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MEETING REPORT

Ellen Williams

8/6/2022

Ellen Williams, Chair

Jason Callahan

8/6/2022

Jason Callahan, Executive Secretary

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May 3, 2022

Opening remarks

Mr. Jason Callahan, Designated Federal Officer for the NASA Advisory Council (NAC) Science Committee (SC), opened the meeting and made administrative remarks. Mr. Callahan introduced incoming Chair Dr. Ellen Williams, replacing outgoing Science Committee Chair Dr. Meenakshi Wadhwa. SC members introduced themselves. Dr. Williams made opening remarks and reviewed the agenda.

Goals of the Meeting

Dr. Williams reviewed the goals of the meeting, including a Science Mission Directorate (SMD) update; a discussion of the new paradigm of NASA commercial delivery of services; a discussion of Inclusion, Diversity; Equity and Accessibility (IDEA) within SMD, an update on NASA's Planetary Protection (PP) Plan and Agency response to the PP Independent Review Board (IRB) recommendations; a climate science update; and potential responses to Division Advisory Committee (DAC) findings and recommendations.

NASA Science Overview

Dr. Thomas Zurbuchen, Associate Administrator (AA) of the Science Mission Directorate (SMD), provided an update. He first acknowledged the outstanding contributions of outgoing Chair, Dr. Wadhwa, and presented her with the Exceptional Public Service Award on behalf of NASA.

Dr. Zurbuchen addressed mission milestones in SMD, noting that in the current budget discussion there would be some missions that may not receive requested levels of funding. He said that thus far, however, it has been an amazing year for space science. The James Webb Space Telescope (JWST) is scheduled to achieve first light in late June 2022. He stated that JWST is a mission with a long history and extremely complex instruments, and the fact that everything is going so well can be attributed to the efforts of NASA Goddard Space Flight Center (GSFC) and the contractors involved in manufacture and assembly of the telescope and spacecraft. The Galactic/Extragalactic ULDB Spectroscopic-Stratospheric Terahertz Observatory (GUSTO; ULDB is the acronym for Ultralong-Duration Balloon) balloon payload is scheduled to launch in December 2022, and several lunar launches will occur in the next year. Dr. Zurbuchen said this is also a great period for asteroid research, with the Double Asteroid Redirection Test (DART) scheduled to impact a double asteroid system in September. The planned launches of Lucy, Psyche, and Janus to a variety of asteroid targets will also occur this year. The Earth Science Division (ESD) will launch the Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of SmallSats (TROPICS) mission, satellites in the Joint Polar Satellite System (JPSS), a science instrument that measures aerosols on the International Space Station (ISS), and the Surface Water and Ocean Topography (SWOT) mission.

Dr. Zurbuchen detailed science highlights, first citing a direct imaging activity carried out by the Hubble Space Telescope (HST) that has been tracking a newly forming exoplanet over a 13-year span. He said HST continues to do amazing research and will now join with JWST to function in a complementary manner. The JWST team continues to work through mirror alignments as it approaches "first light," meaning starlight travels through the optics of the telescope, bouncing off all its mirrors to reach its detectors for the first time. Dr. Zurbuchen said JWST has already shown itself superior to HST's Ultra Deep Field sensor arrangement. NASA's other new telescope, the Interstellar X-Ray Polarimeter Experiment (IXPE), run out of Marshall Space Flight Center, has targeted Cassiopeia A in its initial imagery. The key purpose of IXPE is to measure the polarization of stellar x-ray emissions, which yields information about stars. The first papers from IXPE are due to appear soon.

Perseverance is making progress toward the goal of Mars Sample Return (MSR), having collected 10 samples thus far. The rover is now climbing the wall of Jezero Crater, a scientifically more promising area than previously theorized. Noting there is no such thing as a steady schedule for monitoring Perseverance, Dr. Zurbuchen stated his appreciation for the staff at the Jet Propulsion Laboratory who sacrifice much personal time to the monitoring and care of the rover. The Mars helicopter Ingenuity, a technology demonstration, has made 27 flights to date and is coming to the end of its tech demo life. It will now be used to provide an observation capability. These flights are also mapping out the “landing pad” for future MSR missions. In the Heliophysics Division (HPD), Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites (TRACERS), a multi-spacecraft mission looking at magnetic field reconnection, is one step closer to launch and is just one of eight healthy missions currently scheduled for Heliophysics.

The Axiom mission (AX-1), a private astronaut mission, successfully arrived at the International Space Station (ISS) earlier this year, marking an exciting development for commercial space at NASA. In explaining his view on commercial partnerships, Dr. Zurbuchen quoted Socrates, noting that the secret to success is “building on the new and not fighting the old,” and remarked that it is important for the space science community to be supportive of this new paradigm. In addition, the Commercial SmallSat Data Acquisition (CSDA) program, initiated in 2017 with the purpose of augmenting and/or complementing NASA Earth Science observations, represents a disruptive move. Dr. Zurbuchen said these satellites typically do not provide the best images of the Earth, but the goal is to provide new dimensions to the tools and data scientists use. NASA continues to try to learn what the use cases will be, to price data correctly, and to create a sustained program while continuing to bring other programs onboard. One impact of CSDA can be seen in the fact that the numbers of approved users for each company are rising rapidly. NASA is still in the learning phase with CSDA and has made contract vehicle changes to expand applications across the government. The Agency is also starting to look at publication impacts. As an example of CSDA applications, Dr. Zurbuchen displayed an AI/ML-enhanced image that melded NASA data and commercial data, showing before-and-after images of a landslide in South Africa.

In the Commercial Lunar Payload Services (CLPS) program, there are currently 14 companies that can bid on payloads. Seven deliveries have been awarded, and a total of 44 NASA instruments are planned through 2025. The total award cost is less than \$1B, with an expected cadence of two deliveries per year sponsored by SMD. CLPS has created an innovative instrument platform that also supports a more diverse pool of Principal Investigators (PIs) who tend to be earlier in their career paths. One CLPS awardee, Astrobotic, has designed two lunar landers, the Peregrine and Griffin Landers, both of which are progressing well in hardware and instrument development. Peregrine will be moving into its integration and testing (I&T) phase soon. Dr. Zurbuchen emphasized that the instruments on these landers have undergone full NASA review, in an iterative risk-reducing process. Astrobotic and NASA are building copies of all the instruments for the landers that could be used in alternate lunar locations. Dr. Zurbuchen said the Agency is essentially using CLPS as instrument “movers,” in that CLPS is enabling innovative science deliveries that are schedule-driven, science-driven and providing Decadal-caliber science. CLPS can also help fill the pipeline of future researchers. Dr. Zurbuchen emphasized that these companies are creating jobs, and NASA’s investment is helping to create a broader market. He said the next question is whether the science community thinks there are CLPS-type models that could be used to conduct other types of science missions, such as Mars missions or Earth science missions.

Dr. Zurbuchen addressed the President’s Budget Request for fiscal year 2023 (PBR FY23), noting that NASA’s job is to manage the appropriated monies in the most effective way possible. He said every budget is a compromise and relates to constrained resources, and he stressed that the FY23 budget still needs to go to Capitol Hill for appropriation hearings. Given these conditions, the SMD FY23 budget strategy is to promote US leadership in Earth science and address the climate crisis; lead Artemis science; champion Inclusion, Diversity, Equality, and Accessibility (IDEA) infusion; build a balanced and

innovative program driven by the highest national priorities; and advance open science for all by leveraging cutting-edge data science techniques. Dr. Zurbuchen stressed that the concept of open science is driving all areas of science at NASA. He observed that some of the constraints to engaging more fully in open science strategies are historic in nature and stated that cloud computing is helping with this change. Dr. Zurbuchen stressed that it will be important to stay the course in IDEA, as it has received strong support from both political parties.

The 29 Science missions launched after the adoption of the 70 percent Joint Confidence Level (JCL) requirement have underrun phase C/D budget commitments by a net 2.4 percent. The total Science mission portfolio overrun is 3.7 percent if JWST is included. It is important to note here that missions such as Lucy that were implemented during COVID-19 underran by 9 percent. That said, COVID-19 impacts have been assessed independently, while SMD continues to refine its ability to execute missions within cost commitments. NASA is still working on an Operations Plan for the current budget.

The actual budget request for SMD in FY21 was \$7.29B, but as enacted it was \$7.6B. Comparatively speaking, the Earth Science Division budget is higher than previous years but not by as much as the aspiration of the program; this means that ESD must do a better job of communicating its needs to stakeholders. The Planetary Science Division (PSD) budget is also up, despite COVID-19 having placed stress on its very restricted launch windows. The Astrophysics Division (APD) budget is down somewhat, the Heliophysics Division (HPD) budget is up, and the Biological and Physical Sciences (BPS) program is up for the first time in 15 years. NASA's FY22 appropriations numbers show continued strong support for SMD, with 4 percent growth over the FY21 budget. Support for high-priority missions such as MSR and the Europa Clipper continue. However, the NEO Surveyor mission was cut significantly in the FY23 PBR and its launch date was pushed to 2028.

Dr. Chick Woodward asked for details of science planning for NASA's Lunar Gateway. Dr. Zurbuchen said that a Heliophysics science package has been approved for the external portion of Gateway; it is designed to learn about the characteristics of Gateway's near-rectilinear halo orbit around the Moon. There will also be BPS activities inside Gateway, and SMD continues to assess opportunities. Science is fully expected to be part of Announcements of Opportunity (AOs) going forward. To gauge the community's interest, the Science Committee will hold a joint meeting with the Human Exploration and Operations Committee (HEOC). Dr. Michael Liemohn asked how the science investigations related to the 44 CLPS instruments were distributed across SMD. Dr. Zurbuchen said that much of CLPS science instrumentation is lunar-focused, but he expressed excitement that the latest Planetary Science Decadal Survey recognizes the importance of lunar science across the board. He took an action to clarify the relationships of these instruments to the entire science portfolio. He said he knew there were both HPD and APD instruments in the CLPS portfolio, but not Earth Science. Mr. Weiser and Dr. Williams asked what NASA expects the long-term outcome to be for CLPS. Dr. Zurbuchen said that NASA will need to insist that it not be the only customer for CLPS; NASA believes that the platform is useful for other customers, as well as for other countries. Mr. Weiser asked if there were CLPS programs with plans beyond Artemis. Dr. Zurbuchen said that NASA was looking for opportunities to put new science instruments/sensors elsewhere using CLPS-like programs, adding that there is language in the FY22 budget for using robotic platforms for instruments. He said NASA will need to use all available tools and was expecting commercial companies to be very important as the Agency focuses on new science and more science per dollar. He stated that current questions for the Agency include: Are we using the right model to get to more science per dollar? What should we worry about? Dr. Wadhwa asked what the biggest challenge would be to implementing the latest Decadal recommendations. Dr. Zurbuchen felt that for PSD, the most difficult aspect will be successful execution of MSR. Execution of the program is just as difficult and complex as JWST and it must be accomplished correctly to not destroy the balance in the program. MSR is important but NASA must do a good job moving it forward. He felt that the new

Planetary Science Decadal Survey's emphasis on PI-class missions is good and added that the biggest future challenges, overall, will be program balance, Research and Analysis (R&A), and PI-class missions.

Managing Delivery of Services- ESSIO

Dr. Joel Kearns, Associate Administrator of the Exploration Science Strategy and Integration Office (ESSIO) briefed the Science Committee, focusing on CLPS. CLPS is a unique program in that, to date, it is supporting the Lunar Discovery and Exploration Program (LDEP), a roughly three-year-old program that has not yet landed on the Moon. LDEP is part of PSD and develops lunar science instruments that are to be flown on commercial launches and carried on commercial landers. LDEP has its origins in the X-Prize competitions and was partly enabled by funding released by the cancellation of the Constellation launch vehicle. There was enough maturity in the commercial sector by that time to try out this new paradigm. One goal of LDEP was to have more frequent, lower-cost opportunities to land instruments on the Moon by tapping into companies that already had their own plans to land on the lunar surface. Thus far, LDEP has helped to develop lunar landers such as the Volatiles Investigating Polar Exploration Rover (VIPER); has coordinated with international partners; and has integrated with Artemis science efforts across SMD, with other NASA mission directorates, and with other federal agencies. One example of such coordination is with a Department of Energy (DOE) mission, an Astrophysics investigation on the far side of the Moon. The newly released Planetary Science Decadal Survey also references LDEP by name, indicating its importance to science.

CLPS Task Orders (TOs) are firm fixed-price (FFP) contracts that cover the full scope of delivery of payloads to the lunar surface. Each participating company must seek Federal Aviation Administration (FAA) and Federal Communications Commission (FCC) approval independently of NASA. CLPS deliveries are CLPS provider missions and are not NASA missions. NASA intends to be one of many customers for CLPS services.

Since the inception of the program, seven lunar surface activities are actively in work with initial deliveries expected later this year. Some delays have occurred due to COVID-19 and global supply impacts. There are ten CLPS deliveries planned from 2022 to 2025; a Schrödinger Basin delivery site is still in competition under the Payloads and Research Investigations on the Surface of the Moon (PRISM) call. A number of other companies are targeting the South Pole of the Moon as well. NASA will choose the landing sites for researchers to propose to in the next PRISM call. The Planetary Science Advisory Committee (PAC) has advised that PRISM allow its PIs to select landing sites, and ESSIO is currently discussing this possibility. Dr. Noël Bakhtian asked if NASA were considering the potential contamination of lunar sites that might affect future science, and if affected areas were being documented. Dr. Kearns said that NASA is looking at this issue on a site-by-site basis. For instance, it will be necessary to avoid permanently shadowed regions (PSRs) at the lunar South Pole for Planetary Protection reasons, and no one is planning on landing near or on the lunar North Pole. As NASA updates its Planetary Protection (PP) requirements for the Moon, it will also specify PP and orbital debris policy changes. Delivery providers must comply with US law, but not necessarily with NASA policy; specific constraints will need to be spelled out in each contract. Dr. Kearns, in response to a question, said the majority of CLPS payloads are science-driven and 25 percent of payload capacity is put aside to accommodate technology demonstrations and other non-science-driven projects. NASA specifies these parameters in the proposals. Many NASA investigations will require mobility on the lunar surface; this is also built into the contracts. The first instruments under the CLPS aegis were existing hardware, while universities and commercial entities provided the second group of instruments. The third group of instruments will be provided under PRISM. PRISM 2022 selections will launch in 2025. Dr. Woodward asked how NASA brought in contracting companies. Dr. Kearns said that NASA only brings on a new company when it needs a new capability, however the calls are open to all the companies in the CLPS pool. Each bid has a target window date for landing, and companies respond with landing dates and costs.

These are fixed-price contracts; NASA can choose not to work with a company if they can't provide the service requirements NASA is requesting.

Asked if the CLPS companies must abide by NASA policies, Dr. Kearns said that if an instrument flies on a CLPS vehicle, it must meet NASA requirements. Dr. Linda Godwin asked if there was a requirement for some measure of success: How new are these companies? Dr. Kearns said that none of the 14 companies have yet landed on the Moon, but they all show some evidence that they can fulfill their contracts. Dr. Sara Tucker commented that NASA should avoid buying something from companies that might not be around in five years. Dr. Kearns reiterated the fundamental goals of CLPS, which are based on the expectation that enough companies will succeed by virtue of the planned two-launch-per-year cadence, and the company's own investments in the contracts. One goal in the future is to have these companies field systems that last more than one lunar day/night (this is the current requirement), at which time NASA can plan to build longer-lived assets. Dr. Woodward noted that there have been prior recommendations from the SC on these issues.

Dr. Kearns reported that a total of \$740M has been put into seven Task Orders (TOs) for lunar surface deliveries between 2022-24, with commercial companies providing mobility (lunar rovers) as a service. CLPS companies will also be tasked with getting data back from the far side of the Moon. NASA has required PIs to supply copies or modifications of their instruments. By the time the VIPER launches, there will be more copies of these instruments so that they will not drive the schedule. The CLPS program has also encouraged early-career researchers and universities to engage in instrument building; this is also one of the stated goals of the service. Some PIs are already talking about using the CLPS approach for Mars and asteroid surveys, or Earth-orbiting platforms for maturing technologies. A key Lesson Learned is that NASA can be a critical player in establishing early commercial capabilities. While the vendor pool is technically capable and resilient, it will be difficult to project a future market. NASA must still consider its risk tolerance in the early stages to create the right partnerships. Another Lesson Learned is that there are cultural challenges to be overcome with respect to NASA and contractor philosophies and schedules. Commercial services also have unique risk aspects and postures that must be well understood. Lastly, a key lesson has been that it is important to have fixed, stable interface requirements on these FFP service TOs. It is important to note that many CLPS providers have come up with technical innovations on their own investment dime because they want to attract future customers in addition to retaining NASA as a customer.

Dr. Woodward asked what sort of up- and down-mass capabilities are possible with CLPS, especially if NASA is looking for long-term viability of the program. Dr. Kearns said there was no specification on return mass yet, but that NASA is looking for down-mass capabilities appropriate to those for human landings in the Artemis program. The mass discussion is beginning with the South Pole/Aitken Basin site. The discussion will need to be very specific with regard to samples from certain locations, as well as sampling from surface, subsurface, or PSR sites. This will become increasingly technically challenging. Dr. Kearns added that in-situ resource utilization (ISRU) activities are led by the Space Technology Mission Directorate (STMD), though there is also coordination through the former Human Exploration and Operations Mission Directorate (HEOMD), recently divided into the Exploration Systems and Development Mission Directorate (ESDMD) and the Space Operations Mission Directorate (SOMD). It is important to note here that these activities are related exclusively to ISRU and do not involve sample return. Dr. Williams asked about the source of company funding and if the CLPS companies were capable of raising additional funds. Dr. Kearns said he had limited information about such matters but that individual company websites typically reveal activities they are conducting with other partners and customers. When NASA does an analysis of potential CLPS awardees, it does make assumptions based on how these companies might raise funds. Dr. Woodward asked if electromagnetic (EM) protection was being discussed, as it pertains to operational implications. Dr. Kearns said that the provider must show that the individual EM profile is not harmful. There are ongoing discussions about looking at landings

across time, and about keeping the lunar far side as radio silent as possible. Thus far the selected investigations are only one lunar day in duration, so these EM issues are not significant. Asked if CLPS companies were required to share their data with the Planetary Data System (PDS), Dr. Kearns said that while he could not see how companies can be required to do this, if NASA purchases data from CLPS companies, that data will be inserted into the PDS. Dr. Brad Bailey interjected with clarification via the Webex chat: *“We are also looking to protect certain areas (specific PSRs, heritage sites (e.g. Apollo 11), other int’l landed missions, etc). We are also trying to keep in mind the radio quiet far side and how to keep that environment capable of performing cosmological/radio astronomy research.”*

Public Comment Period

No comments were noted.

SMD DEIA Update

Dr. Karen Flynn, SMD’s Deputy Associate Administrator for Management, briefed the Committee on progress in DEIA, first describing NASA’s Equity Action Plan (EAP) responding in part to White House Executive Order (EO) 13985, “Advancing Racial Equity and Support for Underserved Communities Through the Federal Government.” She provided an overview of activities underway for some time at NASA, many predating the EO. NASA’s Science Strategy incorporates DEIA in its values and priorities. NASA’s Senior Adviser for Engagement coordinates the Agency’s response to the EO. NASA’s Equity Action Plan (EAP) was released after several iterations responding to feedback from public comment and other input. The EAP contains four focus areas: Focus Area 1 covers procurement practices; Focus Area 2, cooperative agreements and grants; Focus Area 3, climate data and environmental justice; and Focus Area 4, equity in civil rights compliance and accessibility to limited-English populations. Focus Areas 2 and 3 contain sizable SMD content.

Focus Area 2: Equity in Grants/Cooperative Agreements

Dr. Michael New, SMD’s Deputy Associate Administrator for Research, detailed four actions under Focus Area 2: conducting a barrier analysis by the end of 2024 to identify factors that appear to discourage proposals from Minority-Serving Institutions (MSIs) and Historically Black Colleges and Universities (HBCUs); increasing outreach and training to ten offerings per year; expanding the Dual Anonymous Peer Review (DAPR) process for proposal review beyond SMD (e.g., STMD will pilot DAPR for one of its upcoming solicitations); and launching the SMD Bridge Program to link HBCUs and other MSIs to NASA and NASA centers in an effort to diversify the STEM community and increase the number of PhDs in STEM, as well as to increase the number of proposals to NASA programs. NASA is seeking self-nominations for participation in the Bridge Program. The Focus Area identifies a number of relevant metrics and a strategy under which activities will be carried out. Asked whether SMD plans to increase funding to MSIs by increasing the Minority University Research and Education Project (MUREP), Dr. New clarified that this work will occur through NASA’s Office of STEM Engagement (OSTEM) and that the goal is to increase the number of research proposals coming to NASA, not to provide funding to institutions. Dr. Flynn interjected that some divisions are working through OSTEM—ESD in particular—and that there is also activity at the division level not reflected in this briefing. Dr. Wadhwa asked if there were any PI 101 or PI Launchpad activities included in this effort. Dr. New said that one of the training efforts involves NASA Headquarters staff teaching Research Opportunities in Space and Earth Sciences (ROSES) proposal writing workshops, an activity that has been under way for 20 years and is typically offered at conferences, that aim to reach underserved groups. The Agency is also doing “road shows” that invite MSIs and HBCUs; PI 101 and PI Launchpad are part of this effort, which has taken place both virtually and at the University of Arizona. The next PI Launchpad will be held in 2023 at the University of Michigan at Ann Arbor, which will be held in conjunction with MSI/HBCU input. Beyond 2023, NASA aims to hold a PI Launchpad at an HBCU. Dr. Woodward asked if NASA would expand its demographic collection. Dr. New said that the Office of the Chief Scientist (OCS) collects data through the NASA Solicitation and Proposal Integrated Review and Evaluation System

(NSPIRES) but does not have demographic data about grant performance; NASA is in the process of determining the best method for acquiring such data. There is a broad recognition that the current data system cannot collect the demographics data that NASA desires.

Dr. Bakhtian asked if anyone is thinking about engaging communities from the beginning, instead of having NASA “helicopter” in with solutions. Dr. New said that “metrics” require dollars, bodies and time, and that this is the area in which NASA is trying to work with communities. The purpose of the Equity Action Plan is to work alongside and co-create with MSIs and HBCUs to develop a Bridge Program that will work. He said he was not sure how much SMD research can be engaged in the way Dr. Bakhtian described.

Focus Area 3: Equity in Climate Data and Environmental Justice

Ms. Kate Becker, Executive Officer in the Earth Science Division, addressed this area, describing the effort as a way to enable communities to do things for themselves. To that end, Focus Area 3 aims to leverage Earth Science and socioeconomic data to mitigate environmental challenges in underserved communities. The first actions will be to: issue Environmental Justice grants to community decision makers; transfer 50 environmental data sets to the Cloud in 2022 with full transfer by 2025; and conduct free multi-lingual training. There are two ROSES calls out now in Environmental Justice. NASA hopes to have selections for the first call by August, in the form of landscape analyses and pilot projects. Metrics will include the number of data sets transferred to the Cloud and the number of community members/decision makers trained to use NASA data to address key environmental issues. NASA recognizes that there may be a lower than desired response rate; a 6-9 month delay in the migration of data to the Cloud; and a lower attendance rate than anticipated. The current strategy is to continue to hold community listening workshops to determine areas of need; NASA held an inaugural workshop in 2021 to listen to social science representatives who work with Environmental Justice issues and groups.

Dr. Woodward asked if CSDA program data would be made available in real time, as well as how other programs would be folded into the program. Ms. Becker said the goal is to have all Earth Science data on the Cloud, which may necessitate expanding commercial licenses to help increase access to data. The Open Science Initiative will also help in disseminating data and allowing more people to participate in science. Dr. Woodward asked how community members would know how to use the data. Ms. Becker said that training programs like Applied Remote Sensing Training (ARSET) program that are aimed at specific topics would be one avenue; ARSET starts at the beginner level with instruction on subjects such as optical data for crop assessment. There is also a program titled Unbound aimed at individuals untrained at using NASA data in the Environmental Justice area. Mr. Weiser asked how outcomes are measured and how information is fed back to the community. Ms. Becker explained that in the process of grant selection, NASA holds an open call to review these grants; the in-person reviews will help build relationships with individuals who can provide feedback from the community over time. Dr. Flynn noted that these efforts will be updated on an annual basis. Dr. Bakhtian asked how many NASA researchers would be involved in the external-facing workshops. Ms. Becker said that Dr. Nancy Searby would be a good source of information on this topic. NASA recently held two proposer workshops for which Dr. Searby indicated, anecdotally, that she had received many emails afterward from new participants. Asked why the initial 50 data sets were chosen for upload to the Cloud, Ms. Becker said that these were the 50 most-used data sets from previous years.

Dr. Jade Singleton addressed next steps for the SMD IDEA Working Group. She said SMD has long understood that it is necessary to pursue both broad and deep strategies to advance the tenets and goals of IDEA programming. Facets of this work involve Inclusion/Culture; Leadership Development (including mentoring); Mission, Programs and Projects; Recruiting and Hiring (including efforts at retention); Research and Analysis; and an Engagement Team (meaning the use of “boots on the ground” to identify

gaps). To this end, SMD established a strategic plan to address IDEA, titled *SMD IDEA Strategic Priorities 2022-23*. There are five goals in the strategy, each with actions and priorities. Dr. Singleton said these actions are agile and will be discontinued if they don't work. For instance, she said, different cohorts move through institutions at different rates and for different reasons and NASA needs to understand how and why this happens. She said it is also essential to ensure that SMD is hearing from the Working Group. Progress indicators, some qualitative and some quantitative, will include pulse surveys to assess the level of awareness of IDEA efforts across divisions, and metrics such as the number of views on Sharepoint sites. NASA's priorities for the external community include SMD engagement with the community to ensure NASA's goal of building a science team reflecting the nation; and strengthening and forging symbiotic relationships with underrepresented communities. IDEA Group recent activities include conducting the SMD Climate Survey & Analysis; engaging in HBCU regional discussions; producing an inclusive language reference guide; working on a Code of Conduct for missions; providing an internal IDEA resource hub; establishing a mentor program beginning in June; and hosting monthly IDEA conversations. She said there are two pilot programs supporting inclusion in ROSES-2022, one in the Planetary Science Division (PSD) and one in the Heliophysics Division (HPD). The PSD program will evaluate offering flexible due dates while the HPD program will evaluate offering four due dates per year. Dr. Singleton highlighted other efforts, including expansion of Inclusion Plans; continuing virtual peer reviews; expanding support for MSIs/primarily undergraduate institutions (PUIs); and working with flight opportunities in STMD to bring commercial providers to sounding rocket and balloon programs, enabling smaller, faster turnaround opportunities for proposers.

Planetary Protection Update

Dr. Nick Benardini, NASA's Planetary Protection Officer, presented an update on planetary protection at NASA. He began by reviewing some organizational changes, including new representation from the international Committee on Space Research (COSPAR), SOMD/ESDMD, and STMD. The newest NASA Planetary Protection Policy documents are: Implementing Planetary Protection Requirements for Space Flight (NPR number TBD) and Planetary Protection for Robotic Missions (NPR 8715.24). The Agency is also in the process of updating the companion documents (NASA Handbooks) to NPRs and NASA Standards publications. Dr. Benardini gave a brief description of the chapter contents of NPR 8715.24.

Dr. Benardini said that the Moon represents a case study in how planetary protection requirements have evolved from the Apollo era to the present. The COSPAR Planetary Protection Policy for the Moon, in concert with some National Academy of Sciences (NAS) recommendations, have changed categorizations for orbiters and certain surface missions over time. There is also a voluntary information request that has been updated for inclusion on NASA's Recommendations to Commercial Space Operators website. The Agency is beginning to evaluate bioburden requirements for Mars missions while also updating planetary protection requirements for missions to small bodies. NASA cannot regulate commercial payloads in terms of planetary protection but can advise the Federal Aviation Administration (FAA), which holds the regulatory authority for commercial payloads. NASA supported the report on the National Strategy for Planetary Protection, published by the National Space Council. The Planetary Protection Interagency Working Group was paused in Fall 2021 but NASA continues to work with the FAA, the Department of Health and Human Services, and the Centers for Disease Control on the subject of restricted sample returns.

Notional forward work on the Mars Exploration trade space includes filling knowledge gaps for both robotic and human exploration; these encompass crew, special regions, sampling for life detection, and *in situ* life detection. NASA is also working to modernize the planetary protection "toolkit" to include molecular biology techniques and held a workshop in January 2022 on Molecular Biology Technology Development. The workshop released a number of preliminary findings that were submitted to *Astrobiology* (April 2022). Dr. Woodward asked who had governance over radioisotope thermoelectric

generators (RTGs) when NASA contracts with commercial providers. Dr. Benardini said that specific NPR documents govern isotopic systems requirements. Asked who governs debris left by missions on the lunar surface, Dr. Benardini indicated that NASA has been engaged with NAS and COSPAR on this issue; the focus is on understanding organic compounds on the surface and is confined to requirements that have been put into place solely for organic contamination and propulsion fuel byproducts. Such things as terrain damage and “lunar litter” are outside the purview of NASA’s Office of Planetary Protection. Dr. Vinton Cerf pondered whether the Artemis Accords speak to some of these concerns and noted that the effort to introduce commercial activity to the Moon raises interesting questions about the conflict between science and private enterprise.

James Webb Space Telescope Update

Dr. Eric Smith, Program Scientist for JWST, provided an update, noting that the telescope represents a major international effort as well as the contributions of 29 US states and Washington, DC. JWST’s journey to the second Lagrange Point (L2) took place after a “textbook” launch on Christmas Day, 2021. The spacecraft was so precisely launched to a direct injection orbit that only a minimal amount of fuel was spent to correct the orbit, resulting in a net effect of doubling the mission lifetime. There was also a camera installed on the Ariane 5 rocket allowing clear imagery of the spacecraft separating from the rocket. All deployments have been completed successfully, comprising 29 spacecraft elements and 24 optical telescope elements. All 178 release mechanisms functioned as planned (139 associated with the sunshield). Currently NASA is commissioning the observatory, during which time all four science instruments will be checked out. Calibration will occur during Cycle 1 observations. Commissioning is a lengthy period of 180 days, driven largely by a cooling sequence designed to protect the optical elements. Only the mid-infrared instrument (MIRI) is cooled actively; the rest are cooled passively. All mirror segments are now below a temperature of 55 Kelvin, allowing movement into the instrument-commissioning phase. There are 730 high-level steps in the timeline, and still about 1000 total steps to go.

Onboard JWST, there are two near-infrared (NIR) instruments and one mid-infrared instrument: NIRCам, NIRSpec, and MIRI; and the Fine Guidance Sensor (FGS). The mission team checked for image sharpness last week using the Large Magellanic Cloud as a subject. There are 17 science modes for the instruments, with redundant capabilities. NIRCам is completely redundant (with two identical modules). Dr. Bakhtian asked if JWST data would be made immediately available to the public. Dr. Smith said the data releases would be hybrid in nature: observers will have the data for exclusive use for twelve months but many young researchers are electing to release their data at once. About 25 percent of the data will be available immediately.

At present, the mission team is running hot versus cold attitude tests to see how the mirrors respond thermally. Dr. Cerf asked if there was a difference between thermal noise effects on mirrors as opposed to sensors. Dr. Smith said that the telescope is more sensitive to things that are off axis such as starlight, hence it is more important to do things like keep the mirrors clean. Dr. Smith credited the Canadian team for its rapid, last-minute work on a tunable filter for its instrument, the FGS, and described the JWST Cycle 1 Long Range Plan. Cycle 1 is scheduled to begin on 27 June and will include the General Observation (GO), Guaranteed Time Observation (GTO), and Early Release Science (ERS) programs. The ERS teams will provide high-level tools and data products that will be useful for writing proposals for Cycle 2. Spectroscopy is already heavily subscribed. The types of science covered by the observation programs include the solar system, galaxies and the intergalactic medium (IGM), exoplanets, stellar physics, and more. Webb community events will be numerous, with 622 host sites registered, and these events will run from the end of June to October. There is also much information about JWST online, including the popular website Where is Webb, as well as presence on various social media platforms.

Dr. Bakhtian asked why data would not be made public immediately. Dr. Smith said that it was a matter of history and prior policy, for the most part. The JWST Memorandum of Understanding (MOU),

however, states that the director of the Space Telescope Science Institute (STScI) can advise NASA on changing the exclusive use period and NASA is expecting to receive a recommendation that the 12-month period be reduced. Dr. Mainzer noted that the effort of conceiving a mission proposal is time-consuming and that the proprietary period of exclusive use spoke to that effort. Dr. Woodward commented that calibration will be an ongoing effort during Cycle 1 so there is a natural iterative process in learning how to use the telescope, further undermining the need for a proprietary period. Asked about funding for Guest Observers (GOs), Dr. Smith said JWST has a \$60 million/year grant program, the largest in APD. Dr. Liemohn asked for some elaboration on the Canadian FGS. Dr. Smith said the instrument had been at risk of not meeting its delivery schedule and was simplified in order to be completed more quickly; the last-minute changes also added an exoplanet masking ability. It should be noted however that the secondary instrument was not part of the Level 1 requirement. Asked to estimate how long the mission would last, Dr. Smith said that JWST could function for more than 15 years. Additionally, the instruments won't have to be turned off after the fuel is spent, so that it could eventually be run like the "warm" phase of the Spitzer Telescope.

Potential findings and recommendations

Dr. Wadhwa noted that she had looked over old findings and recommendations during the last NASA Advisory Council (NAC) meeting and gave a quick synopsis for the benefit of the SC. Dr. Cerf suggested that findings include a formal acknowledgement of the spectacular success of JWST, adding that with the generation of new data, it would be beneficial to combine JWST data with other parts of the spectrum; it would also be useful to identify any metadata that could be combined with previously acquired data. Dr. Woodward noted that APD has an initiative to create an interactive archive that anticipates output from the Roman and Euclid missions. He noted that the HST is now being used most often for its archival data. Dr. Cerf said that Google has conducted much work with large-scale databases and offered to take this discussion to those of his colleagues involved in this effort. Dr. Bakhtian asked whether SMD has a formal way to address the impacts of cost and risk on innovation. Dr. Woodward felt this was a risk tolerance question and that Dr. Zurbuchen is thinking about the balance between NASA and the pace of commercial innovation while borrowing good ideas from both sectors.

The SC prepared to outbrief Dr. Zurbuchen. Dr. Cerf voiced concerns about the significant vulnerabilities engendered by the open source concept and put a link into the chat on the topic. Addressing the question on expanding the use of CLPS beyond the present, the Science Committee considered suborbital commercial flights, "plug n' play" LEO commercial activities, and the sustainability of companies in LEO. Mr. Weiser commented that NASA will need to know if these companies can be sustainable businesses. Are their business models working? He added that the community needs to be educated about CLPS so that it can help NASA think about expanding CLPS to other parts of NASA SMD.

Regarding feedback for IDEA efforts, SC members discussed the need to determine the definition of success in this area. Currently, they saw one focus on ROSES and one on data. Dr. Tucker raised the issue of having a pipeline for helping people move from one level to the next; ROSES has typically been the pipeline enabling PIs to move to larger missions. She thought there should be more of an effort aimed at keeping the pipeline full. She felt it would be beneficial to see a commitment to the pipeline and to helping grantees succeed. Mr. Weiser said the IDEA effort would need emphasis beyond activity to actual outcome. Dr. Woodward commented that a diverse workforce would be needed to execute NASA science. He felt a question for SMD would be how to measure the incremental progress and build metrics in order to identify and support successful programs. He stated that both the nation and NASA would benefit from a work force that is capable of critical thinking. Dr. Williams asked: If NASA's workforce does not look like the face of the nation, how can it inspire the US? How does making a data set available to a marginalized community help? She said there needs to be a symbiotic relationship between NASA and the workforce. Dr. Tucker suggested NASA could start by looking at the organization charts for the

big missions and to consider what message they send. Dr. Liemohn noted that positions matter and leadership matters.

May 4, 2022

Meeting Re-opening

Mr. Callahan called the meeting to order and made administrative remarks. Dr. Williams briefly reviewed the agenda and introduced the day's first briefing.

Climate Science Update

Dr. Katherine Calvin provided an update on climate research at NASA. Dr. Calvin recounted that she joined NASA in January 2022 as Chief Scientist and Senior Climate Advisor, and detailed NASA's place in climate science given the Agency's long history of Earth-observing missions. The Earth's temperature trend has been changing rapidly since temperature recordkeeping began in the late 1800s. The last 8 years have been the warmest on record, resulting in more precipitation, more drought, and more wildfire events. Research indicates that anthropogenic carbon emissions are largely responsible for these changes. Models predict that extreme events will increase as warming increases. Forest cover is decreasing, cities are growing, land use and land cover are changing. Changes in sea level are occurring; snow and ice cover is decreasing, the latter of which has implications for reflective versus absorptive radiation. The nature and balance of carbon sinks and sources is changing. Much of what is known about climate change has been derived from NASA data.

NASA is the agency that performs end-to-end research about the Earth and flies more than 24 Earth observing satellites, some of which have been observing the planet for five decades. NASA develops technologies that can help mitigate or adapt to climate change, such as NASA's aeronautics research and space operations on ISS. NASA also helps in disaster response planning. Dr. Calvin said NASA is working to make climate change data more accessible to researchers, planners, and vulnerable communities. She noted that NASA facilities are also affected by climate change.

This year, NASA will be launching several Earth Science missions. The Earth Surface Mineral Dust Source Investigation (EMIT) launches to ISS in June where it will observe mineral dust as it relates to air quality. The six-satellite Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of SmallSats (TROPICS) mission will launch to monitor the precipitation, temperature, and humidity of tropical cyclones. The Surface Water and Ocean Topography (SWOT) mission will launch in the Fall. It is the first global survey of water running in rivers and lakes and will help to complement data that traditionally comes from stream gauges. SWOT will also provide a better sense of ocean currents and circulation and ocean-mixing effects on temperature. The Aeronautics Research Mission Directorate (ARMD) will be testing the first all-electric airplane. NASA will continue to provide Earth observations and applied science products to those who need them, all while making NASA data more accessible.

Dr. Calvin said one of NASA's Climate Change goals is to lead with partners, such as working with Landsat via the US Geological Survey (USGS), in an effort to show the public compelling imagery and statistics to demonstrate what climate change looks like (for example, displaying the number of days above 90 degrees Fahrenheit). NASA is also committed to establishing an Earth System Observatory that will be completed by end of the decade, implementing interconnected core missions that provide information about aerosols, mass change, surface deformation and change, and surface biology and geology. The goal is to put all this data in one place. NASA will continue to partner in programs such as CSDA, buying data from commercial satellites when it makes sense, and openly communicating to the public.

Dr. Mainzer noted that identifying sources of greenhouse emissions is important to mitigating climate change and asked how NASA could help to facilitate and eliminate these emissions. Dr. Calvin said that NASA is developing technologies that will help to lower emissions and will be monitoring carbon dioxide and methane with the future Geostationary Carbon Observatory (GeoCarb) mission, as well as with air campaigns, helping to enhance climate modeling. Dr. Mainzer asked if it were possible to monitor gas plant leaks with NASA assets. Dr. Calvin said that the fiscal year 2023 President's Budget Request includes language directing NASA to develop a greenhouse monitoring office in tandem with other agencies including the Environmental Protection Agency (EPA). Dr. Godwin asked how NASA could help generate data that can help communities. Dr. Calvin noted that the website <https://climate.nasa.gov/> is a good start, emphasizing that it is a general goal at NASA to make it easier to access useful data. Dr. Williams asked for examples of data products that can inform vulnerable communities. Dr. Calvin cited OpenET (<https://openetdata.org/>), an online soil moisture tool for farmers. Dr. Woodward commented that visualization is important for non-scientists and asked how NASA leverages climate models and interpretive data for the public. Dr. Calvin said that visualizations are dependent on the audience. She mentioned that Goddard Space Flight Center has produced good visualization schemes showing how hot the Arctic has become. Another shows monthly temperature changes over time, as well as seasonal changes and how these have changed over time as well. There are similar maps for seasonal variations in carbon dioxide emissions tied to vegetation. She said it's an evolving, two-way conversation. Dr. Woodward asked how NASA communicates arguments about the accuracy of models. Dr. Calvin said that it is particularly challenging to communicate the uncertainties around modeling to a non-science audience. She said the visualizations about the future are useful in this regard. For example, wheat yields may rise while corn yields might decline in response to the increase in atmospheric carbon dioxide. She said NASA will need to think carefully about how to communicate this sort of information. Dr. Tucker asked about the National Atmospheric and Oceanic Administration (NOAA)'s relationship to climate change data. Dr. Calvin said that NASA has held three major events in partnership with NOAA since the year began. Regarding research, both agencies also collect information about surface temperatures and conduct independent verification, as well as producing a joint report on rising sea levels. EPA, DOE, and the National Science Foundation (NSF) all do climate research and there is coordination among these agencies.

Dr. Liemohn noted that the American Geophysical Union (AGU) has a Thriving Earth Exchange that connects scientists to communities for real-world problems and asked if NASA scientists participate in this activity. Dr. Calvin was unsure if NASA participates but noted that NASA does have several similar activities, such as SERVIR, a partnership with USAID, within the ESD Applied Sciences Program. Mr. Weiser asked how this activity is communicated outward. Dr. Calvin said that NASA keeps track of trainings and social media engagement and thought such monitoring can be expanded to get a better idea of the scope of the Agency's reach. Dr. Bakhtian commented that NASA facilities are impacted by climate change but are also contributing to it. As for making data more accessible, she said, NASA has an incredible soapbox. She asked if NASA could take on the role of educating the public on climate change. Dr. Calvin said that, on the issue of NASA facilities impacting the environment, a 2021 Executive Order directs that all federal agencies examine their emissions. Regarding education of the public on climate change issues, Dr. Calvin felt that NASA does well in making complex science easy to understand. The Agency has a strong outreach team that communicates climate science. She stated that there is also quite a bit of exciting science taking place beyond what was reflected in her briefing, which encompassed only activities in 2022. Dr. Calvin added that NASA needs to listen in addition to speaking, and to determine whether it is saying the right things, in the ongoing process of communication.

Division Advisory Committee (DAC) Reports

Astrophysics Advisory Committee (APAC)

Dr. Woodward, Chair of the APAC, provided an update. The committee held its most recent meeting at the end of March 2022. Its next meeting will be in June to address the Astrophysics Division's Senior Review. The March meeting agenda included discussion of the FY22 appropriation and budget wedges for mission development; appropriation language directed to NASA; funding for technology maturation; various missions and the impacts of COVID-19 and global supply chain issues; revision of the cost cap for the Roman telescope; GUSTO schedule slips; and the awarding of the Rossi Prize to the Neutron Star Interior Composition Explorer (NICER) team. The committee discussed some APD highlights, including the latest tally of exoplanets (5000 found, 4 percent of which were terrestrial in nature); and the successful launch of JWST, the International X-Ray Polarimetric Explorer (IXPE), CubeSats, and suborbital launch campaigns.

Dr. Woodward brought to the attention of the SC a set of specific APAC findings and recommendations on the James Webb naming controversy:

Findings:

Information contained within the Agency Freedom of Information Act (FOIA) document tranche suggests a new urgency for the NASA historian to assess carefully documents in the historical archives of the State Department and the Truman Library.

The APAC was dismayed to receive no formal record decisions and associated findings, despite the committee's specific request, that summarized the decision-making process that resulted in the Observatory's name remaining as is.

The APAC notes that NASA is committed to complete the additional investigation promptly, in the next few months, and to report publicly on the results.

• ***Recommendations:***

The APAC requests the APD strongly encourage the NASA historian's office to document fully and completely in a written report the current status of the ongoing investigation of archival materials, conversations, and other sources by the committee's 2022 July meeting.

The APAC advises that advancing the resolution of the Webb investigation may require additional future work and requests a schedule for timely and crisp completion of these activities.

The APAC requests the NASA historian be invited to provide a thorough debrief to the committee for the record at the committee's 2022 summer meeting.

The APAC advises APD to consider development of written policies and guidelines-of-practice of naming flagship missions that could build community trust and endorsement.

The APAC suggests that the findings of the NASA historian, the issue of James Webb memorialization, and the naming of future observatories be discussed by the NASA Advisory Council (NAC).

Other APAC findings and recommendations

Findings:

APD has successfully launched the flagship great observatory JWST, IXPE, the Colorado Ultra Transit Experiment (CUTE), and conducted a successful suborbital launch campaign of 7 balloon launches that will enable scientific advancement in many fields.

The mission lifecycle costs of the Roman Observatory have increased over original mission commitments and careful management strategies are ensuring success.

APD has thus far responded effectively to implement some of the recommendations contained within the Astro2020 Decadal Survey.

APD is trying to formulate ways to enhance the Astrophysics Theory Program (ATP), as recommended in the Astro2020 Decadal Survey.

APD is taking steps to build a strong portfolio for time domain and multi-messenger science.

APD evaluated the results of the ROSES Inclusion Plans Initiative as a pilot in the context of the ATP program; the initiative is being extended to other programs over three years.

APD has shown leadership in building excellence in the NASA workforce by initiating efforts to support work-life balance.

The APAC endorses the initial APD plan to implement enforceable Codes of Conduct requirements for science teams.

Recommendations:

The APAC requests regular updates on the cost and schedule of the Roman Observatory. The APAC requests an update regarding the next MDEX opportunity now delayed.

The APAC requests a presentation on the status of GUSTO at its next meeting.

The APAC requests a presentation on the Stratospheric Observatory for Infrared Astronomy (SOFIA) close-out process plans, including mission data archive completion at the NASA/IPAC Infrared Science Archive (IRSA) and aircraft asset preservation. The APAC recommends that NASA extend the SOFIA mission close-out process to FY2023 to carry out the Cycle 10-selected peer reviewed proposals.

The APAC requests APD initiate a review of whether the community research and analysis funding profiles and formulae used in pointed Great Observatory mission models (e.g., Hubble, Webb) is applicable to survey missions (e.g., Roman, Euclid) to maximize the scientific return.

The APAC requests a presentation on the evolution of the NASA Science Mission Directorate (SMD) Bridge program and a broad strategic overview of the implementation of IDEA initiatives at the committee's next meeting.

The APAC advises APD to communicate effectively and in a timely fashion with the astrophysics community and other stakeholders with regard to release of a Probe Announcement of Opportunity (AO), envisaged in the Astro2020 Decadal Survey.

The APAC requests APD to provide frequent updates on action related to time-domain and multi-messenger science.

The APAC advises APD to continue close evaluation of the ROSES Inclusion Plans Initiative, as it extends to different programs.

The APAC requests Kevin Murphy, Transform to Open Science (TOPs) lead, to discuss with the committee at a future meeting the developments in this area, with a particular focus on the national needs and sensitivities to national security awareness of widely accessible and distributed scientific software codes.

Planetary Science Advisory Committee (PAC)

Dr. Mainzer, Chair of the PAC, presented an update of activities. The PAC had its last meeting in February; the next meeting will take place 21-23 June, principally to examine the Planetary Decadal Survey following its release. At the previous meeting the PAC received updates on PSD, the R&A Program, and Analysis Group (AG) reports. The PAC took note of the launch of the DART mission in November 2021. DART is scheduled to impact a double asteroid system in late September 2022 and will provide an exciting test of a critical technology for Planetary Defense. The Europa Clipper mission continues on its path to launch. Its imaging system has achieved first light and the spacecraft is on track to move into the Assembly, Test, Launch, and Operations (ATLO) phase toward a 2024 launch. The recent Decadal Survey made some key recommendations: the highest priority for the next decade is MSR, while recognizing the concern that the mission is ambitious and costly. The Survey contains language that supports MSR in the context of planetary program balance. The Survey also recommends that the next major Flagship be a Uranus orbiter and probe (with the caveat that the costs not overwhelm the portfolio) and that the Near-Earth Object (NEO) Surveyor be the highest priority for the Planetary Defense Coordination Office (PDCO). The Survey also includes a State of the Profession discussion and a discussion on keeping the community free from harassment. Lastly, the Survey contains recommendations for eight New Frontiers (NF)-class missions as well as NF and Discovery program cost caps.

PAC findings and recommendations (presented as information)

Finding 1: Several PAC AGs highlight that, while there is value in sharing software, the current draft of SPD-41 leaves a number of critical issues unclear. There are concerns that the policy could disadvantage new proposers and those without institutional resources to aid in compliance. The PAC commends NASA for putting the draft policy out for public review and encourages NASA to fully address the concerns raised by the AGs and by the community through the public comment process.

Finding 2: The PAC commends NASA for supporting inclusion, diversity, equity, and accessibility (IDEA) efforts in planetary science and working towards inclusive NASA-supported conferences and meetings. However, community-voiced concerns still remain regarding how to improve inclusivity and safety for under-represented minorities at NASA-supported conferences/meetings.

- ***Recommendation:*** To continue advancing IDEA principles in the community, the PAC recommends that NASA should leverage existing IDEA efforts, such as the IDEA Inter-AG working group, the NASA HQ IDEA group, or social scientists who focus on IDEA, to ensure that all NASA-supported conferences are as inclusive and safe as possible along multiple axes of representation, and particularly for historically excluded communities.

Finding 3: The PAC appreciates the initial efforts to identify avenues of community service within the planetary science community and estimated costs and issues associated with potential direct payment for such work. These efforts present an important starting point for a needed discussion and effort.

- **Recommendation:** In response to the request for PAC feedback with respect to prioritization for potential initial PSD efforts, the PAC recommends a first focus on funding surveys/studies of the workforce to assess the state and concerns of the planetary science community, as these seem less complicated to initiate with funding and may help fill important information gaps.

Finding 4: The PAC notes that the impacts of COVID-19 have been numerous and are likely to be felt for years to come, by both individuals and larger efforts such as mission teams. Impacts may result in lower productivity in professional tasks and/or ability to participate in community service work and may be unevenly distributed within the community. Identification and measurement of impacts are needed to guide mitigation efforts. Surveys of the workforce can provide critical sources of relevant information, either directly about impact or indirectly by looking at who is participating and in what capacities. The most recent workforce survey for the planetary science community was prompted by the ongoing Decadal Survey and was collected prior to COVID-19.

Recommendation: The PAC recommends that NASA consider commissioning a new survey, with a primary aim of assessing COVID-19 impacts and institutional support for community service. Input on the construction of the survey should be solicited from social scientists, community groups containing relevant expertise (such as the cross-AG IDEA working group or the AAS/DPS Professional Climate and Culture Subcommittee (PCCS)), and/or those involved in constructing and analyzing the last workforce survey.

Dr. Mainzer concluded by announcing she would be completing her activities as PAC Chair in July.

Heliophysics Advisory Committee (HPAC)

Dr. Liemohn, HPAC Chair, presented an update and noted that HPAC is to have its next full meeting 5-6 May; at present, there are no findings or recommendations to put forth. The meeting agenda will include Space Weather and a discussion of Heliophysics R&A. Dr. Liemohn shared some newsworthy notes: the Parker Solar Probe (PSP) “touched” the Sun, having achieved ever closer proximity to the Sun through a succession of highly elliptical orbits. The probe finally went under the supersonic/subsonic transition at a distance of 19 solar radii, which is effectively inside the solar atmosphere. PSP will achieve a distance of less than 10 solar radii by 2025. Dr. Liemohn highlighted a paper in *Nature Communications* reporting data on superfast radiation belt loss to the atmosphere. The study showed that nonlinear “super-diffusion” occurs in geospace and this diffusion is advection out into the magnetosphere. This marks the first time the phenomenon has been observed by two HPD assets, the Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission, and Electron Losses and Fields Investigation (ELFIN), a student-operated CubeSat mission. The finding argues for a Heliophysics Observatory system fleet, as these sorts of observations are not possible without coordinated measurements. In this regard, Dr. Liemohn noted that Heliophysics science would also benefit greatly from more modeling efforts.

Earth Science Advisory Committee

ESAC Chair, Dr. Sara Tucker, provided an update, noting that the ESAC has not met since its Government Performance Review Act (GPRA) reporting exercise and has not had a meeting with an agenda since March 2020. The Committee is working to form an agenda for a late June meeting that will include an ESD update, the first for ESD Director Karen St. Germain; the 2017 Earth Science Decadal Survey and plans for Designated Observables missions; Earth Science Explorers and the Earth Venture missions (e.g., EMIT); open source science and commercial data buys; and modeling strategy development. The Earth Science Decadal Survey recommends that NASA establish a new program element within ESD, a category called “incubation,” intended to help develop concepts for high-priority observables that are not yet feasible to be considered in the next Decadal Survey, and ESAC will hear about a selection of recent incubation studies (30-35) in areas of boundary layers and surface vegetation

topography as well as a report from the ASAC on the matter. A DEIA review is on the agenda, focusing on how the NASA-wide initiative is being reflected in ESD. The last scheduled topic will be an Earth Science Communication Strategy.

Discussion

Dr. Bakhtian asked if ESAC had specific areas of focus on climate change. Dr. Tucker said yes, one ESAC focus is on carbon cycle and climate, and that there is strong representation of climate expertise on the Committee. She noted that Dr. Calvin, the Senior Climate Advisor, sits in the advisory space between the Applied Sciences Advisory Committee (ASAC) and ESAC, at the directorate level. While she reports to the Administrator, she is not a political appointee and is the first Climate Advisor for NASA. Dr. Woodward observed that there is increasing activity involving inexpensive satellites and CubeSats. He found it interesting that all the divisions are adopting these platforms to do exciting science that is also valuable to workforce development. He asked for Committee thoughts on face-to-face versus virtual meetings, given that APAC members feel that it will be very important to have a frank and public discussion on the JWST naming controversy. Dr. Bakhtian asked about data archiving and its implications for Open Data. Dr. Woodward said that there is an Agency-wide move to open data; in APD particularly, new missions will be returning massive, petabyte-level quantities of data, raising concerns about how to apply modern data science techniques. He said APAC is concerned that this is an under-scoped effort, and is also concerned about data fidelity, robustness, and distribution of data products. Archive modernization is an Agency-wide activity but it is hard for NASA to keep up with the rate of change in data science and in data handling techniques. He said NASA must also be cautious about open source code, as the policy has implications for national security. Dr. Woodward referenced the Big Data Task Force report (C. Holmes, *et al.*), and suggested a revisit of the topic. Dr. Tucker cited an ESAC concern for continued temporal and spatial coverage to support climate observations, noting that the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) mission turned out to be an unexpected climate mission. It will be important to ensure that NASA is working with other agencies for temporal and spatial continuity.

Dr. Mainzer reiterated that NASA has the capability of pinpointing sources of greenhouse gas emission and asked why it was not doing so, given that there are both nonprofit and for-profit companies taking this up challenge. Dr. Godwin asked if there were a way to identify the top 10 or 20 greenhouse gas emitters. The Committee agreed that this was possible, but that funding is a barrier. Dr. Mainzer felt that NASA should simply move ahead and do it. Dr. Woodward commented that ESD's SERVIR program has had great impact in improving agricultural planning in Africa, and that there is also CSDA data that could be helpful in this regard. The problem, he said, is how to use such data in cooperation with other agencies to pinpoint the location of greenhouse gas emissions. In this regard, he thought it might be useful for the SC to make some policy suggestions. Mr. Weiser said that NASA possesses rich data and extraordinary models, and thus might be able to find organizations with which to partner, and to help softly influence decisions that these organizations make. Dr. Williams commented that what NASA might like to do and what NASA is authorized to do can be quite different. Pinpointing methane sources, she said, would have to be addressed within NASA's science mission, and that cooperation with regulatory agencies such as EPA (as described by Dr. Calvin) provide an appropriate mechanism for translating NASA's research results. Dr. Tucker said that having the data publicly available is most important. Dr. Woodward noted that NASA can provide the observational continuity over time and should be encouraged to do this. Mr. Weiser suggested presenting the issue as one of education, in which NASA could disseminate the information directly to affected communities. He noted that JPL already does an excellent job of communicating what it does, and its simulation and visualization capabilities could work very well in this capacity as they did with the widely viewed and lauded Perseverance landing simulation.

Dr. Woodward commented that SMD has been able to accomplish an extraordinary amount of work over the last three years, maintained by a dedicated workforce. He felt this accomplishment should be recognized and applauded.

Findings and Recommendations Discussion

The Committee fielded input on the expansion of the CLPS model for procuring commercial services to other areas of SMD. Mr. Callahan took an action to write up the discussion. Mr. Callahan also took an action to determine the science makeup of currently planned CLPS instruments.

The Committee considered the question of ESSIO science and the question of balance within the new Planetary Science Decadal Survey, deferring further discussion to the next meeting.

The Committee discussed constraints on commercial activities at the Moon and issues such as “lunar litter.” Mr. Weiser noted that it was a complicated policy issue as well as a real science issue, given that these activities may imperil future science investigations. The Committee agreed that issues such as the contents of the Artemis Accords, documentation of affected areas on the lunar surface, planetary protection policies covering organic compounds and volatiles, the plans of the international community, and dust control on the lunar surface are also relevant and should be more thoroughly examined.

The Committee discussed how to account for the long-term viability of new space companies in NASA procurement of services, as well as returning mass from the Moon commercially for science/commercial purposes.

The Committee discussed further SMD IDEA updates on measuring various outreach efforts to MSIs and HBCUs, and how to reach non-traditional communities with training, Cloud access, and other tools.

The Committee discussed climate science. Dr. Tucker said that, regarding interagency collaboration, the SC would do well to confirm how the agencies are working together and to comment that it is critical to continue the collaborations. She appreciated Dr. Calvin’s answer on confirmation of observations from numerous Earth Science data sets and their application to different models. She recommended a finding on the subject. Mr. Callahan asked if NASA should lead reporting on the multiagency activity. Dr. Bakhtian noted that NASA has been taking a strong lead on educating the public on climate science and might be suited to take a larger role in the interagency collaboration, leading the effort to identify impact goals and how they are measured. Dr. Mainzer said that there is a data gap in measuring greenhouse gas emissions in terms of spatial and temporal continuity that NASA should work to address. She said NASA should also expand its efforts to monitor greenhouse gases. Dr. Bakhtian commented that there should be feedback loops to better understand how to have an impact with the data NASA collects regarding climate change. In addition, she said, NASA needs to ensure that researchers incorporate IDEA practices from the very beginning of projects and programs. Mr. Callahan asked if this comment implied that NASA should be training researchers in how to incorporate IDEA. Dr. Williams felt that the program calls themselves would have to codify the requirements for IDEA activity. Dr. Bakhtian suggested that the SC recommend that NASA train researchers to fully embrace equity and serve the underserved communities in its research efforts, where applicable. Dr. Godwin recommended that NASA have virtual meetings to educate communities on how to use NASA data, and to concentrate on local efforts. Otherwise, she said, it might be missing some grass-roots efforts by non-professionals. Drs. Bakhtian and Williams emphasized that IDEA is not just about giving out grants to the underserved but making sure that the grantee is supported to be able to succeed. Dr. Williams couched the recommendation in terms of creating strong metrics for the achievements and implementation of IDEA concepts. Mr. Callahan took an action to work further with Dr. Zurbuchen on clarifying how IDEA outcomes are measured.

The Committee discussed a finding praising the JWST team and the meritorious performance of SMD throughout the COVID-19 lockdown. Dr. Bakhtian suggested opening the data embargo on JWST. Dr. Mainzer noted there were large international partners on JWST and said she would be hesitant to support such a finding, adding that there are individual proposers who have their own data management plans, so immediate data accessibility is probably not an issue. She added that the PAC had raised concerns about NASA's SPD-41 policy and the legal implications of releasing software code.

Dr. Bakhtian commented on risk tolerance postures in CLPS, and how best to communicate to the public what risk or failure truly means in these commercial missions. Dr. Godwin felt that CLPS instruments were not on the critical path for Artemis. Mr. Weiser said that Artemis critical path ideas are enmeshed in VIPER because results could be critical to Mars in the future. He noted that as much as half of the science currently listed for the Artemis program is being conducted through CLPS missions, thus the SC could conceivably make recommendations on the science balance for CLPS. Dr. Liemohn said that HPD had held entire workshops for Artemis science and Gateway and imagined that there are many more ideas to be proposed. He said CLPS would be an interesting way to test a telescope on the far side of the Moon as just one example.

Outbrief to the SMD DAA

Dr. Williams briefed Ms. Sandra Connelly, Deputy Associate Administrator (DAA) for SMD, on the outcome of the SC meeting, presenting recommendations to expand planetary protection efforts at the Moon to consider future science impacts from lunar litter and a broader focus on human activity that may also undermine future science missions, as well as the obligations of commercial partners. She also detailed recommendations on data gaps in Climate Science; NASA training for researchers on how to implement IDEA where applicable; and disseminating NASA data tools to local communities through virtual training sessions.

Dr. Williams presented findings on providing training and infrastructure to help underserved grantees succeed and building timelines and other tools to measure trends, expected impacts, and hiring practices; the continuation of a robust interagency collaboration on coordinating climate data; potential NASA leadership on educating public on climate issues using behavioral science expertise; and applause for JWST and the excellent performance of SMD throughout the COVID-19 pandemic. Dr. Williams also commended the CLPS presentation for its content and clarity.

Ms. Connelly asked for some clarifications on the IDEA discussion and whether the SC had any thoughts about the future of work. Dr. Williams felt the workforce topic was worthy of continued discussion and Dr. Tucker said she had provided Dr. Zurbuchen some material on that subject. Mr. Weiser said that there is a general recognition that a mix of science and engineering—the latter of which needs to be conducted in person—is critical to NASA missions. He said that there are extraordinary tools, models, visualizations, and other methods required to get information to the public and that NASA needs to better understand how to engage with this information. As one avenue for feedback, he said, NASA could embed data in platforms that farmers use every day and could measure the data consumption rate in each application.

Ms. Connelly thanked the Committee for its service, findings, and recommendations. Mr. Callahan adjourned the meeting.

Appendix A **Attendees**

Science Committee Members

Dr. Ellen Williams, ***Chair***, University of Maryland
Dr. Noël Bakhtian, Lawrence Berkeley National Laboratory
Dr. Vinton Cerf, Google, Inc.
Dr. Linda Godwin, University of Missouri
Dr. Michael Liemohn, University of Michigan
Dr. Amy Mainzer, Arizona State University
Dr. Sara Tucker, Ball Aerospace
Mr. Marc Weiser, RPM Ventures
Dr. Charles Woodward, University of Minnesota
Mr. Jason Callahan, Designated Federal Officer, NASA Headquarters

Other Attendees

Amy Reis
Joan Zimmermann

Appendix B

Science Committee Membership

Dr. Ellen Williams (Chair)
University of Maryland

Dr. Noël Bakhtian
Lawrence Berkeley National Laboratory

Dr. Vinton Cerf
Google, Inc.

Dr. Linda Godwin
University of Missouri

Dr. Michael Liemohn
University of Michigan

Dr. Amy Mainzer
Arizona State University

Dr. Willie May
Morgan State University

Dr. Sara Tucker
Ball Aerospace

Mr. Marc Weiser
RPM Ventures

Dr. Charles Woodward
University of Minnesota

Mr. Jason Callahan, Designated Federal Officer
NASA Headquarters

APPENDIX C PRESENTATIONS

1. Science Mission Directorate Update; *Thomas Zurbuchen*
2. Managing Delivery of Services: ESSIO; *Joel Kearns*
3. SMD Diversity, Equity, Inclusion and Accessibility Update; *Karen Flynn, Kate Becker, Michael New, Jade Singleton*
4. Planetary Protection Update; *Nick Benardini*
5. James Webb Space Telescope Status; *Eric Smith*
6. Climate Science Update; *Katherine Calvin*
7. Astrophysics Advisory Committee Report; *Charles Woodward*
8. Planetary Science Advisory Committee Report; *Amy Mainzer*
9. Heliophysics Advisory Committee Report; *Michael Liemohn*
10. Earth Science Advisory Committee Report; *Sara Tucker*

APPENDIX D
AGENDA

NAC Science Committee Meeting
NASA Headquarters
May 3-4, 2022

Agenda
(Eastern Time)

Tuesday, May 3, 2022

9:00 – 9:15	Opening Remarks / Introduction of Members	Mr. Jason Callahan Dr. Ellen Williams
9:15 – 9:20	Goals of the Meeting	Dr. Ellen Williams
9:20 – 10:20	NASA Science Update	Dr. Thomas Zurbuchen
10:20 – 10:35	Break	
10:35 – 11:25	Managing Commercial Delivery of Services – Exploration Science Strategy and Integration Office	Dr. Joel Kearns
11:25 – 11:35	Public Comments	
11:35 – 12:50	Lunch	
12:50 – 1:40	SMD Inclusion, Diversity, Equity and Accessibility Update	Dr. Karen Flynn Ms. Kate Becker Dr. Michael New Dr. Jade Singleton
1:40 – 2:25	Planetary Protection Update	Dr. Nicholas Benardini Dr. Elaine Seasley
2:25 – 2:40	Break	
2:40 – 3:30	James Webb Space Telescope Update	Dr. Eric Smith
3:30 – 4:00	Wrap-up Discussion	All

Tuesday, May 3, 2022 – Non-public Session

4:00 - 5:00	Discussion with SMD AA.	Dr. Thomas Zurbuchen
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Wednesday, May 4, 2022

8:00 – 8:10	Re-open Meeting	Mr. Jason Callahan Dr. Ellen Williams
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8:10 – 9:00	Climate Science Update	Dr. Katherine Calvin
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9:00 – 10:00	Division Advisory Committee (DAC) Chair Report Astrophysics Advisory Committee Planetary Science Advisory Committee Heliophysics Advisory Committee Earth Science Advisory Committee	Dr. Charles Woodward Dr. Amy Mainzer Dr. Michael Liemohn Dr. Sara Tucker
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10:00 – 10:15	Break	
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10:15 – 11:30	Discussion, Recommendations, and Findings	All
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11:30 – 12:00	Outbrief to SMD Deputy AA	Dr. Ellen Williams Ms. Sandra Connelly
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12:00	Adjourn	
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Appendix E

Webex Chat Transcript

Tuesday, May 3, 2022

from Brad Bailey (Int) to everyone: 10:57 AM

We are also looking to protect certain areas (specific PSRs, heritage sites (e.g. Apollo 11), other int'l landed missions, etc). We are also trying to keep in mind the radio quiet far side and how to keep that environment capable of performing cosmological/radio astronomy research.

from Noel Bakhtian (Ext) to everyone: 10:58 AM

Thanks Brad

from Noel Bakhtian (Ext) to everyone: 10:58 AM

Are international partners included in these policies, in the hopes that all future countries doing this abide by same policies?

from Brad Bailey (Int) to everyone: 11:01 AM

Yes, but in pieces... some guidelines are laid out in COSPAR documentation, some are defined in the Artemis Accords, etc. But not all Moon-bound countries have agreed to a specific set of governing policies at this time.

from Noel Bakhtian (Ext) to everyone: 11:01 AM

Thanks!

from Noel Bakhtian (Ext) to everyone: 11:03 AM

There was a slide that mentioned that the hope is that NASA isn't the only customer of CLPS services - can international customers do missions through CLPS too?

from Noel Bakhtian (Ext) to everyone: 11:04 AM

Got answered verbally - thanks!

from b harvey Ext (Ext) to everyone: 11:27 AM

CPLS doesn't share with PDS?

from Brad Bailey (Int) to everyone: 11:32 AM

One small edit is that PDS isn't technically required for ALL science, but archival in a public repository that makes the most sense for a particular science instrument NLT 6 mos post-ops is required (PDS will host most of our science though)

from b harvey Ext (Ext) to everyone: 11:33 AM

why?

from Nino Cucchiara he/him, NASA HQ (Ext) to everyone: 1:05 PM

Q to Dr. New: can you say few words about how SMD plans to increase the obligated dollar to HBCU/MSI? Are we talking increasing MIRO/MUREP?

from Nino Cucchiara he/him, NASA HQ (Ext) to everyone: 1:42 PM

Q. to Dr. Singleton: can you comment on the inside-out approach. Specifically, how can SMD do step 1 without Step 5

from Nino Cucchiara he/him, NASA HQ (Ext) to everyone: 1:43 PM

In other words, [are] you trying to change inside without knowing what is needed from the community from the Diversity angle (you cannot know what you do not know)

from Noel Bakhtian (Ext) to everyone: 1:53 PM
what's COSPAR?

from Noel Bakhtian (Ext) to everyone: 1:53 PM
thanks

from Jason Callahan (Int) to everyone: 1:54 PM
The UN Committee on Space Research, where international planetary protection standards are discussed.

from Noel Bakhtian (Ext) to everyone: 1:55 PM
thanks!

from VINTON CERF (Int) to everyone: 2:45 PM
this makes me think of the streaming video show called Domino Masters....

from VINTON CERF (Int) to everyone: 2:55 PM
I have a question about the temperature of primary and secondary mirrors/instruments

from IRMA RODRIGUEZ (Int) to everyone: 2:55 PM
Is there a link to the video?

from VINTON CERF (Int) to everyone: 3:35 PM
Finding: The NASA Advisory Council Science Advisory Committee finds the successful launch and commissioning of the James Webb Telescope to be nothing short of spectacular. The committee anticipates extraordinary data to come from this new set of instruments. Combining this new data with archival data may pave the way for new insights into the history of our universe. We offer our enthusiastic congratulations on the JWST successes thus far.

from VINTON CERF (Int) to everyone: 3:36 PM
are we supposed to be seeing slides for these findings? I am only seeing the introductory slide

from Jason Callahan (Int) to everyone: 3:37 PM
Vint, no. Mini is just reading. I will send out the slides later.

from VINTON CERF (Int) to everyone: 3:38 PM
<https://openssf.org/>

from VINTON CERF (Int) to everyone: 3:45 PM
We'll know we have really arrived on the Moon when the first MacDonald's is opened there....

from Noel Bakhtian (Ext) to everyone: 3:45 PM
no organics there :)

from VINTON CERF (Int) to everyone: 3:45 PM

er, Moonshakes?

from Noel Bakhtian (Ext) to everyone: 4:47 PM

<https://www.mckinsey.com/business-functions/people-and-organizational-performance/our-insights/its-time-for-leaders-to-get-real-about-hybrid>

from Noel Bakhtian (Ext) to everyone: 4:48 PM

some general stats: <https://www.forbes.com/sites/forbesbusinessdevelopmentcouncil/2021/08/19/the-future-of-work-remote-hybrid-and-in-office/?sh=33ce2edc6168>

from Noel Bakhtian (Ext) to everyone: 4:49 PM

https://www.economist.com/special-report/2021-04-10?utm_source=google&utm_medium=cpc&utm_campaign=a_21futurework&utm_content=work&gclid=Cj0KCQjwpcOTBhCZARIsAEAYLuXtD5-FSk_aTY2QS7DJ_N_f2e3cvNzqjFiPIXEVM0_sFub5XGHPpAAaAhBXEALw_wcB&gclsrc=aw.ds

Wednesday, May 4, 2022

from Lori Glaze (Int) to everyone: 9:19 AM

Thanks for your service, Amy.

from Amy Mainzer (Ext) to everyone: 9:20 AM

It's been a pleasure! Glad to have the opportunity.

from Noel Bakhtian (Ext) to everyone: 9:21 AM

impressive diversity on the agenda!

from Lori Glaze (Int) to everyone: 9:34 AM

Kate [Calvin] is at the Agency level

from Lori Glaze (Int) to everyone: 9:35 AM

she replaced Jim Green as Chief Scientist; + climate role

from Noel Bakhtian (Ext) to everyone: 11:14 AM

what's AO?

from Amy Mainzer (Ext) to everyone: 11:26 AM

AO=announcement of opportunity (the solicitation for a proposal, either for a mission or for a research grant)

from Noel Bakhtian (Ext) (privately): 11:29 AM

is this open to public?