program, there is science funding for development of MSR and Mars Ice Mapper, and funding for instrument payloads in all of SMD to close out knowledge gaps for Artemis. Asked if there would be an expansion of rideshare opportunities on CLPS missions or other Moon to Mars activities, Dr. Glaze said that CLPS are commercial missions, and that each

participating commercial entity has the option of offering rideshares. Dr. Zurbuchen added that these discussions with CLPS providers are ongoing. In all other cases for NASA launches, it is a matter of policy to consider rideshares, including CubeSats and ESPA-ring opportunities, for additional science. Dr. Zurbuchen highlighted the ride-share opportunities associated with the Psyche launch as an example, and said SMD was looking at opportunities both in Earth's orbit and away from Earth.

Asked what he viewed as the biggest vulnerabilities arising from the COVID-19 outbreak, Dr. Zurbuchen cited much ambiguity at the moment, even among the best experts. NASA is looking at all options using a staged approach, and will continually assess the situation. He anticipated that the largest impact would be on face-to-face meetings. If travel is restricted, NASA will have to prioritize urgent activities to keep missions going. It is too early to predict all of the effects, but all key center leaders have been queried and consulted. The missions affected the most are the ones that have planetary windows and orbit specificities: M2020, Lucy, and Psyche. Next in line for impacts are any missions that are late in the integration and testing phase, such as JWST. Landsat and some other satellite missions might be impacted, as well.

Goals of the Meeting

Dr. Wadhwa enumerated the goals of the meeting, noting that she would have to step off briefly from 2:00 – 3:00 p.m. Eastern, at which time Ms. Denning would lead the meeting. The goals of the meeting were to be focused on providing advice on topics such as 1) Moon to Mars/Artemis including near-term science on VIPER and overall approach informed by a discussion with the incoming Human Exploration and Operations Mission Directorate (HEOMD) AA; 2) NASA responses to NASEM report recommendations; 3) the new PI Launchpad Workshop; and 4) the Division Advisory Committee (DAC) updates. The Science Committee also would hear about an SMD data management strategy that responds to previous SC findings.

Spitzer Space Telescope Legacy

Dr. Thomas Soifer, with Dr. Sean Carey and Dr. Michael Werner, provided a presentation about the end of Spitzer's mission, and its enduring legacy. Launched on Aug 26, 2003, Spitzer achieved a cryogenic life of 5 years, 8 months, followed by more than 10 years of a "warm" mission. Spitzer has produced more than 8800 refereed papers to date, and has been successful beyond expectations, as well as far beyond its original Level 1 requirements. The telescope's infrared (IR) abilities enabled it to see through the dust in the galactic planes, illustrating why multispectral sensors are critical to understanding the universe. The advantages of space for IR astronomy include 100% transmission; a 10^6 decrease in sky brightness translates to a gain in sensitivity of over 10^3 over ground-based (GB) platforms. A stable environment also provides measurements to parts in 10^5 or better. These factors have enabled Spitzer to do major work in exoplanet discoveries.

A key attribute of Spitzer was the coldness of the telescope; originally, in the 1990 design, the whole system was launched cold with a large cryostat, an approach that was heavy and expensive. To reduce the cost of Spitzer, mission planners took advantage of radiative cooling and an Earth-trailing solar orbit. Spitzer was as sensitive as a 30-meter GB telescope for resolving infrared point sources. Spitzer was an 85-cm cold telescope, covering wavelengths from 3 -160 microns, capable of both imaging and spectroscopy. Gains for observations included a 1000-fold gain in sensitivity, which allowed a million-fold gain of mapping speed. Solar orbit provided gain in efficiency of observations (7000 hours per year). The orbit also contributed to stability for instruments, allowing long staring times at individual targets or orbits.

Spitzer has produced a rich scientific legacy in the study of dusty galaxies and galactic evolution; in viewing the first billion years of the universe; and for the discovery of exoplanets. Much of the universe is hidden by dust, an observation first revealed by Spitzer's Infrared Array Camera (IRAC) follow-on

surveys. Spitzer allowed us to increase redshift sensitivity and look back 11 billion years into the past, resolving great detail in galaxies such as M81, where imaging revealed how dust is heated by young, developing stars. M82, as well, is much more luminous in the mid- and near-IR range than in the visible (90% more luminous). Spitzer helped to demonstrate prodigious star formation in this galaxy, which deepened understanding of the rate of star formation. By observing a shrouded starburst in II ZW 96, in the infrared, Spitzer helped to quantify its hidden star formation.

Spitzer excelled in helping science approach Cosmic Dawn (the first billion years), by discovering the most distant galaxies. The "drop out" redshift method, using both Hubble and Spitzer images, has enabled observers to find galaxies 13B years in age or older. Searching for galaxies beyond redshift 10 with both Hubble and Spitzer have allowed us to get to about redshift 11.09, or 400 million years after the Big Bang.

Dr. Sean Carey addressed the Spitzer exoplanet legacy, which allowed characterization of "hot Jupiters" and rocky worlds outside the Solar System, through observation of transits. Spitzer helped to map the brightness of Hot Jupiter HD 189733b, and was able to measure the temperatures of the day sides and night sides of these hot Jupiters. The telescope also helped characterize the atmospheres of some exoplanets, led to the first detection of water vapor outside the Solar System, and also demonstrated that not all hot Jupiters are the same: nine planets have eastward or zero phase of temperature peaks, but CoRoT-2b uniquely has a westward temperature peak. Two Super-Earths observations also revealed that they had markedly different atmospheres, demonstrating the diversity of rocky systems orbiting close to their stars. Spitzer also viewed the seven planets in the TRAPPIST-1 system, which would fit well inside the orbit of Mercury, and were able to find the "habitable" zone in the system.

Dr. Soifer discussed the impact of Spitzer by way of the h index, or the number of times peer-reviewed papers cite data. The Hubble has one of the highest h indices (257). Spitzer has an h index of 185, but normalized to age, Spitzer has had the highest impact. Spitzer has provided more than 115,000 hours of science observations, has been cited in more than 8800 refereed papers to date, as well as many other papers resulting from the heavy use of Spitzer archives. It is notable that Spitzer's cost cap drove innovation (radiative cooling, orbit) of the satellite design; and its technology development was crucial to final performance. The simplicity of the facility and instrumentation made operations highly efficient. Spitzer demonstrates that Guest Observer (GO) multispectral science is critical for advancing knowledge. Furthermore, user community involvement proved key to Spitzer's success, and archival research continues to be highly productive.

Dr. Michael Werner commented that the amount of information extracted from exoplanets was extraordinary, which is a tribute to both the telescope and the creativity of the user community. One other point, true of most NASA observatories, is that Spitzer shows what humans can do when they are well supported and empowered. He thought Spitzer was a good pole star for what people can do when they have the opportunity.

Dr. Wadhwa congratulated the Spitzer team for its wonderful presentation featuring ground-breaking science, and was impressed by the scope of the science, and the number of people involved. She asked if there were any estimates of how many scientists participated during the lifetime of the mission. Dr. Werner felt it would have been hard to track this quantity because there had been so many repeat customers. A good fraction of the astronomical community has used Spitzer in one way or another. Spitzer had a very large observing program that took large amounts of data in key science themes, such as galactic plane surveys. It was a large community-based effort that emphasized giving the data away. Asked if there were any way to assess Spitzer's impact on early career researchers, Dr. Werner was not sure if it was possible, but noted that a recently held conference had included many students and "grand-students" of early Spitzer investigators, a very gratifying outcome. Young researchers also have been

leading some recent archival studies. An effort is under way to canvass the current population to determine this. Spitzer managed to fund its community well. Dr. Anne Verbiscer, a Spitzer user, expressed her thanks, commenting that Spitzer helped her discover the largest planetary ring in the Solar System in 2009. Dr. Woodward, another Spitzer user, commented that the telescope had made a big impact on the workforce through post-graduate support. He felt that the community was well-led, particularly in terms of the archive. Dr. Werner said the motivation for the legacy program came as a hedge against an abrupt cessation of the mission; it was so successful in both unbiased and targeted surveys that the mission continued to keep the legacy elements. This idea came from the community through a series of workshops.

Division Advisory Committee Reports

HPAC

Chair Dr. Michael Liemohn presented a status of the Heliophysics Advisory Committee (HPAC). There have been no activities since the last HPAC outbrief, as it has not met since the last SC meeting. Much has been happening in HPD, however, and Dr. Liemohn offered some highlights. Solar Orbiter (SO) was launched from Cape Canaveral on February 10; it will make several fly-bys of Venus, where it will be able to view the off-ecliptic heliosphere, and be an excellent complement to the PSP. SO will allow better views of the Sun, in regions that were previously poorly sampled. In the meantime, the PSP is discovering interesting data about the near-Sun environment. Right now PSP is at 26 solar radii (R_s), and will eventually get to 11 R_s. PSP has been finding interesting phenomena such as "switchbacks" in the interplanetary magnetic field, connecting plasma waves with particle acceleration, and has been encountering more dust than expected.

The low-Earth orbit (LEO) Ionospheric Connection Explorer (ICON) mission, launched on October 10, is studying the equatorial and upper atmosphere. ICON clearly imaged the shadow of the December 26 solar eclipse over Indonesia, where it showed how the upper atmosphere dramatically changed during the eclipse. The Phase 2 awards for the HPD DRIVE Science Centers will be the largest R&A projects ever awarded by HPD, reflecting the recommendations of the last Decadal Survey. HPD also has created a Heliophysics Mission Design School; it will hold two sessions per year, with the intent of bringing together science and engineering students in a mission implementation/design concept process. The first session is scheduled for August, the second in November. The School will provide a nice complement to the SMD-led PI Launchpad series. Dr. Wadhwa asked if there were any HPAC issues for discussion at the next meeting, such as a response to the recent NAS report on ride-share opportunities. Dr. Liemohn said HPAC had not yet formally reviewed this report, but that HPD certainly is interested in ride-along opportunities. Dr. Nicky Fox, Director of HPD, commented that HPD definitely wanted to have the HPAC weigh in on the report, as well as an Access to Space workshop, the decadal mid-term report, and pre-work for the new 2023 decadal survey.

Dr. Wadhwa took a moment to reflect on the recent passing away of NASA mathematician Katherine Johnson, who made pioneering contributions to NASA's early lunar exploration (an appropriate time to reflect in light of the upcoming lunar discussion).

Moon to Mars/Artemis Science

Mr. Steve Clarke, Deputy Administrator for Exploration (DAAX), provided an update on Moon/Mars activities. Last year LDEP brought on nine CLPS companies, and since that time has on-ramped five more: SpaceX, Sierra Nevada, Blue Origin, Tyvak and Astrobotics. These are companies that can take larger, heavier payloads to the Moon, and were chosen with VIPER in mind. Additional payloads are under discussion. CLPS now has a pool of 14 providers that can bid on task orders.

Currently, Task Order (TO) #2 is in process with Intuitive Machines and Astrobotics. The Astrobotics order includes lunar payloads and in-line technology demonstrations, to launch in September 2021. The Intuitive Machines project is under review, and NASA is looking to award at the end of March, also working toward a 2021 launch. TO #20A is designed to deliver VIPER in late 2023, with an accelerated mid-2023 option. CLPS is picking up the cadence. The 2021 CLPS delivery manifests include a mix of science, technology and exploration payloads (magnetometers, LIDAR, navigation demonstrations, and neutron spectrometers). NASA also will be taking performance data on Intuitive Machine's liquid oxygen (LOX) methane propulsion system. A provisional 2022 CLPS manifest includes projects that are leaning more toward PI-driven science payloads. A Moon Rover with Exploration Autonomy (a Moon ranger targeted the lunar polar region) is among these.

The next instrument call will be carried out through Payloads and Research Investigations on the Surface of the Moon (PRISM), starting with a request for information (RFI); the intent is to amass a catalog of instruments to award from 2023 through 2024. LDEP has shared this approach with the community and has received positive feedback. Lunar Trailblazer is a small satellite concept (12 CubeSats, "ESPA-grande" size) that carries a lunar thermal mapper and mineral mapper, which addresses a number of science questions. The lunar mobility strategy will be focused on ground truth of volatiles, in-situ resource utilization (ISRU) materials, as well as longer-duration missions. NASA is also putting out a TO study to existing CLPS providers to see if they have mobile capabilities, and also is talking with internationals including ESA and the Canadian Space Agency (CSA), who are interested in providing rovers. NASA also recently received responses to an RFI directed toward other companies that might provide rovers.

NASA has just announced that a space weather science instrument suite will fly on Gateway, which will include ESA and NASA contributions. The DAAX Office program scientist has been actively involved in internal and external engagements, and was at the table when the Human Landing System (HLS) was evaluated. Due to the coronavirus, NASA is postponing a planned lunar surface science workshop, and now is looking at conducting virtual workshops that eventually will lead to a face-to-face conference. The workshop received 172 abstracts. The DAAX office also has been leading SMD integration for payloads, and has been working with HPD on a suite of instruments for attachment to Gateway, among other activities.

Dr. Brad Bailey provided some insights on the science efforts in the Moon to Mars and Artemis programs, and on the planning and strategy for conducting science on the lunar surface. The Moon provides a natural laboratory for certain experiments. There is the potential to establish a radio astronomy network that can exploit the Moon's radioquiet far side, as well as projects that can advance the understanding of exoplanet development. These projects also feed forward to Mars. A number of common themes have arisen from studies that have assessed the value of the Moon in furthering Solar System science, including geochronology, or the impact history of the Earth-Moon system. The Moon also provides a platform to observe the universe; allows study of the effect of solar wind on airless bodies; and enables full-disc viewing of the Earth. The Moon can be used to develop an historical record of the ancient Sun, as lunar dust grains retain these particles. This latter investigation is suited to crew exploration on the surface, and sample return. Investigations enabled by the lunar environment spans life sciences, fundamental physics, and materials science. The science strategy at the Moon follows closely along with what the LDEP office is doing: sending instruments to the surface, and working with international and commercial entities. SMD is doing this in lockstep with HEOMD via Dr. Jacob Bleacher. Science proposed by 2024 includes polar landers and rovers to carry out the first exploration of permanently shadowed regions (PSRs); nonpolar landers and rovers to the Crisium region; orbital data; and initial research for ISRU.

There is a planned Lunar Surface Science Workshop in Denver, CO (which was in April but now is postponed), which will be a joint SMD/HEOMD/STMD conference to address priority locations within six degrees of the South Pole Aitken (SPA) basin. The workshop will focus on what technology development will be necessary to enable crews to conduct science, and what type of infrastructure will need to be emplaced. Lunar exploration enables a bold new era of human discovery; having humans and crew allows the mobility to visit geologically interesting features, and to conduct human-aided sample selection. Understanding volatiles will advance the development of sealed collection canisters; crew can install and employ more delicate instruments, using the Moon as a stable platform to study the universe. The science community is understandably keen on the return of lunar samples.

Dr. Woodward asked, with respect to human vs. robotic exploration, can this science effort tip the balance for crew? Humans can carry out science much more efficiently, and do initial prospecting. Taking advantage of human vision and cognition makes a powerful case for human involvement. Mr. Clarke said that with CLPS providers, the hope is to have the ability to go anywhere on the surface, including places where humans would not be sent (such as PSRs). Asked about planning for telecommunications and downlink infrastructure, Mr. Clarke noted that LDEP is working in the Agency to look at the requirements for common data relay, and is discussing an overall Agency strategy to accomplish this. Gateway will be one communications asset. It is recognized that there will need to be relay assets for far-side communications. Responding to comment regarding an Inspector General's report on the high cost of human activity regarding SLS, Mr. Clarke said that as CLPS is independent of SLS, it will not be impacted by SLS findings. The intent is to continue this part of the lunar exploration effort, which will support human exploration as well, perhaps by sending pre-emplacement of tools.

Volatiles Investigating Polar Exploration Rover (VIPER)

Dr. Anthony Colaprete, Project Scientist for the VIPER, presented details of the project, first giving a brief history. In 1994, the Clementine mission revealed the first evidence of water-ice on the Moon. Lunar Prospector provided more data, and the Lunar Crater Observation and Sensing Satellite (LCROSS) confirmed the presence of subsurface water and ice. The M^3 instrument on Chandrayaan confirmed the presence of ice at the lunar poles. VIPER is the next step in understanding the nature and abundance of lunar water. It is now known that the Moon has all three forms of Solar System water (endogenic, sequestered external, and in-situ). At present, there is a poor understanding of water distribution, which can be remedied by making surface observations and measurements. The previous Decadal Survey supports these ideas, as does the Scientific Context for the Exploration of the Moon (SCEM) document's science goals, and previously published strategic knowledge gaps (SKGs) for science and human exploration. A lunar polar volatiles mission is a "sweet spot" between science, exploration, and commercial actors. Ultimately, we need to understand what, where, and how much water there is on the Moon. VIPER differs from previous missions in that it builds on standard terrestrial investigations that identify or discover mineral "reserves" (i.e. prospecting), to understand the depth of ice and ice concentration. VIPER's goal is to identify a "reserve" of water on the Moon. NASA also has studied this problem with the U.S. Geological Survey (USGS). It is known that the Moon has surface frosts, pyroclastic deposits, areas of shallow bulk water (down to the one meter depth), and deep bulk water. These sources are being considered by ISRU teams.

The mission must sufficiently characterize an area to evaluate its water supply; and will use three steps to characterize minerals. It will be necessary to understand how the water got emplaced, and why it has survived in a location (retention) to strengthen predictive models. There needs to be a better understanding of crater mixing, temperature control and variation, as well as lateral spatial scales of ice stability depths; in the latter case, a rover would need to sample across scales from tens to hundreds of meters. Temperature can be used as a proxy to define locations as dry, deep, shallow, and surface. The variability of the ore deposit, the total yield for certain areas and volumes, and the variability from one site to another also needs to be assessed. All these measurements can be integrated into the creation of a

resource map, which can begin to generate some predictions as to how much water we can find, and where. Monte Carlo simulations of rover passes over a resource map have yielded an idea of how much sampling will be needed to characterize an area, resulting in a 10-20% error on a given traverse. Similar exercises and simulations have been carried out for subsurface sampling requirements.

The current concept for VIPER is a 400-kg solar array rover meant to last 90 days on the lunar surface. It will carry a mass spectrometer, neutron spectrometer, infrared spectrometer, and a one-meter drill that carries temperature sensors, to be delivered via a CLPS lander. The VIPER site selection near the poles will provide enough sunlight for operation, and there will be some overlap with Artemis landing site options. An example of a traverse would be at a South Pole site north of Nobile: 91 days, 20.5km (with returns to "safe havens"), 6 PSR visits, 24 science stations, and 40 drill sites. It has been requested that the rover go at least 30m into a PSR. The rover can only operate for 6 hours in a PSR, currently. Dr. Woodward asked if the project was taking topographical data into account. Dr. Colaprete said that the project is using a path-length multiplier to accommodate zig-zagging, and also was working on getting the resolution down, determining shape from a shading algorithm. The neutron spectrometer would be used as a sounding instrument. On Mars, a ground-penetrating radar (GPR) or other geo-sensing technique might be more appropriate. Dr. Liemohn noted the project's focus on the identification of volatiles for extraction or usage, and asked if there had been any coordination with the science community on fundamental discovery knowledge. Dr. Colaprete noted that VIPER does make measurements that are fundamentally important to lunar science, and that the project was working with SMD's Dr. Sarah Noble to make the connections. Lots of the usual suspects are involved here. Mr. Marc Weiser asked: how much are you balancing between remote and autonomous drive? Dr. Colaprete said that the project was using "wave-point" driving, which involves setting a point 4-8 meters away, toward which the rover drives autonomously. The approach is a mix between human-in-the-loop teleoperation and autonomy, and helps to accommodate short communication lags (seconds). It still is a work in progress. A fully autonomous robot might be best in the future. Mr. Weiser felt the mission would be served best by a highly optimized scheme to take advantage of the time on the surface. Asked if the VIPER would be seeking volatiles on human scale, Dr. Colaprete said the plan was to cover a total area of 1000 square meters, excavated down to a meter's depth. Measuring to depth will be difficult, remotely, which is why it is important to get to the surface.

Public Comments
No comments were noted.

Science on Gateway: Heliophysics Space Weather
Dr. Jacob Bleacher, HEOMD's Chief Exploration Scientist, presented a briefing on science that can be accomplished at the Gateway. As the Gateway will serve as a sustainable outpost in space for the exploration of the Moon and beyond, it will enable crew to reach cis-lunar space and the lunar surface; and enable, demonstrate and prove technologies for lunar surface. The Phase I Gateway architecture includes a Power Propulsion Element (PPE), a Habitation and Logistics Outpost (HALO), and a logistics capability for crew. Gateway also manages the Exploration Extravehicular Activity (xEVA) system (the lunar space suit). U.S. companies are exploring mature deep habitation concepts under the Next Space Technologies for Exploration Partnerships (NextSTEP) Broad Area Announcements (BAAs). The PPE is being developed by Maxar Technologies and HALO by Northrop Grumman. Logistics is being managed at Kennedy Space Center, and xEVA is being led out of Johnson Space Center. Phase I will focus on missions and systems to enable humans on the Moon in 2024. Phase I establishes minimum systems to support a 2024 lunar landing while also supporting extensibility for 2024, and provides a command center and aggregation point for crew. Phase II Gateway will establish a sustainable and long-term presence on the Moon, and will focus on resilience, sustainability, and robustness in the lunar architecture, using an open architecture and interoperability standards. All of this is dependent on partnerships—international partners already are embedded at all levels. International interoperability standards will encourage future

partnerships. A 2018 Gateway science workshop resulted in a number of ideas. Opportunities at Gateway will be limited, however. It is much smaller than ISS (the size of two large closets vs. a five-bedroom house), and will probably only receive one re-supply visit per year. Currently, the program is focusing on long- and short-term plans simultaneously, which is a little different than business as usual. NASA is addressing this by identifying a limited number of lunar-related science projects that could be done in the early phase of Gateway development, pursuing activities that buy down risk for crew, conducting science unique to the Gateway environment, and also pursuing payloads that facilitate student engagement and public outreach. Some common themes that have been identified from discussions with international partners are: understanding the radiation and space weather environment, and heliophysics science. The first two experiments scheduled to fly on Gateway are a heliophysics experiment and an ESA-led radiation package. The two experiments have complementary instrumentation, and represent the strong partnership between the four other agencies involved (ESA, CSA, JAXA, and Roscosmos).

Dr. Jamie Favors addressed the details of these first two payloads, which will help to establish early science return for the program, and which also will provide critical space weather data to protect crew at both Gateway and the Moon. The instruments also are complementary with those of the Heliophysics missions, Time History of Events and Macroscale Interactions during Substorms (THEMIS), and Acceleration, Reconnection, Turbulence and Electrodynamics of the Moon's Interaction with the Sun (ARTEMIS). The HPD payload will enable 1) collection of data on solar energetic particles, solar wind structures and galactic cosmic rays (GCRs), 2) a synoptic view of global energy input into the magnetosphere during solar storms and substorms, and 3) how magnetic reconnection occurs. These data will lead to solar energetic particle (SEP) forecasts to support Artemis, SEP nowcasts, and the measurement of higher energies that have the potential to impact crew. The payloads also will feed forward to Mars; science collected here will advance understanding of what measurements and techniques will be needed to enable forecasting for crew *en route* to, and on, Mars. At the same time, the future GDC will be providing information about the ionosphere and thermosphere on Earth.

Dr. Liemohn asked: what is the energy range of the proposed Miniaturized Electron and Proton Telescope (MERIT) instrument with respect to SEP? Does it cover the energy range of the bulk of energetic protons? Dr. Favors said the MERIT's energy range is a couple hundred MeV (Mega electron-volt). Dr. James Spann added that the instrument is focusing on the suprathermal energy population, while electrostatic analyzers will capture thermal ranges. Dr. Hoffman commented on the excellent quality of the presentation, adding that the addition of more space weather stations will be very valuable. He asked: What will the human crew do when they are there? Are the crew serving as guinea pigs for radiation? NASA needs to pay close attention to the actual science that is made possible by presence of humans at Gateway. Dr. Bleacher said that the project also is investigating options for internal activities, and plans to leave medical supplies in the HALO. NASA also wants to understand radiation effects on hardware, food, and medicine; these data also will feed forward to Mars needs. Dr. Thomas Herring asked: how concerned are you about the accelerated development schedule? Dr. Favors noted that the instruments were selected for their maturity, and that there is high confidence in their operational capability. The directorates are also leaning in to make these payloads possible. Dr. Bleacher added that there is much unheralded work behind this effort. Dr. Woodward asked if the risk posture had been relaxed to achieve the schedule. Dr. Fox commented that the project should be thought of it as tailored class D; HPD is taking a risk on the ability to deliver the instruments, and that it is understood that it is an optimistic schedule; however HPD has gone to great lengths to identify and provide high technology-readiness level (TRL) instruments that pose no risk to crew.

Wrap-Up Discussion

Dr. Woodward asked if there were any final publications planned for Spitzer to synopsize its total science output. Dr. Verbiscer reported she would be contributing to the subject in an upcoming *Nature Astronomy* issue. Ms. Denning said that she would check back with Spitzer scientists and make the issue available.

Dr. Wadhwa brought up the workforce issues endemic to missions with long lifetimes, and pondered how the work force might be better tracked or assessed. Dr. Herring commented that Spitzer influenced several generations, and that it would be worthwhile to track, in a measurable way and from the outset, the community served by these major observatories. It also would be beneficial to track the diversity of these teams. Dr. Herring agreed to craft a finding to this effect.

Dr. Woodward inquired as to how much the space weather environment can be measured from the lunar surface, adding that unanticipated environmental effects can affect science return. Are the scientific requirements for radio communications from the far side known? Ms. Denning sent these questions to the relevant presenters.

Dr. Hoffman noted what he considered to be some wishful thinking on the possibilities of servicing space telescopes to keep them cryogenically sound. He mentioned that Spitzer originally had been proposed as a Shuttle release. Dr. Woodward asked what the Agency-wide strategy or plan would be to manage all the components of telecommunications with respect to Gateway, given that we already know bandwidth is strained. Dr. Michael New noted that NASA's 70m dish in Canberra will be offline for 6-12 months while it undergoes renovation; however, NASA has contingency plans to enable continuing communications with spacecraft such as Voyager and New Horizons during the repair period. The last time such facilities underwent a major overhaul was in the early 1970s; the renovation is overdue.

Dr. Liemohn said he had been struck by the comparison of sizes of the ISS to Gateway; does this mean there can be no permanent crew at Gateway? What does it mean for human-in-the-loop experimentation? Dr. Hoffman asked: what are the plans to use humans to carry out science at Gateway, or on the Moon for that matter? Mr. Weiser recommended a finding on the VIPER's speed as a limiting factor. He observed that doubling VIPER's speed would increase the number of drill sites. Dr. Herring expressed his concern about impacts from the human exploration program budget on the science budget. Dr. Wadhwa noted that the SC had issued a finding directly related to this matter at its last meeting. Ms. Denning offered to send the November finding to the SC for further consideration. Ms. Denning noted that Dr. Colaprete had provided an answer to a previous VIPER question and that she would be sending it to the Committee. Dr. Liemohn commented that while the THEMIS/ARTEMIS constellation had enough fuel to orbit the Moon, it wasn't designed for prolonged orbiting. He felt that the proposed space weather mission for Gateway was the right one. The SC noted the value of the Moon to Mars presentations and asked for frequent briefings on these activities into the future.

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Ms. Denning and Dr. Wadhwa re-opened the meeting and SC members re-introduced themselves.

NASEM and IRB/IRT Results Implementation

Dr. Michael New co-briefed with Dr. Alan Zide, describing NASA's response to a number of reports from the NASEM and from NASA's independent review boards (IRBs) and independent review teams (IRTs). Because some advice is or may become cross-cutting, in order to better manage responses, NASA has tasked a single policy analyst as a Report Response Manager (RRM). This individual has the responsibility to ensure that responses to the reports are managed in a timely manner. Dr. New's briefing focused on four reports: the draft NASA Science Plan, the PPIRB report, the NASEM assessment of SMD's Science Activation Program, and the NASEM report on open software policy.

The draft NASA Science Plan is SMD's accompaniment to the NASA Strategic Plan. NASEM reviewed the plan, and provided 17 recommendations to improve the document. The Agency has accepted most of the recommendations and revised the plan accordingly. NASA will release the final version of the plan within months.

The PPIRB was established in response to a NASEM report entitled *Review and Assessment of Planetary Protection Policy Development Processes*, and a recommendation from the NAC. The PPIRB examined the scientific, engineering, industrial, legal, and program management aspects of planetary protection, and issued 77 findings and recommendations. SMD responded by requesting that the Space Studies Board (SSB) form a new discipline committee, the Committee on Planetary Protection (CPP), to be active until at least the end of the SSB contract. NASA has requested a number of reports from this new discipline committee: a review of PPIRB findings and recommendations; a study on Moon planetary protection (protecting Apollo sites, etc.); a study on Mars planetary protection categorization; planetary protection for human missions to Mars; a study on small bodies planetary protection; and an update of NASEM's 2012 publication on icy worlds.

The Board on Science Education (BOSE) conducted a study on NASA's Science Activation Program (SciAct), and issued a number of findings associated with seven recommendations. In response, the SciAct has formed a partnership with the Board. BOSE will assist the SciAct Program through facilitation and execution of a series of planning meetings and workshops to help establish mid-level objectives to guide the portfolio's work. BOSE also will create a short-term ad hoc consultancy to allow BOSE staff and committee members to continue to support implementation of report findings with SciAct leadership in real time, as well as present and disseminate the committee report to different audiences. SMD will bring experts into the process, to provide guidance in key areas.

A 2018 report entitled *Open Source Software Policy for NASA Earth and Space Sciences* identified seven goals, and 10 recommendations regarding a wide range of issues. In response, SMD has stood up a Strategic Data Working Group, and will be hiring a full-time Science Data Officer to implement the recommendations. In addition, SMD took four steps in ROSES 2020 to implement the NASEM study:

- After 4 years of requiring data management plans in all ROSES proposals, the evaluation of these plans will now become a part of the Merit Criterion.
- All new software created with funding from ROSES2020 awards now is expected to be released as open source software under a permissive license and uploaded to the NASA GitHub.
- A new solicitation allows for proposals to maintain, sustain, or extend existing open source libraries, frameworks and tools.
- A new supplement program allows existing and new awardees to request a fixed cost supplement to be used to begin transitioning legacy software to open source.

Dr. Zide provided a description of the HPD response to a report from the NASEM Committee on Solar and Space Physics (CSSP) that HPD had requested in seeking guidance on how it could take advantage of short-notice rideshare opportunities. The report concluded that science suited to an agile rideshare program can be categorized into three groups: space weather and space climatology enabled by temporally continuous observations; systems and contextual science enabled by spatially distributed observations; and exploratory science enabled by novel observations (e.g., technology and new vantage points). From an implementation perspective, the CSSP report recommended that HPD be more programmatically efficient to be able to respond in a timely manner, and create "shelvable" instruments that are ready to ride. HPD also should accept a little more risk posture in these opportunities.

Dr. Vinton Cerf commented that with regard to NASA policy on open source data, the Agency needed to make sure to maintain the integrity of open-source software: how can NASA protect the software, and keep it from being modified? Ms. Ellen Gertsen, co-leader of the Strategic Data Working Group, said that NASA is very sensitive to the issue, and that the Agency would retain original software in archives. Dr. Cerf asked if the new solicitations for open source data were out on the street. Dr. New affirmed that they were, and Dr. Cerf requested an email containing links to the call. Dr. New enlarged on Ms. Gertsen's

remarks, noting that NASA would obviously have to develop more controlled repositories, beyond the present use of GitHub. Dr. Cerf offered to check on how the Jet Propulsion Laboratory's (JPL) software is being protected, to enable comparisons. Dr. Woodward asked what kind of International Traffic in Arms Regulations (ITAR) restraints or commercial priority restrictions would be involved in the process. Dr. New said that ITAR restrictions would be applied as a matter of course, and for commercial entities, NASA requires a permissive license. If the code is proprietary, open source would be a tricky prospect, and thus would be discouraged in proposals. If the code that runs the system is proprietary, however, he didn't think that the code written in that language would be restricted. If one were to create a new data language (IDL) and copyright it, or if one were to write something in IDL, it doesn't seem possible to restrict that. Dr. New also did not think that "reach-through" agreements would be relevant here. Asked about the status of the new NASEM committee on planetary protection, Dr. New said the request has been sent to SSB, and that NASA has requested that the committee's first order of business be to assess the planetary protection categorizations at the Moon. Currently, NASA is waiting for the NASEM to send a formal proposal, after which the committee will get under way.

SMD Data Management Strategy

Ms. Ellen Gertsen led an update on SMD's Strategic Data Management Working Group (SDMWG), first offering some history. In January 2015, the NAC chartered the Ad Hoc Big Data Task Force (BDTF) to study and identify best practices in big data. The final report of the BDTF was delivered to the NAC Science Committee in November 2017, which led to the prioritization of data management and science computing across SMD as an area for assessment and action. In February 2018, SMD chartered the SDMWG with representatives from each division to develop a SMD-wide strategy to enable greater scientific discovery, over the next five years, by leveraging advances in information technology to improve SMD science computing and data archives.

SMD developed its data management strategy based on four overarching principles: 1) improve discovery and access for all SMD data to immediately benefit science data users and improve the overall user experience; 2) leverage current technology for the discovery, access, and effectiveness of NASA's data, as well as enable new technology and analysis techniques for scientific discovery; 3) identify large-scale and cross-disciplinary/division science users and use cases to inform future science data system capabilities; and 4) champion robust theory programs that are firmly based on NASA's observations. Given the breadth and potential impact on the SMD community, NASA hosted workshops for archiving users and others in order to collect stakeholder feedback, leveraged NASEM recommendations on open software, and created the basis for an RFI to help shape guidance. As a result, SMD has adopted core tenets and guiding principles in its approach to data management:

- The status quo will not work. The rate of change in this area exceeds current capacity and current systems are not set up to allow us to be aspirational in the next five years without significant investment.
- Create a strong foundation that enables SMD to be responsive as the field changes.
- Centralized constraint model that 1) sets policies for all of SMD, 2) deals with exogenous risks/opportunities, and 3) shares best practices across the entire community will be managed by an SMD Data Officer.
- Not implementing a fully centralized approach. Consistent with the recommendation of the NAC SC, divisions must be responsible for the specialized components and implementation of policies to meet the needs of their communities.
- May want to reassess this model over time. Periodic evaluation, considering the needs and best practices in the future, is appropriate. Divisions also should be encouraged to conduct similar reviews over time to evolve their specialized capabilities.
- Management of equipment and hardware can be centralized.
- Want people who know the data to manage the data where it sits.

SMD has established a vision and mission statement. The vision is to enable transformational open science through continuous evolution of science data and computing systems for NASA SMD. The mission is to lead an innovative and sustainable program supporting NASA's unique science missions with academic, international and commercial partners to enable groundbreaking discoveries with open science data. SMD will continually evolve systems to ensure these are usable and support the latest analysis techniques while protecting scientific integrity.

Addressing specific findings and recommendations, Ms. Gertsen noted that NASA has adopted a standard open data policy for all new missions, and standard open data requirements in ROSES, using a lifecycle approach. NASA also is implementing some recommendations on high-end computing (HEC) to understand its true supply-and-demand profile. HEC assessments now will be made no less than every five years. Dr. Tsengdar Lee, Program Manager for HEC, already has initiated an assessment. In responding to recommendations on archive modernization, the SDMWG felt it was important to engage with data professionals in doing cross-cutting science discovery; to have experts in data science work with the archives to ensure they are state of the art; and to improve access to journals to make science papers more available to the public.

Pilot programs in SMD are in progress for exploring advanced capability, and making investments in training in Artificial Intelligence and Machine Learning. The position for the SMD-level Data Officer will be posted on USAJobs within the next month. Dr. Cerf offered to provide the announcement to some colleagues. Dr. Wadhwa asked if the new SMD Data Officer would assess existing gaps in some science databases. Ms. Gertsen thought that such a task would be more of a long-term goal, as SMD moves to a more common metadata system for all the disciplines. Dr. Woodward asked if the intent was for NASA to develop centers of excellence for data management. Ms. Gertsen thought that while what is available in industry far exceeds NASA, she didn't think the Agency was ready to make the shift to all-commercial sourcing.

Discussion

Dr. Cerf addressed details of the Research Data Alliance (RDA), funded by both National Science Foundation (NSF) and the National Institute of Standards and Technology (NIST), the idea of which is to explore how to preserve large amounts of data, metadata, calibration, reprocessing, etc., for both large and small data collections produced by space science. He felt that the RDA would be a valuable complementary activity for NASA. Dr. Woodward commented that the proposed $20K supplements for transitioning to open source probably were not adequate. Dr. New commented that the initial thought was that NASA could offer "seed" awards to fund some concept development, and then eventually endorse the process more fully. Dr. Liemohn commented that there already are data modernization programs in PSD and HPD, and was glad to hear about supplements for existing grants. He asked: is there any large effort in work for code modernization? Dr. New said there already were efforts in developing tools to increase the science value for planetary data archives, and hoped that other divisions were moving in that direction, as well. Dr. Herring asked for Dr. New's thoughts on inertia in the system, pushback on file transfer protocol (FTP), and how many carrots and how many sticks it would take to effect modernization. Dr. New said he was placing some hope in generational change; in addition, he felt some more experienced researchers would have revelatory moments when using new methods. Eventually proposers will have to play by NASA rules if they want grants. By analogy, he noted that microbiology journals won't accept papers if the microbes under study are not part of established, standardized collections. NASA will have to convince people of the value of modernized data, and move on.

Dr. Verbiscer said she understood that SMD was planning to consolidate social media profiles. Dr. New surmised that she was referring to NASA Office of Communications activities. One activity was to eliminate redundancy in NASA-associated websites, and the second was to consolidate social media

accounts such as Twitter and Facebook. NASA has concluded that the total reach of programs such as NASA Sun have greater reach than individual mission website presences. Dr. Verbiscer was skeptical of the idea that one umbrella site would broaden the reach. Dr. New recommended that the SC schedule a briefing from the Office of the Chief Scientist's Jim Green, and from SMD's Emily Furfaro, a social media specialist. Dr. Michelle Larson commented that her institution had gone through a similar activity, and supported the conclusion that consolidation of social media seems to be a good approach. Ms. Denning took up the briefing request as an action item for the next meeting. Dr. Wadhwa asked if the new SMD Data Officer would have budget authority. Dr. New said this was a question for Ms. Gertsen; he thought the position would be largely a coordinating function, but it may have some budget associated with it. Ms. Denning took an action to send the job announcement to the whole Committee. Mr. Weiser and Dr. Cerf noted that they wished to share it with several contacts. Dr. Liemohn thanked the presenters for the briefing on rideshare opportunities. Dr. Wadhwa requested that Dr. Liemohn comment on the recent National Academies report once he had reviewed it. Dr. Liemohn added that he had particularly liked the concept of instrument "shelvability."

The Committee briefly noted potential advice on the lunar program's impact on the SMD budget; ISS vs. Gateway volume/space; the VIPER rover's traverse speed, capabilities, and mission length; the Spitzer Space Telescope; and potential fallout from the ExoMars delay. Dr. New commented on the last potential finding, noting that the only effect thus far has been the postponement of the MOMA Participating Scientist program at NASA; there have been no other impacts to ESA partnerships.

Division Advisory Committee Reports

ESAC

Dr. Thomas Herring, Vice Chair of the Earth Science Advisory Committee (ESAC), provided an update. The ESAC held a meeting earlier in the week, after not having met face-to-face for some time. The committee heard updates on ESD and its decadal survey implementation strategy, DO studies, reports on the Earth Venture and Earth Venture–Continuity 1 programs, decadal survey incubation studies, the ESD commercial data buy, machine learning and artificial intelligence, and cross benefits between the applications and research programs. The FY20 appropriated budget of $1.97B largely supports ESD, but Earth Science Explorers are currently on hold. Dr. Herring addressed some features of the FY21 budget: what's changed is that FY21 supports the initiation of the first DO mission, the selection of Geosynchronous Littoral Imaging and Monitoring Radiometer (GLIMR) as next Venture Class-Instrument (EVI) mission; confirmation of the GeoCarb mission; and additional resources to support interagency requirements as recommended by the Satellite Needs Working Group. What's the same: FY21 supports 22 on-orbit missions, including instruments on the International Space Station (ISS); Surface Water and Ocean Topography (SWOT), NASA-ISRO Synthetic Aperture Radar (NISAR), the newly re-named Sentinel Freilich 6; Landsat 9; and Tropospheric Emissions: Monitoring of Pollution (TEMPO).

Major accomplishments of late included the launch of the Orbiting Carbon Observatory-3 (OCO-3) to ISS; launches of two CubeSat missions; and the entrance of PACE and CLARREO-PF into Phase C (implementation). Earth Science continues to make progress in Decadal Survey missions – the first EV Continuity mission, cost capped at150M, has been selected. Implementation of the Earth Science Explorer program will be a subject of the midterm report. The five DOs for mandatory acquisition, (Aerosols; Clouds, Convection, & Precipitation; Mass Change; Surface Biology & Geology; Surface Deformation & Change), have been condensed to four (one is a combined mission).

ESAC noted that the Program of Record is mostly implementing the recommendations of the DS, although the committee harbors some concerns on the EV-Continuity selection, currently scheduled to be launched in 2027. If the JPSS-2 satellite needs to be replaced earlier than expected, the instrument would

not be ready, and a new instrument design would pose a risk to continuity if the budget decreases its margin. In addition, ESAC notes that as the EVM brings in new investigators, the PI project management team needs to be carefully selected by the PI, given the size and complexity of the missions. The ESAC is also concerned that the Earth Science Explorer line is on hold due to budget constraints. The Committee applauded ESD collaborations and partnerships, and observed that it was impressed with the cross-benefits and impacts of the Applied Sciences Program (ASP). Data buys by ESD also have been important, but ESAC is concerned about restrictions in the end-user license agreements (EULAs), which can potentially impact derived products. ESAC will form findings and recommendations based on these concerns at a later time.

Dr. Wadhwa asked if overall, ESAC was comfortable with how the Decadal Survey was being implemented. Dr. Herring said yes, this was the case, and added that Ms. Sandra Cauffman, Acting Director of ESD, currently was planning to postpone the Explorer line until 2023; if ESD were to receive a consistent budget for the Explorer line, then the division could move toward it. Dr. Herring said that ESAC agreed with this approach. Dr. Cerf said he had worried about Administration resistance to Earth Observing (EO) programs of all kinds, but instead, he had the impression that there is indeed a vigorous program, with much support from Congress. Ms. Cauffman commented that the division had not been hampered and has continued to receive the budget needed; her only concern was the next Decadal Survey budget wedge.

APAC

Dr. Charles Woodward, new Chair of the Astrophysics Advisory Committee (APAC), reported on APAC's March meeting, the first in some time. Findings and recommendations are not yet complete. Major topics reviewed were APD updates on FY21, which appears relatively healthy, supporting JWST in 2021, maintaining the cadence of Explorers and of the Pioneers program for small satellites. APAC received mission updates on WFIRST, JWST, SOFIA, Laser Interferometer Space Antenna (LISA), and Super Pressure balloon campaigns. As noted previously, the FY21 calls for termination of SOFIA, and provides no funding for WFIRST.

APAC heard science highlights, including a presentation from the Spitzer Space Telescope Science Center on the total return of the mission. APAC appreciated Spitzer's unanticipated discoveries over its long lifetime. An outreach event on the Hubble Space Telescope (HST), commemorating the 30 year mission, has been delayed due to COVID-19. Despite the lack of funding in the FY21 budget request, WFIRST passed Key Decision Point-C (KDP-C) in January 2020. The telescope's flight hardware, spacecraft, coronagraph technology development unit are in testing. The WFIRST work force is approaching 1000 people, and the mission sill is on track for launch in mid-2020s. The search for a launch vehicle has been instituted, because the spacecraft is driving design. The APAC agreed with NASA's move to reclassify WFIRST's coronagraph instrument as Class D, with its own separate cost cap. The committee discussed the status of JWST, and was pleased with the program's confidence in achieving the March 2021 launch date. Two key milestones have been completed in JWST acoustic and vibration testing. APAC recognizes that technical risk for the mission still exists: fairing depressurization requirements, membrane release devices, and non-explosive actuators, all of which have correctable issues. The APAC also has three main concerns related to some recommendations on SOFIA Operations and Maintenance Efficiency Review (SOMER) and the SOFIA 5-Year Flagship Mission Review (FMR), and their implementation. The committee has requested information from the project, and thus APAC is not yet able to give advice on whether the project's findings are feasible and well-founded.

APAC is very interested in work force development, and applauds the initiation of the NASA PI Launchpad, as well as continued funding for the NASA Earth and Space Science Fellowships (NESSF); now known as Future Investigators in NASA Earth and Space Science and Technology (FINESST). APAC applauds NASA's attention to programs that are increasing participation of young scientists in

SMD disciplines. APAC also would like to view JWST during its Fall meeting, before it is shipped off for launch. Dr. Wadhwa said she was interested in APAC's thoughts on SOFIA, and would carry them back to the SC when finalized. She asked if APAC had any thoughts about whether the fellowship programs were increasing work force diversity. Dr. Woodward said the committee discussed identifying and tracking these individuals within legal constraints, and was looking at gender distribution as a first cut. APAC also had a discussion with Dr. Michael New on the PI Launchpad initiative and how to better engage underrepresented communities.

PAC

Dr. Anne Verbiscer, Chair of the Planetary Science Advisory Committee (PAC), gave a status of the Committee. The PAC has met twice since the last SC meeting. At the most recent telecon on December 6, the PAC heard a PSD status report, a PSD R&A status report, a report from the Planetary Senior Review, a report on the Space Telescope Science Institute's (STScI) Dual Anonymous Review process, a briefing from Dr. New on SMD plans for Dual Anonymous proposal reviews; and reports from analysis groups (AGs): the Venus Exploration Analysis Group (VEXAG), Small Bodies Analysis Group (SBAG), Outer Planets Analysis Group (OPAG), Mars Exploration Analysis Group (MEPAG), Lunar Exploration Analysis Group (LEAG), Mapping and Planetary Spatial Infrastructure Team (MAPSIT), and the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM). Findings from the telecon included encouragement for NASA in its efforts to implement the Dual Anonymous Peer Review (DAPR) process. PAC also issued findings on the potential impact of satellite constellations on NASA's near-Earth object (NEO) detection programs; delays and cancellations in the selections for planetary major equipment facilities (PMEF) calls, and a consequent concern for a potential lack of facilities to receive samples from OSIRIS-REx, as well as future samples from Mars. At the PAC's March meeting, the Committee heard reports about the PSD status, R&A, Planetary Protection, the Mars and Lunar programs, the Planetary Defense Coordination Office (PDCO), the Planetary Data System (PDS), the Planetary Data Ecosystem, a special Exoplanets in Our Backyard (EIOB) meeting (a very successful meeting on synergies between astrophysics and planetary science); astrophysics assets for Solar System observations; an update on JWST (Cycle 1 proposals are due on May 1); the establishment of a new Mercury AG; and the PSD AG reports.

The committee received briefings about the FY21 budget, which includes $35M dedicated to a new start for a NEO Surveillance Mission (NEOSM), and four finalist selections in the Discovery program: Trident (a Neptunian moon mission), Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging (DAVINCI+), Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy (VERITAS), and the Io Volcano Observer. The PAC is in the process of finalizing findings on the Europa Clipper launch vehicle; the Internal Scientist Funding Model (ISFM); anticipated missions in the next New Frontiers Announcement of Opportunity (AO); the WFIRST capability for Solar System observations (the ability to track moving objects); applause for the Planetary Data Ecosystem; and Senior Review results.

Dr. Wadhwa asked about the broader implications of implementing DAPR and how these were being assessed. Dr. Verbiscer said that PSD and SMD definitely are including expertise from social scientists in this area. Dr. New commented that SMD had two social scientists involved in the STScI experiments, and has invited them to review the NASA effort in DAPR. SMD plans to carry out data analyses on DAPR's impact on diversity. Asked about ISFM issues, Dr. Verbiscer explained that PAC had discussed it in 2018, and since that time PAC had not had any feedback on ISFM metrics: e.g., how many ISFM-funded scientists are sitting on panels and doing community service? Dr. Zurbuchen fielded the question, and said he thought SMD now was ready to start talking about ISFM after the accumulation of three years' worth of metrics. He said that he had made the decision to delay the output until the results were reviewed by the Office of the Chief Scientist, and offered a briefing on the metrics at the next SC meeting.

Dr. Cerf commented that he worried about small satellites interfering with NEO detection and asked if there was an identified solution. Dr. Verbiscer said that her understanding was that it is an active problem. Dr. Herring noted that satellite interference might impact NASA's ability to carry out the Agency's congressionally mandated goals, and that NASA would likely have more clout than individual scientists or organizations in approaching the problem. Dr. Zurbuchen welcomed a finding or recommendation on the subject. Dr. Cerf asked if ISS could make useful observations of the satellite constellations (and their impact on ground-based observations). Dr. Woodward said he knew of one company that had experimented with darkening one of its spacecraft, but did not know if ISS had the ability to observe small commercial satellites; other agencies are definitely concerned about LEO clutter.

Debrief to SMD AA

Dr. Wadhwa provided a synopsis of the potential outcomes of the meeting. SC is considering 1) a finding or recommendation that NASA develop tracking metrics for the professional development and diversity of the work forces that are associated with large, long-duration Decadal missions; 2) a finding or recommendation on the traverse speed and mission duration of the VIPER; and 3) advice on the scope and size of Gateway and potential limitations on humans doing active science there. Dr. Cerf offered to provide a connection to the NSF/NIST Research Data Alliance. Asked about the new Data Officer position in SMD and budget authority, Dr. Zurbuchen noted that while the officer was initially conceptualized as a coordination function, the budget goes through the SMD AA's office, and can be managed variably. The role may very well change, but what is certain is that SMD wants a person who worries about data and software management 100 percent of the time.

Conversation with HEOMD AA

Dr. Zurbuchen introduced Mr. Douglas Loverro, HEOMD's new Associate Administrator, noting that he and Mr. Loverro had been colleagues before their arrival at NASA.

Mr. Loverro said he had been in his position for 102 days, addressing the major task at NASA: to get us back to the Moon to stay, as well as to maintain Commercial Crew services, ISS, and other elements of human research in space flight. The major goal is returning to the Moon by 2024, sustainably, and then moving on to Mars. At present, he did not have a plan locked into the budget or into policy as yet. He said he based his approach on the maxim: if it is not necessary, it is a distraction. NASA has been asked to do something very difficult. NASA announced on March 12 that it would emplace some science experiments on the Gateway. The Gateway itself is not on the critical path to the Moon, which frees HEOMD to concentrate on lunar surface and lunar mobility planning, while science instruments help enable other aspects of getting back to the Moon. The development of Apollo's Lunar Exploration Module (LEM) was put on contract 6.5 years before landing on the Moon. To make Artemis happen in an expeditious fashion, NASA must remove program risks, and retire the highest risks. Risk must be moved into the earlier phases of development. Currently, there are 34 critical operations to get to the Moon; these operations must be performed within a 4.5 year schedule, which necessitates making wise decisions. To return to the Moon quickly and sustainably, NASA will have to decouple speed and sustainability issues. The Agency must recognize that when the goal to return to the Moon was moved from 2028 to 2024, NASA had not made the necessary changes to make the new direction happen. Mr. Loverro noted that his team is asking the key questions and coming up with the answers that assure him that NASA will get to the Moon by 2024, and get there sustainably. NASA will roll out this plan when it is done.
It will be necessary to plan for issues, failures, unknowns, and budget cuts, and plan for mitigations. With regard to the emerging coronavirus situation: do we have to do temperature checks on everybody at Stennis, for instance?

Dr. Wadhwa said she was pleased to hear Mr. Loverro's support for science, and asked how he planned to decouple "fast" and "sustainable." Mr. Loverro said that this decoupling was achieved in part by taking Gateway out of the critical path to the Moon. If Gateway were to get behind schedule, especially if Solar

Electric Propulsion (SEP) got into trouble, this would put into question the entire Moon shot. By decoupling Gateway, HEOMD can accommodate other players. For example, not a single international partner would have been ready to launch to Gateway until 2026. Lengthening the Gateway schedule also reduces cost. If that had not been possible, NASA would have had to cancel Gateway.

Dr. Hoffmann asked about HEOMD's commitment to SLS for the first lunar landing. Mr. Loverro said that NASA simply cannot get to the Moon without SLS; it will be necessary to get Orion to trans-lunar injection. He believed that the U.S. commercial enterprise will come up with robust answers, but NASA still will need SLS and transporters. Dr. Cerf asked: how critical is it to return to the Moon in the terms of utility? Can we establish a useful presence in the absence of Gateway? Mr. Loverro noted that if schedule were not an issue, one could argue that NASA could get to the Moon without the SLS. However, one also needs to see the excitement in the work force, in recruiting, and in the commitment to the 2024 launch date. He thought that the schedule acceleration had a positive impact as a great way to engage young students, as happened during the Apollo era. The Moon landing will encourage STEM engagement as well.

First SMD PI Launchpad Workshop

Dr. Erika Hamden presented a report on the results of an SMD PI Launchpad Workshop, created in response to the lack of diversity of proposers observed in the Astrophysics Explorer program, and to the paucity of women in PI roles and on science teams. The problem is variable in the other disciplines. NASA Headquarters has some limited influence in setting priorities, but is in fact at the very end of a long chain of decisions made by other groups. However, NASA can provide information about timelines (when to start building a team), contacts (who should you talk to at NASA Centers), industry partners; how to talk about a science case which is still evolving, and advice on how to be comfortable with uncertainty and the iterative nature of science. Dr. New and Ms. Gertsen of SMD, and Dr. Hamden co-planned the workshop, with the aid of a $100K contribution from the Heising-Simons Foundation and a $30K contribution from NASA. A STEM-equity consultant was hired and every attendee was funded. Each aspiring attendee filled out an application containing questions that focused on science, leadership, teams, and decision-making. Of 130 compliant applications, 40 people were funded. Of the 39 attendees, 2/3 were female. The workshop was held in Tucson in November 2019 over the course of 2.5 days, and included the participation of roughly 25 mentors, speakers, and industry partners. The workshop also included a workbook and agendas that Dr. Hamden offered to share with the SC. NASA also has held short sessions at recent American Geophysical Union (AGU) and American Astronomical Society (AAS) meetings to describe some of the workshop content. The next workshop may well be a bit longer to more thoroughly cover the issues.

The PI Launchpad 2019 agenda included topics such as creating a science case (panel), requirements (short talks), science traceability matrix, what to expect from the proposal process, how to build a science team (panel), how to get support from your home institution (panel), speed networking with industry and Centers, pitch development, proposal timelines, and how to tell a story.

Key takeaways gathered from a short survey were: the participants were appreciative, and several participants said the workshop had helped in their networking; 92% agreed it was a good use of time; and 93% felt they knew the next step they wanted to take (pre-assessment, 13%). Improvements were seen in almost all areas queried, such as developing science goals and objectives, pitches, and team-building. One astrophysics SmallSat investigation was an immediate result, and several other proposals are going forward. A website with conference materials will be posted, and an original paper will be written. This was a highly idiosyncratic workshop, which should be expanded in scope and generalized so that it can serve more people. It is important to distinguish what Headquarters can do vs. Centers and other players. Another PI Launchpad is planned for August in Ann Arbor, MI. This one will be three full days, and SMD is planning to lengthen the call for NSPIRES to 8 weeks and evaluate the word count for proposals.

NASA feels there should be a PI Launchpad every year, but the next one should include some expert advice for improvements. NASA would like to develop an incubator process (such as planetary science summer school at JPL) and to post material on-line for those who cannot attend.

Dr. Woodward commented that the PI Launchpad is an excellent idea, and suggested that the planners consider the recommendations from the TEAM-UP Task Force's report, *The Time is Now*. Dr. Hamden requested an email from Dr. Woodward on the report, and agreed it would be good for NASA to target areas where underrepresented people reside. This is one of the reasons why SMD feels it would be beneficial to obtain more expert advice. Dr. Woodward noted that there are legal constraints within NASA on collecting diversity information. Dr. New said that SMD had submitted a request to the NASEM to perform an *ad hoc* study on ways to increase the diversity in NASA leadership, because NASEM is not as limited in its ability to collect demographics information. Dr. Wadhwa asked if NASA would be contributing toward future PI Launchpad meetings. Dr. Hamden said she had been in discussions with the Heising-Simons Foundation to obtain a five-year grant, with an eye toward long-term funding. General SC support to keep these efforts going also would be useful.

Discussion of Findings and Recommendations

The SC discussed the final disposition of findings and recommendations. Both findings on VIPER and Spitzer workforce were changed to recommendations. SC considered whether the discussion of the PAC finding on interference of small satellite constellations with NEO detection should be raised to level of the SC. Dr. Woodward supported the need for a study of the subject, and the finding went forward. The SC revised a final finding on the PI Launchpad concept, noting the value of continuing the efforts; and approved a data management finding noting the utility of the RDA and the importance of validating open use software before use on NASA systems. Dr. Wadhwa adjourned the meeting at 1:00pm.

Appendix A
Meeting Attendees
(Virtual Meeting)

Science Committee Members

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
Michael W. Liemohn, University of Michigan
Anne Verbiscer, University of Virginia
Marc Weiser, RPM Ventures
Charles Woodward, University of Minnesota
Elaine Denning, **Executive Secretary,** NASA Headquarters

NASA Attendees at Headquarters
Brad Bailey, NASA HQ
Jacob Bleacher, NASA HQ
Steve Clarke, NASA HQ
Jamie Favors, NASA HQ
T. Jens Feeley, NASA HQ
Nicky Fox, NASA HQ
Ellen Gertsen, NASA HQ
Lori Glaze, NASA HQ
Mike Henry, NASA HQ
Paul Hertz, NASA HQ
Wynette Hoskins, NASA HQ
Shea Kearns, NASA HQ
Douglas Loverro, NASA HQ
Michael New, NASA HQ
Dawn Oliver, NASA HQ
Ruth Siboni, NASA HQ
Gerald Smith, NASA HQ
James Spann, NASA HQ
Lucia Tsaoussi, NASA HQ
Craig Tupper, NASA HQ
Alan Zide, NASA HQ
Thomas Zurbuchen, NASA HQ

Non-NASA Attendees at Headquarters
Joan Zimmermann, Zantech IT

Telecon/Webex Attendees
Mitzi Adams, MSFC
Gabriel Adler, NASA HQ
John Allen, NASA HQ
Gina Anderson, NASA

Lorella Angelini, NASA
Jaya Bajpayee, NASA Ames
Adriana Bankston, University of CA
Louis Barbier, NASA HQ
Brian Bond, NASA
Francesco Bordi, Aerospace
Ben Bussey, NASA HQ
Christopher Caisse, NASA HQ
Sean Carey, JPL
Sandra Cauffman, NASA HQ
Lin Chambers, NASA HQ
Amy Chaput, Stellar Solutions
Felicia Cho, NASA HQ
Stephen Clark, Spaceflight Now
Anthony Colaprete, NASA Ames
Stephen Davison, NASA
Dwayne Day, NAS
Monty DiBiasi, L. DiBiasi Associates
Tammy Dickinson, Science Matters Consulting
David Eisenman, JPL
Daniel Evans, NASA HQ
Richard Fischer, NASA
Jeff Foust, Space News
Craig Fry, NASA MSFC
Michele Gates, NASA
James Green, NASA HQ
Loren Grush, The Verge
Erika Hamden, University of AZ
Robert Hanley, NASA
Kenneth Hansen, NASA HQ
Phillip Harman, UCDC
Brian Harvey, BA&Associates
Hashima Hasan, NASA HQ
Joan Higginbotham, Collins Aerospace
George Ho, JHUAPL
Cat Hofacker, Aerospace America
Timothy Horvath, NASA
Grace Hu, OMB
Marcia Joseph, NASA HQ
Linda Karanian, Karanian Aerospace Consulting
Gilbert Kirkham, NASA HQ
Michael Kneely, Ventura Capital
Janet Kozyra, NASA HQ
Miriam Kramer, Axios
Rob Landis, NASA
Bill Latter, NASA
Sarah Lipscy, Aerospace
James Lochner, USRA
Margaret Luce, NASA HQ
Kamala Lyon, University of CA
Shawn McEniry, NASA

David McKenzie, NASA MSFC
Carolyn Mercer, NASA
Douglas Messier
Michael Mealling, Starbridge Venture Capital
Bonnie Meinke, Ball Aerospace
Michael Meyer, NASA HQ
Gene Mikulka, Talking Space
Debra Needham, NASA
Michael Neill
Sarah Noble, NASA HQ
Michael Nord, JHUAPL
Jorge Nunez, JHUAPL
Lucas Paganini, NASA HQ
Mario Perez, NASA
Arik Posner, NASA HQ
Patricia Rausch, NASA HQ
Leonardo Regoli, JHUAPL
Joe Roulette, Reuters
John Rummel, ECU
Richard Rogers, Stellar Solutions
Edward Semones, NASA
Bette Siegel, NASA HQ
Thomas Soifer, JPL
Eric Smith, NASA HQ
Marcia Smith, SpacePolicyOnline.com
Florence Tan, NASA HQ
Jon Van Noord, University of MI
Ryan Vaughan, NASA
Cheryl Warner, NASA
Michael Werner, JPL
Ashlee Wilkins, U.S. House of Representatives

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. Pat Patterson
Space Dynamics Laboratory

Dr. Anne Verbiscer
University of Virginia

Mr. Marc Weiser
RPM Ventures

Dr. Charles Woodward
University of Minnesota

Appendix C
Presentations

1. NASA Science Overview and FY21 President's Budget Request; *Thomas Zurbuchen, Craig Tupper*
2. Goals of the Meeting; *Meenakshi Wadhwa*
3. Spitzer Space Telescope Legacy; *Tom Soifer, Sean Carey, Mike Werner*
4. Heliophysics Advisory Committee; *Michael Liemohn*
5. Moon to Mars/Artemis Science; *Steve Clarke, Brad Bailey*
6. VIPER; *Anthony Colaprete*
7. Science on Gateway: Space Weather; *Jacob Bleacher, Jamie Favors*
8. NASEM and IRB/IRT Results Implementation; *Michael New, Alan Zide*
9. SMD Data Management Strategy; *Ellen Gertsen*
10. Earth Science Advisory Committee; *Thomas Herring*
11. Astrophysics Advisory Committee; *Charles Woodward*
12. Planetary Science Advisory Committee; *Anne Verbiscer*
13. SMD PI Launchpad; *Erika Hamden*

Appendix D
Agenda

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

NASA Advisory Council
Science Committee

March 12-13, 2020

Telecon Meeting

Revised Final Agenda
(Eastern Time)

Thursday, March 12

9:30 – 9:40	Opening Remarks / Introduction of Members	Ms. Elaine Denning Dr. Meenakshi Wadhwa
9:40 – 11:00	NASA Science Overview FY21 President's Budget Request	Dr. Thomas Zurbuchen Mr. Craig Tupper
11:00 – 11:15	***Break***	
11:15 – 11:25	Goals of the Meeting	Dr. Meenakshi Wadhwa
11:25 – 12:15	Spitzer Space Telescope Commemoration	Dr. Thomas Soifer Dr. Michael Werner Dr. Sean Carey
12:15 – 1:15	***Lunch***	
1:15 – 1:30	Division Advisory Committee (DAC) Chair Reports Heliophysics Advisory Committee	Dr. Michael Liemohn
1:30 – 2:15	Moon to Mars/Artemis Science	Mr. Steve Clarke Dr. Brad Bailey
2:15 – 3:00	Volatiles Investigating Polar Exploration Rover (VIPER)	Dr. Anthony Colaprete
3:00 – 3:10	***Break***	
3:10 – 3:15	Public Comments	
3:15 – 4:00	Science on Gateway: Heliophysics Space Weather	Dr. Jacob Bleacher Mr. Jamie Favors
4:00 – 4:30	Wrap-Up Discussion	All

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

4:30	***Adjourn for Day***	

Friday, March 13

8:30 – 8:35	Re-Open Meeting	Ms. Elaine Denning Dr. Meenakshi Wadhwa
8:35 – 9:10	NASEM and IRB/IRT Results Implementation	Dr. Michael New Mr. Alan Zide
9:10 – 9:30	SMD Data Management Strategy	Ms. Ellen Gertsen Mr. Kevin Murphy
9:30 – 10:00	Discussion	All
10:00 – 10:45	DAC Chair Reports (Continued) Earth Science Advisory Committee Astrophysics Advisory Committee Planetary Science Advisory Committee	 Dr. Thomas Herring Dr. Charles Woodward Dr. Anne Verbiscer
10:45 – 11:15	Preliminary Outbrief to SMD	Dr. Meenakshi Wadhwa Dr. Thomas Zurbuchen
11:15 – 11:30	***Break***	
11:30 – 12:00	Conversation with HEOMD Associate Administrator	Mr. Douglas Loverro
12:00 – 12:20	First SMD PI Launchpad Workshop	Dr. Erika Hamden
12:20 – 1:00	Discussion, Findings and Recommendations	All
1:00	***Adjourn Meeting***	

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 909 851 126 and the password is SC@Mar2020 (case sensitive).

**** All times are Eastern Time ****