

NASA ADVISORY COUNCIL
PLANETARY SCIENCE ADVISORY COMMITTEE

March 1-2, 2021

Virtual Meeting
Washington, DC

MEETING REPORT



4/5/2021

Amy Mainzer, Chair

Stephen Rinehart, Executive Secretary

Table of Contents

Opening and Announcements, Introductions	3
PSD Status Report	3
ESSIO Update	6
Astrobiology Update	7
Planetary Defense Coordination Office	8
Mars Exploration Program/Mars Sample Return	9
Decadal Survey Update	12
Research and Analysis Program Update	15
Inclusion Diversity Equity and Accessibility (IDEA) Update	17
General Discussion	19
<i>Analysis Group Updates</i>	
MExAG	21
VEXAG	21
LEAG	21
SBAG	22
MEPAG	22
OPAG	23
MAPSIT	24
ExMAG	24
ExoPAG	24
General Discussion	25
Findings Discussion	26

Appendix A- Attendees
Appendix B- Membership roster
Appendix C- Agenda
Appendix D- Presentations

***Prepared by Joan M. Zimmermann
Zantech, Inc.***

March 1, 2021

Opening and Announcements, Introductions

The Executive Secretary of the Planetary Science Advisory Committee (PAC), Dr. Stephen Rinehart, opened the meeting, welcomed members of the committee, took roll, and introduced PAC Chair, Dr. Amy Mainzer.

PSD Status Report

Dr. Lori Glaze, Director of the Planetary Science Division (PSD), presented a status of the division, first remarking on the COVID “anniversary”—it has been one year since NASA initiated work in a virtual environment. Dr. Glaze noted that challenges associated with COVID limitations persist, especially in terms of impact to early career (EC) scientists (networking opportunities missed, potential impact of reduced levels of productivity). She noted that the impact is not uniform, and that it would behoove the community to watch where the challenges occur and react accordingly. Dr. Glaze encouraged EC scientists to reach out, contact their mentors, and try to identify gaps in order to address them.

The Fiscal Year 2021 (FY21) budget appropriations bill was passed at the end of December 2020, and it shows continued strong support for science, which overall has done extremely well at \$7.3B, an amount that exceeded the official request. PSD received \$40M above the original request (\$2.7B), which supports Decadal Survey language regarding Mars Sample Return (MSR), the Europa Clipper, Planetary Defense goals, the Double Asteroid Redirect Test (DART) and the Near Earth Object Survey Mission (NEOSM). Europa Clipper has been given permission to use a non-Space Launch System (SLS) launch vehicle. The distribution of funding is still to be determined as NASA goes about getting its Operating Plan (OP) approved.

Included in the PSD fleet are a number of Commercial Lunar Payload Service (CLPS) missions. There are now up to five CLPS launches planned, at a cadence of about two launches per year. This is a great achievement and an exciting time for lunar exploration within PSD. The latest and biggest news, however, is the flawless landing of the Perseverance rover at Mars on 18 February, which beamed to Earth a series of absolutely amazing video images of the rover landing, parachute deployment, and spacecraft maneuvering to reach its landing site near Jezero Crater. The rover managed to touch down only 1.7 miles away from its target, which is near a fractured unit believed to contain olivine. The hazard map that characterizes the landing site (a river delta) shows how well terrain-relative navigation (TRN) worked to identify the small safe areas for landing. Color images thus far being transmitted are breathtaking, while rover checkout continues. In upcoming weeks, the rover team will deploy its “helicopter” drone technology demonstration, after which the rover will begin its sample-caching mission in earnest. The broadcast of the rover landing had about 4.2M peak viewers, with more than 20M views on YouTube cited during the last week of February. The Perseverance landing also elicited heavy Web traffic, and notable social media mentions from the President and First Lady of the United States, and former President Barack Obama. Dr. Glaze offered lauded the entire rover team for doing an outstanding job under difficult conditions.

The Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) spacecraft will execute a final flyby of the asteroid Bennu on 7 April to image the asteroid, including the sampling site, after which it will image the body for a full 4.3-hour rotation period, and then depart from Bennu on 10 May, to return to Earth in 2023. The Lucy mission is on track for a first NASA mission to the Trojan asteroids; the Assembly, Test, Launch and Operations (ATLO) phase is progressing well, and the spacecraft’s pre-environmental review has been passed. Lucy’s launch window opens in October 2021, to arrive at the Trojan asteroid region in August 2027.

The DART mission is currently experiencing technical challenges associated with the DRACO imager and solar array fabrication. The Science Mission Directorate (SMD) has conducted a risk assessment, and is now considering a secondary launch window, which opens in November 2021, and which supports an (unchanged) arrival date at Didymos, in September 2022. Within the SIMPLEX program, Q-PACE launched on 17 January; however, the spacecraft beacon has not yet been detected. The mission's Principal Investigator (PI) is constructing a second ground station to continue attempts to contact the Q-PACE satellite. The CLPS payload, LunaH-Map, is scheduled for delivery in March 2021. Janus and Lunar Trailblazer passed their Key Decision Points-C (KDP-C) milestones, while Escapade is working toward its KDP-C. PSD recently completed the 2020 Senior Review for the Juno, and Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight), missions. The Juno team was approved to bring the spacecraft to its end-of-life in 2025. Juno's final orbits will fly by three of Jupiter's Galilean moons: Ganymede, Io, and Europa. There have been recommendations to support additional Juno Program Scientists. InSight was approved for a two-year extension; its focus will be on long-duration seismic data set, and operation of the weather station. Mole recovery efforts have been concluded. The InSight team got the mole beneath the surface of soil, but progressed no further. The solar arrays are now collecting a fair amount of dust, which will present a challenge for the Mars winter, but the team expects continued success in operations.

The Volatiles Investigating Polar Exploration Rover (VIPER) lunar mission, working with the Exploration Science Strategy and Integration Office (ESSIO), just passed its KDP-C, thus has been confirmed and is moving to phase C. The Europa Clipper continues to move forward and is doing well, with the mission in the building hardware phase. The mission is completing its reporting on the December 2020 Critical Design Review (CDR), and working toward a launch readiness date in 2024, and acquiring a commercial launch vehicle (LV) via a competitive process. Instrument cost control is also going well. The top concern at present is COVID's impacts on the work team, in addition to some minor technical issues that are also being worked. Within the Discovery program, Step-2 selections are expected in mid-July. Within the New Frontiers program, the Dragonfly mission to the Saturnian moon, Titan, is progressing to confirmation, and a New Frontiers 5 draft Announcement of Opportunity (AO) is under way.

In the area of community initiatives, Decadal Survey panel meetings are going forward. SMD has also initiated a National Academies of Science, Engineering, and Medicine (NASEM) study on Diversity and Inclusion (D&I) in the Leadership of Competed Missions, and has also has requested of the NASEM Committee on Planetary Protection a detailing of criteria that will govern landing sites for robotic missions on Mars. Other community opportunities include the Next PI Launchpad workshop, which is scheduled for 14–25 June, to be held virtually and partly asynchronously. The Lunar and Planetary Science Conference (LPSC) is also coming up, and will include a one-hour NASA Headquarters briefing on Thursday, 18 March. PSD is initiating a new Senior Review of the Planetary Data System (PDS) discipline nodes, and to date, the SMD ROSES Gaps request for information (RFI) has had all responses assessed. Major findings from the RFI can be found at [https://science.nasa.gov/science-red/s3fs-public/atoms/files/Sheth_RFI%20Gaps_APAC_Oct2020.pdf]], while NASA works to respond to the findings. The Research and Analysis program (R&A) has been assessing COVID-19 augmentations and funded extensions; the absolute deadline is 5 March 2021. ROSES 2021 was released on 12 February — all PSD Data Analysis Programs (DAPs) will be assessed by a dual-anonymous peer review (DAPR) process. In addition, ROSES 2021 has No Due Date (NoDD) submissions in place for seven programs: Solar Systems Workings, Emerging Worlds, Exobiology, PICASSO, Laboratory Analysis of Returned Samples, Solar System Observations, and Planetary Data Archiving, Restoration, and Tools (PDART).

Response to PAC findings

In response to PAC Finding 1 on the matter of the damaged Arecibo Observatory, NASA acknowledges the impact to the planetary science community, and plans to continue to use the Goldstone radar facility for tasks once served by Arecibo. Goldstone is a better pointing facility, but with a more limited range in comparison to Arecibo. NASA has completed some upgrades and repairs at Goldstone, which will be used to monitor and view NEOs. The loss of Arecibo also opens opportunities for NASA and the community to think about future planetary radar capabilities.

Responding to PAC Finding 2 on R&A funding, which details its concerns about low selection rates, and deferred opportunities for certain programs, etc., NASA shares PAC's concern about selection rates, and continues to regard selection rates as high-priority issue for PSD. PSD will continue efforts to improve transparency and identify valuable advice in this matter. Dr. Glaze noted that the ROSES NoDD effort is intended to provide flexibility for all in the selection process.

Responding to PAC Finding 3 on the Mars Ice Mapper (MIM), which entails concern about how MIM appeared in the Mars mission portfolio, NASA concurs with and accepts the finding. In March 2021, NASA will hold a Pre-Acquisition Strategy Meeting, followed by the establishment of a MIM Project Office at a NASA center. NASA seeks to have the science community play a more integral role in MIM.

Responding to PAC Finding 4, entitled Diversity in Mission Leadership, NASA thanks the PAC for the finding, and concurs that the Mars Exploration Program Office and the Mars Sample Return (MSR) teams in particular are lacking in diversity. NASA will continue to investigate ways to broaden that diversity.

Responding to PAC Finding 5 on the separation of MEP and MSR organizations, NASA concurs with the finding and has drafted a Memorandum of Understanding (MOU) to address the issue.

Dr. Mainzer congratulated PSD for the remarkable achievement of the Mars Perseverance rover, especially under such challenging conditions. She noted also that there is a huge array of launches coming up for PSD, which will also take place under challenging conditions, and was looking forward to explore ways to help EC researchers learn about careers at the Agency and in the community. Dr. Serina Diniega asked if NASA had any plans on how to get a better sense of where COVID impacts were being felt, such as collecting data on how many grantees have requested augmentations or extensions. Dr. Glaze said that this was still a key issue, which has been a subject of increasing discussion within the senior leadership as it tries to better understand the nature of the disproportionality. She felt that others beside NASA were also thinking about these issues, and that it would be important to incorporate the responses and experiences of other organizations. Dr. Glaze thought the impact of COVID would be felt for years to come in all aspects of work, but did not yet have a specific answer as to how the impacts would be assessed. Dr. Diniega recommended obtaining social science expertise to tease out some of these questions. Dr. Glaze agreed, and welcomed more feedback on the matter. Dr. Lynn Carter asked about details of the SIMPLEX review. Dr. Glaze said SIMPLEX two projects are in phase C and one is working its way to CDR; PSD is still doing the assessment, but does not have a funding window for the next one. She said she would share Lessons Learned when available. Dr. Diniega commented re: the Arecibo finding, that the PAC was also concerned about impact on the facility's local community, and scientists of color, in particular, due to the Arecibo failure. Dr. Glaze said that this might be something to address further with the Planetary Defense Coordination Office (PDCO). SMD is very much aware of the need for strong Science, Technology, Engineering, and Mathematics (STEM) engagement, which had been one of the more transparently successful functions of the Arecibo Facility. Dr. Mainzer asked Dr. Glaze if she had any insights regarding the changing administration and NASA leadership. Dr. Glaze said she was pleased to have Bhavya Lal as Chief of Staff working with President Biden's transition team, and that she had every expectation of success going forward. The post-election team was led by Dr. Ellen Stofan, and Mr. Steve Jurczyk is now filling the Acting Administrator position while awaiting a nomination for the next NASA Administrator—no formal nominations have been put forward as yet. The Moon to Mars

program does have great support from President Biden, in the meantime. Dr. Mainzer asked a general question about the evolution of MSR. Dr. Glaze noted that the successful landing of Perseverance is “Chapter One” of MSR, and that NASA fully expects to be able to collect samples. PSD received great feedback from both the MSR Independent Review Board and Standing Review Board on the fundamentals of MSR. MSR Phase A has begun and is moving forward well, and is actively incorporating findings from both review boards.

Exploration Science Strategy and Integration Office (ESSIO)

Dr. Joel Kearns, the new Deputy Associate Administrator (DAA) for the Exploration Science Strategy and Integration Office (ESSIO), gave a status of the organization. The vision for ESSIO is to define and lead the science strategy for NASA’s Artemis/Moon to Mars initiatives, and to provide integration between SMD, the Space Technology Mission Directorate (STMD) and the Human Exploration and Operations Mission Directorate (HEOMD), other government agencies, and international partners. ESSIO also have a charter to promote a lunar economy to produce rapid, frequent and affordable access to the lunar surface and cis-lunar space.

The current organization has an expanded cadre of Program Scientists and maintains a group of Program Executives. ESSIO works closely with PSD with an early technology and payload program, and has an office at Johnson Space Center to aid in implementation. ESSIO oversees Artemis science objectives and mission traceability to science priorities. The Artemis III Science Definition Team (SDT) Report is final and available at nasa.gov/reports. The Artemis III SDT constructed a notional program that captures the highest-priority science for the first human landing on the Moon since the Apollo program. The science falls into three main categories: sample collection and return; *in-situ* and field science; and deployed experiments. Dr. Kearns noted that the SDT did a great job under difficult circumstances, and a very tight timeline. ESSIO is also very grateful for the white papers and feedback from the lunar community. The SDT focused specifically on the needs of the first human landing, but the report has implications for the entire Artemis program. The results are being briefed across NASA to help guide development and decision-making to accommodate science needs, as the SDT continues to seek input from the community. Lunar Surface Science Workshops are ongoing. These workshops are a series of monthly one-day sessions for the purpose of obtaining community input on high-priority questions for lunar science; thus far ESSIO has been getting 200–300 participants per session. Past topics include Volatiles, Samples, and Dust and Regolith, while upcoming workshop topics in 2021 are Physical Sciences and Fundamental Physics. In the Commercial Lunar Payload Services (CLPS) program, there are now 14 companies on the catalog that can respond to a Task Order (TO). The first six lunar surface deliveries have been awarded, with deliveries beginning in 2021. NASA has just awarded the Crisium payload to Firefly Aerospace. In the beginning, innovative science deliveries to the Moon were very schedule-driven vehicles, but today ESSIO is transitioning to investigator-driven calls (DALI for technology development, PRISM for instrument development), while ultimately it seeks to focus on Decadal-Survey caliber investigations.

PRISM is meant to produce science-driven payloads, and PRISM calls are expected to occur regularly. The two PRISM locations for the first call are: the Reiner Gamma magnetic anomaly (lunar swirl), and the Schrödinger far-side basin impact melt. CLPS deliveries from 2021-24 include the VIPER rover (2023), and two 2021 lunar lander payloads being built by Intuitive Machines and Astrobotic. CLPS activity is a NASA-wide resource, and can also be used for technology and exploration. ESSIO holds MOU agreements with STMD and HEOMD to enable maximum utilization of each SMD-led CLPS delivery: SMD receives payload space on CLPS deliveries. International partners are also interested in CLPS; NASA is in discussion with the Canadian Space Agency, European Space Agency, Japanese Space Agency, and KASI (South Korea) for using CLPS to launch small rovers, retroreflectors, and a volatiles investigation package. The Lunar Reconnaissance Orbiter (LRO) continues to operate, providing imaging for future landing targets.

Dr. Kearns reviewed the latest news from the Apollo Next Generation Sample Analysis (ANGSA) activity; there will be a special session at LPSC describing results. Dr. Mainzer asked how data accessibility in the CLPS program was to be handled. Dr. Kearns said that NASA is paying CLPS providers simply for their delivery service; thus there are data that NASA might be interested in (fuel management, precision landing), and which might be available for purchase. Depending on each contract, NASA can buy additional data from these companies. It's up to the company to decide what it would like to sell to NASA. "Contributions in kind" is not really an applicable concept in CLPS. Each product must be stated explicitly in each task. NASA owns the data for its own instruments, however, as they are NASA-funded and owned; these data would go to the archives. Dr. Dana Hurley asked if PRISM were to be an annual call. Dr. Kearns confirmed that the call would be annual, with a date yet to be determined, and that there would be a community announcement ahead of time. It is believed that ROSES will be used as the vehicle for the PRISM call. Dr. Diniega commented that CLPS is an interesting model, and wondered who in the community would be getting to play in this arena. She asked if CLPS were considering diversity and inclusion. Dr. Sarah Noble said that this was the case, and that NASA is intentionally trying to provide opportunities to expand the pool for instrument-building. Dr. Kearns said that the hope is that the faster cadence of PRISM would allow participation of a wider part of the community over a period of time.

Astrobiology Program Update

Dr. Mary Voytek provided an update on the Astrobiology Program. ROSES-2020 proposals were due in May 2020; 156 proposals were submitted, and 23 were selected for funding (14.7% selection rate). Exobiology in ROSES-2021 will be executed as a No Due Date (NoDD) program; it is expected that review panels will be held every 2–3 months, and that Rolling Evaluation Panels will be split into 4–5 topics. As previously noted in the PSD Update presentation, the ROSES-2020 Habitable Worlds program, will be reviewed under DAPR guidelines. For ROSES-2019, 65 proposals resulted in a selection rate of 10.7%. Currently, there are three active FINESST (formerly known as NESSF) proposals that are supporting graduate students. Planetary Science and Technology from Analog Research (PSTAR) will be moving to a biennial call, and therefore was not solicited in ROSES-2020; at present PSTAR has 7 active grants and one active NESSF award.

The Interdisciplinary Consortia for Astrobiology Research (ICAR) is replacing the NASA Astrobiology Institute (NAI) Cooperative Agreement. The first ICAR has selected eight teams, with awards to be made soon. ICAR allows five-year awards, with an average size of \$5M. The cadence of ICAR awards will be every three years. The next topics are to be determined, but will include such topics as life detection.

Dr. Voytek enumerated the measures of success used to evaluate Research Coordination Networks (RCNs):

- Investigators carry out and propose interdisciplinary research through new collaborations stimulated by RCN interactions
- Demonstration of technology transfer between research areas and disciplines
- Produces a plan for utilization of current mission data and spawns ideas for new and exciting missions (if applicable)
- Influences Decadal Surveys for all SMD Divisions v Enhances international engagement
- Supports development of early Astrobiology community

The RCN, NexSS, co-hosted a follow-up conference to Habitable Worlds 2017, which was held virtually in February. The conference received 207 abstracts, and had 411 paid registrants, with a very strong early career presence. The conference demonstrated how much the community has expanded, with participants very engaged in a research area very important to NASA. Last year, the RCN, Ocean Worlds (Habitable Worlds), held a workshop, *Ocean Sciences Across the Solar System*, which was a joint initiative between

PSD and the Earth Science Division (ESD), established to identify overarching topics and questions; leverage comparative oceanography; study Ocean Worlds as integrated systems; understand the properties of environmental change in Ocean Worlds; and refine methods to look for past and extant life. White papers are forthcoming for each topic identified during the workshop. Dr. Voytek noted that these new joint research areas will either need new money, or new priorities, to enable future work on cross-divisional efforts, and that she hoped to bring these ideas to senior management.

The RCN effort, Early Cells to Multicellularity, is coming within the next few months. PSD released an RFI in March 2020, which received nine RFI responses on themes, structure and operation. Dr. Voytek encouraged the community to check out FAQs on the Exobiology Website, which also contains information about workshops, programs and activities. The Astrobiology Program, NPP Fellows, currently has 14 active NASA Postdoctoral Program (NPP) Fellows and one NASA Postdoctoral Management Program (NPMP) Fellow, and five new Fellows that will soon join pending start dates. Fellows are remaining productive during the pandemic, and many are back in the lab. The program is not accepting applications for the 1 March deadline, but it will accept proposals for the November deadline.

The International Summer School in Astrobiology was cancelled for 2020, however the 2021 session is scheduled for 5–10 September 2021, contingent on travel approval. The topic is searching for life on Mars. Dr. Voytek encouraged post-doctoral students to apply, as the school provides important training for Early Career researchers. The AbGradCon meeting was cancelled in 2020, but the next one is scheduled for 14–17 September 2021, at the Earth Life Science Institute in Tokyo. Applications are currently open. Other events coming up include Astrobiology Learning Progressions, which are a collection of interdisciplinary narratives, one for each of 23 different astrobiology concepts, which progress in subject depths that are designed for four separate grade bands. The narratives are meant to serve both educators and astrobiologists.

Dr. Voytek briefly described the outcome of Astrobiology for the Incarcerated, a program piloted from 2017 to 2019 with funding from the NASA Astrobiology Program. Lectures were presented to 1400 adults, in 26 facilities in four states. A manuscript now in press will present an assessment of the pilot, at which time it will be shared with the PAC. Astrobiology has also produced a variety of outreach items, such as graphic histories, and extremophile “trading cards.” Dr. Mainzer asked how all the Astrobiology research efforts get infused into future Flagships mission concepts. Dr. Voytek said that one requirement for the RCNs is coordination with the various Analysis Groups (AGs). Astrobiology is also part of the upcoming Planetary Decadal Survey. All missions with Astrobiology interests have assigned deputies where position openings allow, and a number of astrobiologists are serving on Decadal Survey panels.

Planetary Defense Coordination Office

Dr. Kelly Fast provided an update on the Planetary Defense Coordination Office (PDCO). In 2020, there were 107 known close approaches of NEOs within lunar distance, one estimated to be as large as 200 m. There were also seven close approaches within the distance of geosynchronous satellites. One of the more notable objects, 2020SO, was recently spectroscopically confirmed to be a Centaur upper stage from the 1966 Surveyor 2 launch. The International Asteroid Warning Network, which has conducted observing campaigns in the past, is planning to use a last opportunity on 6 March of this year for viewing Apophis (in advance of its extremely close approach in 2029), when the object will pass within 0.11 Astronomical Unit (AU) of Earth. The NEO Observations Program, which had been challenged at the peak of COVID impacts in March of 2020 due to numerous observatory closures, is now all green, fortunately,

The year 2020 was a record year for asteroids of all sizes, with almost 3000 discoveries. In the area of 140 m+ objects, however, the discovery rate is still flat, demonstrating the fact that NASA has hit the limits of current capabilities; a total of 548 140 m+ objects were discovered in 2020. To date, from

inception of efforts, 25,192 Near Earth Asteroids (NEAs), 9569 140 m+ NEOs, and 113 Near Earth comets have been discovered.

Mr. Lindley Johnson addressed the characteristics of the NEA population and survey progress through 2020. For 1-km objects and larger, the survey is about 90% complete, and for 0.5-km to 1-km objects, the tally is about 80% complete. Completeness drops off quickly at about a few hundred meters in size. Progress in identifying the 140 m+ population, estimated to be about 25,000, is slowing. Of the 140–300 m NEO category, 54% are not found. At the current rate of 500 discoveries per year, it will take several decades to get to completion of the George E. Brown Act goal, established by Congress. Mr. Johnson reported that the Goldstone radar facility is now running full-time, but given that it is a shared resource with the Deep Space Network (DSN), it is not always available for viewing or characterizing NEOs. The Arecibo facility is being decommissioned after having completely collapsed in December 2020. Stabilization, environmental remediation, and cleanup are being performed by the National Science Foundation (NSF), while NASA is tracking their efforts closely. NSF is planning a workshop in June of this year to look at the future of the Arecibo facility for passive radio science, and perhaps a future radar capability. NASA is in active discussion with NSF and the US Space Force for future planetary radar capabilities. In addition, NASA is conducting a technology demonstration for next-generation planetary radar, using phased array antennae. Called the Cis-Lunar Environment Array Radar (CLEAR), it is a project at the Kennedy Space Center.

Mr. Johnson reiterated Dr. Glaze's earlier comments on the second launch window for the delayed DART launch (which starts on 24 November 2021, running to February 2022). Despite the launch slip, the spacecraft will still impact Didymos at the same time. DART integration and testing (I&T) continues to progress; wing inspections are going forward after environmental testing, and the spacecraft itself is being prepared for thermal vacuum at the Applied Physics Laboratory (APL). NEOSM is also moving forward; the only news at the moment is that a decision to move to phase B has been delayed pending assessment of financials. A Program Management Council (PMC) meeting is currently scheduled for the last week in May. Dr. Conor Nixon asked if PDCO was tracking detection statistics for comets. Mr. Johnson confirmed that this was the case, and that NASA has identified 113 Near-Earth comets within 130 million miles of Earth's orbit. Dr. Mainzer asked how US Space Force interests might overlap with NASA's with regard to radar capabilities. Mr. Johnson noted that the US Space Force requires situational awareness in cis-lunar space, such that their desired extended radar capabilities will overlap with the needs and interests of the planetary radar community. The Space Force is interested in everything 100 km and above Earth's surface. Asked about the archiving of Arecibo's data, Mr. Johnson said that NASA is continuing its support of Arecibo data analysis, that Arecibo data will become a part of the PDS.

Mars Exploration Program and Mars Sample Return

Mr. Eric Ianson provided a status of the Mars Exploration Program (MEP), first offering kudos to the Perseverance team for doing a phenomenal job. He noted that media coverage was incredible throughout the world; there were almost 200 interviews with NASA scientists and personnel in the 48 hours before and after the 18 February landing. In other updates, InSight made its final attempt on 9 January to deploy the mole; this effort is now ended, and InSight will spend the rest of its mission listening to seismic activity on Mars. Senior Review (2019 and 2020) letters have been sent to the Mars Science Laboratory (MSL), Mars Reconnaissance Orbiter (MRO), Mars Atmosphere and Volatile Evolution (MAVEN), Mars Odyssey (Ody), Mars Express, and InSight mission teams. The MIM statement of intent has been signed by NASA, the Japanese Space Agency (JAXA), the Italian Space Agency (ASI) and the Canadian Space Agency (CSA), setting the stage for an MOU later this year; MSR is also doing a "pre-ASM," and assigning a NASA center to MIM. There should be more substantive news in this area by the next PAC meeting.

Mr. Ianson noted that Ody, MRO, MAVEN and ESA's ExoMars provided excellent coverage for the Perseverance landing. Ody provides most of the relay support for InSight. MRO supported the Entry Descent and Landing (EDL). MSL/Curiosity recently achieved 3000 sols on Mars. MAVEN has been doing exciting science during solar cycle 25, and also provided support for Mars EDL. Briefly touching on the FY21 appropriation for the MEP in particular, Mr. Ianson reported that 2021 funds will provide the resources needed to fulfill MEP objectives, including phase A activities for Mars Sample Return (MSR).

Dr. Michael Meyer provided Mars science highlights. In anticipation of the Perseverance landing, MEP held a caching strategy workshop on 21 January, which had 255 participants; the workshop report is being finalized and guidelines will be posted. The NASA/ESA MSR Science Planning Group-2 has been meeting regularly, and will issue a report in the Spring of this year. The United Arab Emirates (UAE) Mars probe, Hope, and the Chinese Mars orbiter/lander/rover, Tianwen-1, arrived at Mars nearly contemporaneously with the Perseverance rover, a notable achievement. MEP has brought in two new Deputy Program Scientists. New MAVEN data indicate that dust storms are responsible for driving water loss at Mars. MSL Curiosity is now leaving the clay-bearing unit and is approaching the sulfate-bearing strata at Mount Sharp, where it is believed that the strata will yield clues as to why the planet started to lose its atmosphere. The Mars Architecture Strategy Working Group (MASWG) report was completed in November 2020, and concluded that MSR should proceed as planned; NASA should support missions that address fundamental science at Mars; NASA should retain a programmatically distinct Mars Exploration Program; missions and instruments should be openly competed to the extent possible; and a robust Mars exploration program will require affordable access to multiple places on Mars, as well as affordable long-lived orbiters.

Mr. Ianson addressed the rationale for separating the MEP and MSR organizations. For multiple decades, the success of MEP has enabled ground-breaking science and built the engineering and science foundation for MSR. Establishing the MSR program as a separate implementation organization conforms with the 2019 NASA policy that states that Flagship missions are directly accountable to the responsible Mission Directorate, in this case, Associate Administrator Dr. Thomas Zurbuchen. The creation of an MSR program distinct from MEP provides for a focused approach to mission implementation and objectives for both programs. Mr. Ianson detailed the reporting lines in the SMD Mars Exploration organizations, and said that MEP and MSR are finalizing a Memorandum of Agreement (MOA) to codify the relationship between the organizations. Mr. Ianson noted that key areas of coordination, as stated in the MOA, will be supported by biweekly coordination meetings. Dr. Michael Meyer is PSD's Lead Mars Scientist, and serves as both the MEP Lead Scientist and as the MSR Program Scientist to facilitate coordination and provide cohesion. A Joint Steering Group (JSG) between MEP and MSR will be used to resolve any issues between the programs. MEP personnel will participate in MSR Life Cycle Reviews; MSR personnel will participate in Mars 2020 Critical Event Reviews; and MEP and MSR will coordinate on MSR Campaign outreach. A recent example of coordination is joint MEP/MSR participation in National Environmental Policy Act (NEPA) work for the MSR Sample Receiving Facility (SRF). Primary interactions between the Program Offices, in addition to its regular coordination, will include science community coordination and public outreach. Mr. Ianson concluded remarks by noting that MEP is a long-term ongoing program, which will continue after MSR, while MSR is a single-project program with a beginning and end.

Mars Sample Return Program

Mr. Jeff Gramling presented details of the MSR program. MSR is a complex mission that requires a set of capabilities that have been only recently demonstrated, and it is only possible as a result of the \$10B+ investment that NASA has made over decades, along with a strong partnership with ESA. In recognition of the nature of the advances required, SMD commissioned two independent cost/schedule estimates; formed an IRB to conduct a two-month examination of the program, and established the program's SRB

to conduct the Mission Concept Review (MCR) as an Agency review. As a result, it is now understood that the 2026 launch date for MSR is challenging, and that the budget phasing requires further assessment.

Mr. Gramling reviewed the basic architecture of the MSR effort, which began with the successful landing of Perseverance. MSR will require an Earth Return Orbiter (ERO), whose primary payload is the Capture and Containment Return System (CCRS) and the Sample Retrieval Lander (SRL). ESA will build and launch the ERO; NASA will build and launch the SRL. The Mars Ascent Vehicle (MAV) is to be provided by NASA, and the Sample Fetch Rover (SFR) will be built and provided by ESA. After the samples are retrieved, the samples will be delivered by the SFR, and/or Perseverance will be placed into the Orbiting Sample (OS) container aboard the MAV, which will then launch the OS into Mars orbit for rendezvous with, and transfer to, the CCRS onboard the ERO. The samples will then return to Earth on the ERO, which will release the Earth Entry Vehicle (EEV) for a landing in the US.

Dr. Meyer provided the science rationale behind MSR. The primary driver lies in the fact that 50% of the rocks on Mars are over 3B years old, and are therefore likely to yield the best record of what was happening in the Solar System when life was beginning on Earth. Perseverance is capable of selecting and caching 43 samples. A total of 15 NASA/ESA Returned Sample Scientists have been competitively selected for the Perseverance Science Team. In preparation for a Mars Sample Return Facility, teams from the Jet Propulsion Laboratory (JPL) and Johnson Space Center (JSC) have conducted site visits at 18 Biosafety Level (BSL)-IV facilities, and have issued a report. The Committee on Space Research (COSPAR) Sample Safety Assessment Protocol Working Group, consisting of NASA and ESA members, is developing a recommendation for determining when samples are safe for distribution. Dr. Meyer displayed some notional pathways for Perseverance. The rover must cache samples where the SFR can retrieve them, and it also must be determined whether Perseverance can drive the samples to the SRL. The mission team must determine how to preserve two pathways in such a way as to mitigate potential failures in either pathway. The diversity of samples is also under consideration; 20 different types have been identified, including Jezero regolith and marginal lake deposits. Perseverance has shown that TRN is successful; now the issue is where to put samples in potential pathways, and how to minimize the time for collecting them and getting them back to Earth. The two main MSR challenges, ultimately, are to protect the samples from Earth, and to protect the Earth from the samples.

Mr. Gramling took up the presentation once more and briefly detailed the SRL flight system vehicle, including the Cruise Stage (CS), SRL payloads, the MAV, SFR, and Sample Transfer Assembly (STA), and the Orbiting Sample (OS). The current campaign timeline has the ERO and SRL launch in 2026, allowing SRL to avoid the Mars winter and global dust storm season. In this scenario, EDL would also occur in a favorable season, enabling more favorable SRL mass margin. Beyond 2028, conditions are not favorable for MSR launch. For the architecture under consideration, the next “good” opportunity after 2028 is 2035. MSR and NASA are in the process of responding to the IRB’s top six recommendations:

- Further explore mission architectural and vehicle options as currently planned 2026 MSR launch schedules are not compatible with NASA’s Class A/Category 1 mission risk levels, and planned Phase A trade studies need enhancement.
- Re-plan the program for SRL and ERO launches in 2028 with the potential of a 2027 ERO launch continuing to be studied for feasibility and potential benefits.
- Maintain the current schedule to PDR in order to minimize technical and schedule risk.
- Increase the budget to reflect a most-probable Phase A-D cost between \$3.8-4.4 billion. Includes increasing the 2022-2024 Fiscal Year (FY) budget profile by a total of approximately \$500 million.
- Simplify current Center organizational roles and responsibilities, which are unduly complex.

- Consolidate HQ program management of MSR and M2020, and integrate the science and operations of both missions.

Decadal Survey Update

Dr. David Smith presented a status on the progress of the latest Decadal Survey for Planetary Science. The process is driven by the Statement of Task, which outlines what the sponsors (NASA, NSF) want the survey committee to do [www.nas.edu/planetarydecadal]. This time around, there is a higher profile for both Astrobiology and Planetary Defense. The 19-member Steering Group is led by Drs. Robin Canup and Philip Christensen. There are six supporting panels, organized by destinations: Moon and Mercury, Venus, Mars, Small Bodies, Giant Planet Systems, and Ocean Worlds and Dwarf Planets. Boundaries between the panels are permeable. A key difference for this Survey is that the report will be organized thematically, not by destination, and around high-level science questions (a chapter for each) and key topics.

The Steering Group first met on 30 September 2020; overall, the Group has been averaging three to four meetings per week. Each panel has met at least ten times; a typical meeting is held in the afternoon to respect the differing time zones of the participants. Details of all the meetings are all available on the Decadal Survey website. Progress to date includes the reception of more than 500 papers; the Steering Group has identified twelve key questions; nine studies are underway at three design centers; and a contractor to conduct an independent cost and technology evaluation has been identified, and will be onboard soon. The Survey draft outline is complete, and a cross-cutting panel has been formed to deal with The State of the Profession. In addition, cross-panel groups for the 12 key science questions are being assembled, as well as for the programmatic chapters (e.g., Planetary Defense and R&A).

The panels considered the pool of publicly available mission concept studies, and have identified 15 gap-filling concepts. Some of these studies came from white papers, some from the previous Decadal Survey, some were related to Planetary Mission Concept Studies (PMCS) or previous large-class mission studies. A detailed questionnaire was completed for each concept and presented to the Steering Group in early December 2020. The Steering Group ranked these and sent the top nine to NASA in late December. By mid-January, studies of all nine concepts were under way, three each at APL, Goddard Space Flight Center (GSFC), and JPL. Each study team includes a “science champion” from the originating panel. Preliminary and final study reports should be done by late March and late April, respectively. It is important to note that these nine concepts are not the finalists—all PMCS and other missions recently studied are still in play.

Dr. Nixon asked if the identity of the science champions would be made public. Dr. Smith indicated that the NAS policy is to keep these identities confidential. Asked if any scientists were present on the panels that would constitute conflicts of interest. Dr. Smith said there were none, and further noted that science champions are not equivalent to study leads. Dr. Diniega asked if writing group memberships would be shared publicly. Dr. Smith said that the only writing group working at the moment is the State of The Profession, and that one can look at the past meetings of the groups to see who was present at the closed sessions. For example, some speakers at past meetings included Louis Barbier and Elizabeth Cole.

Discussion

Dr. Nixon asked about what known effects there are of cosmic, radioisotope thermal generator (RTG), and other radiation sources, on Mars samples. Dr. Meyer said the short answer is that MEP doesn't think it's an issue. Samples that can be retrieved will be from the first 10 cm of surface; this material has been on the Mars surface for millions of years. The caching tubes will be left close to the surface. The transit back to Earth is about 18 months; radiation in space is known to be about twice that encountered on the

surface of Mars. Another source is the flux from ultraviolet radiation (UV) on the Mars surface, and its effect on certain molecules, but the samples will be protected from UV radiation by the container. The other major radiation source is from galactic cosmic rays (GCRs), but they are of low flux, but their effects build up over a period of time. Dr. Meyer didn't think the expected amount of radiation could affect any organic molecules present in the samples, although it might kill an organism.

Dr. Mainzer asked if there were a science team for MSR. Dr. Meyer said that MSR is not doing science, although its Participating Scientists are paying attention to samples. There are Program Scientists for both MSR and MEP, thus one can imagine something will come up that will need the attention of scientists. Dr. Mainzer asked what happens if things don't go as planned. Dr. Meyer noted that the Perseverance science team does have the expertise; they have the best embodiment of the knowledge; and that NASA would be relying on them to collect the right samples, and decide which ones to leave behind. The Perseverance science team will be engaged throughout the entire process, to the point of the SRL phase. There will be ample opportunity for the science community to discuss which samples are to be returned to Earth. Dr. Diniega said she could imagine there would be science input needed beyond the point where the samples are *en route* back to Earth, in the case of an anomaly. Dr. Meyer said that the MSR mission is planning for success; if something goes wrong, NASA will assuredly establish a tiger team to determine the science questions that might arise in the event of an anomaly.

Dr. Britney Schmidt said she was concerned about a large chunk of the MSR budget being wrapped up in a non-science mission; if MSR is really performing a life detection mission, it does not have much representation for the long-term science goals of sample return. She asked: to what degree is the Astrobiology program being engaged in MSR? Dr. Meyer noted that life detection is indeed a goal of MSR, and the selected science team members represent this goal; he thought that the team was well suited to address Astrobiology questions and to select samples with the highest potential for life detection. He said he would hesitate to stand up yet another group to advise them, as there are already over 400 scientists on the science team. Dr. Schmidt enlarged the issue to the remainder of the program elements, and thought the mission should have a science team in the loop for the longer-term decision-making. Dr. Meyer said that this is the purpose of the Mars planning group, and an "uber-document" from the International MSR Science Planning Group that addresses longer-term decision-making. Dr. Mainzer commented that MSR presumably has thresholds and de-scope options, and she asked: to what extent will the science community be part of the process at these threshold and de-scope points? Dr. Meyer said that this would not be known until sampling actually begins. If MSR found something that has high organic content, e.g., a real-time decision process would ensue, and certainly the science community would be a part of that decision. This Spring, the MSR Sample Planning Group (MSPG) will release a report on the subject of sample planning; the planning group also includes international partners. Dr. Jennifer Glass said she was interested in more details on how scientists can participate over the next ten years, as many Early Career researchers are looking for ways to participate. Another issue is the who can propose instruments in the SRF. Dr. Meyer said the MSPG was working through these issues; the first meeting was in June 2020; he added that the intent is to be open as possible and to have the full participation of the science community. Dr. Lynn Carter commented that the Mars2020 Participating Scientist (PS) program is oversubscribed. Dr. Meyer said there would be another PS opportunity in three years. Dr. Mainzer asked how MSR was being treated in the Decadal Survey. Dr. Glaze noted that the Survey has been asked to make a full set of recommendations on MSR. They are not forbidden from ranking it. The SOT was intended to give them flexibility to fully scrub the MSR mission in the context of a balanced portfolio.

Dr. Nixon asked if there were an opportunity to place science payloads on the orbiter (ERO) that will fetch the capsule from Mars orbit and bring it back to Earth. Mr. Gramling said he did not believe there are any plans to do so on the ESA provided spacecraft. Dr. Meyer concurred, adding that the function of the ERO is to get to Mars, help with communications, and actually catch the sample(s) that gets to orbit. Nor are there any plans for a cubesat delivery, but Dr. Glaze indicated that there is an SMD policy about

launching cubesats when there is excess capacity on a launch. Thus, cubesats for MSR could be a potential SIMPLEX opportunity.

Dr. Diniega asked how does NASA deals with Decadal Survey output. Dr. Glaze noted that once the Statement of Task is given to the NASEM, the process is completely independent from NASA. There is a solid firewall between the organizations, and it is there for a purpose. NASEM itself also has a rigorous review process, resulting in a generally stellar job on carrying out the task. When the Survey is released, NASA will be provide a public, line-by-line recommendation response that will be posted on the NASA and Lunar and Planetary Institute (LPI) websites. Dr. Diniega asked whether NASA has a chance to comment on the process itself. Dr. Glaze said that that is a discussion that occurs only after the release of the report. In the past, Lessons Learned activities have certainly resulted in changes in the Decadal Survey process.

Findings Discussion

Dr. Mainzer initiated a discussion of potential findings, first commenting that the PAC appears to support a thorough engagement of the science community in MSR; she noted that there was also some concern about the cost growth of MSR. In addition, she felt the PAC should help to ensure that the CLPS program is accessible to the community, and maximally inclusive. In regard to MIM, there should be strong community engagement in the project, as well. Finally, Dr. Mainzer expressed concern about the impact of COVID, especially on Early Career researchers. Dr. Diniega felt the community should be actively thinking about how the Mars 2020 (M2020) Perseverance mission connects through the longevity of the entire MSR campaign, all the way to sample science on Earth. In addition, she felt the PAC should consider the different types of opportunity available through commercial programs as NASA expands from the Moon to Mars, and who has access to these opportunities. Also, how is NASA going to be looking at the impacts of COVID? Who suffered most and least? NASA should engage with the right practitioners (i.e., social scientists) to determine this, and partner with NSF, perhaps, on the subject. She felt that there may be positive effects of COVID to be considered, such as the widespread adaptation of virtual communications. Dr. Mainzer added that NASA should also think about how to mitigate the impacts. Dr. Glaze said that it was not yet clear how NASA would deal with COVID, beyond trying to identify best practices to understand what can be done. She absolutely agreed that appropriate studies would be needed, but did not think NASA would necessarily be the best institution to do those studies. She welcomed a PAC recommendation on just how to do this. Dr. Mainzer felt the discussion to be a good basis for a finding on how to be proactive about COVID impacts.

Dr. Justin Hagerty made a comment on CLPS accessibility; Dr. Glaze said she appreciated the question and wanted to know if it had been sufficiently answered. Dr. Mainzer commented that the PAC is still trying to learn about CLPS and accessibility of data. Dr. Glaze reiterated, to be clear, that any NASA-funded instruments that produce data, will be publicly accessible as per NASA policy. In addition, after the first two CLPS launches, there will be a scientist associated with every Task Order.

Dr. Schmidt asked about the nature of the NEOSM review, as she felt the project seemed to be dragging, especially given its relative importance. Dr. Glaze said that the team has gone through technical review to get to phase B, however Headquarters has decided to pause and look at the funding landscape, and to ensure that NEOSM have the full support of Agency administration, and the federal budget. There is no particular review, *per se*. Dr. Mainzer commended the addition of Deputy Program Scientists to the MSR team. Dr. Glaze agreed, but added that the move doesn't fully check the box on aspects of diversity that NASA should keep in mind.

Dr. Rinehart opened up the phone lines for public questions. No further questions were raised.

March 2, 2021

Research and Analysis Program Update

Dr. Rinehart presented a status of the R&A program in the PSD. In ROSES 2020, some issues related to COVID have delayed the release of results. ROSES 2021 is out now; all data analysis programs (DAPs) are being reviewed via DAPR. NoDD programs are also open now. Dr. Rinehart clarified language on the idea of “no duplicate proposals”:

- No proposal can be submitted to more than one program in the same ROSES year; nor may it be submitted if it is currently under consideration by another program covered by C.1
- For NoDD programs: No proposal can be submitted to any NoDD program if it was previously submitted within the past year (12 months).

The same rules apply to resubmitted proposals. If there is any question, Dr. Rinehart urged proposers to seek clarification from a Program Officer.

In other updates, LPSC is all virtual this year; the PSD Town Hall will be a sort of “NASA Night.” During the breaks each day, there will be a virtual booth, wherein two or three Program Officers (POs) will be present for a chat, the idea being to introduce younger folks to their POs, to foster human connections. Dr. Rinehart reiterated comments about compliance, noting that R&A is continuing toward much stricter compliance checking, and is going to crack down much harder. R&A is particularly concerned about compliance in the areas of post-grant data archiving, publication archiving, and data policy.

Regarding the budget for FY21, the numbers are public record. Discussion of the budget is off the table while NASA is waiting for an approved Operating Plan; after the Plan is approved, final budget numbers can be posted and discussed. COVID augmentations are open until 5 March. Dr. Rinehart noted that a significant number of requests have been received that are not eligible; letters should be out today for eligible, highest-priority requests. Addressing the meaning of “uncosted” funds, he explained the three categories of funds: committed, obligated, and costed. The requirement for the COVID augmentations was that they funds exceed no more than 20% of the uncosted budget. The reason for this is that NASA knew it could not afford to fund every request, and wanted to respond to the most urgent needs. For those researchers who are below 20% of their money, or have fewer than 6 months left, NASA wanted to make sure they got the money first. For those on the edge, NASA is waiting to see if they dip below 20% by 5 March. He noted that all programs have been taxed 15% of the funding available for new selections to fund these augmentations.

Habitable Worlds proposals are in and the review process has begun. Several proposals have been returned due to no attempt to follow the DAPR guidelines. There were many other small noncompliance errors; for now, NASA will warn those offenders and allow them to proceed, making allowance for mistakes. The most common mistakes are a failure to follow numbered reference scheme, and accidental inclusion of names.

All the Terms of Reference (ToRs) for the AGs have now been updated, and all follow the same model to ensure greater consistency. Historically, PSD has provided some support for the AGs, but in an inconsistent manner. PSD is seeking proposals through the Topical Workshops, Symposia, and

conferences (TWSC) program element to provide support for the PAGs, including a small amount of funding support for the PAG chairs.

Questions for the PAC from R&A

1. What should be our programmatic response to low selection rates? When rates fall below 10%, the concern is that quality proposals don't get funded; what can we do to help the community? Some things we have considered- move program to a biannual cadence; continue annual cadence but narrow the program scope; simply accept a low selection rate. One thing that cannot be considered is increased program funding; if PSD can do that, it will, but it is an obvious and easy solution when possible.
2. How do we encourage post-award compliance? Following OSTP policy, all publications resulting from NASA funding (more half of grant holders are unaware of this requirement, and of those who were aware, only a small fraction were complying) are to be archived in PubSpace. The other part is the Data Management Plan, which is required of all proposals prior to selection. We are open to any suggestions to get people to comply. One possibility mulled over thus far by R&A PSD is to ask for post-grant reporting to continue until all funded papers and data are properly archived.
3. Incentivization of service, particularly service on review panels. Some members are eager to volunteer service, while others never agree to serve. How can we encourage and incentivize service to the community. It is obvious that the community benefits from such service, and it is better to have more people to carry the load.

Dr. Joe Westlake commented on low selection rates, asking if it were possible to get more information on the number of proposals coming in. Do the low selection rates signify that there are some researchers struggling to survive year to year on R&A grants? What is that a symptom of in the community? Is it being unable to support students, or wanting to expand research projects? Dr. Rinehart thought the problem was twofold: a general increase in proposal budgets, but with no real data on why this has occurred. The other observation he offered was that the bigger the budget, the lower the selection rate. While not exactly a truism, he felt it was a consistent observation. MATISSE offered \$1M per year, allowing a researcher to sustain a group for a while. He said he didn't have any good interpretations for the issue. Dr. Schmidt agreed with Dr. Westlake, and felt that NASA should simply increase budget for R&A. She added that the PAC should be very worried if NASA was spending money on a technology program that does not support scientists. In terms of programs like PSTAR, Dr. Schmidt averred that technology development is not just being done at NASA centers; while overhead rates are rising quickly at universities. The number of things that organizations will cover is going down. More people are in soft money positions; it becomes more of NASA's problem if the community can't fund itself.

Dr. Rinehart said he would love to have an offline conversation about what NASA can do to influence institutions, but the matter remains outside of NASA's actual purview. The point is, what can PSD do in the absence of new money? Does the community prefer an annual call with 6% selection rate, or a biannual call with a 12% selection rate? Dr. Schmidt said it was important to think about infusing more money into R&A; most researchers would much rather have the chance to propose. Shifting topics around might work, but could also ruin cadences for some people. If there was a way to use Congressional interest items in the budget to help with these low selection rate areas to give them a shot, NASA should do that. Dr. Rinehart noted that NASA does look for these opportunities and tries to fit the tasks within the Congressional language. It can't always be done, but NASA can try. NASA absolutely cannot control

the direction and budget that it receives from Congress. Dr. Rinehart indicated that he was hearing the message that the community would much rather propose even if there is a low rate of success. Dr. Mainzer brought up the possibility of providing a more thorough review of step-1 proposals in order to reduce the effort put into writing full proposals. This two-step process, however, means more than double the work for both POs and reviewers. Dr. Mainzer noted that the two-step process is usually for bigger missions, but in those cases, there is a cost-benefit trade—has anyone tried to look at the trade? Dr. Rinehart said that the trade means R&A must remove 70–80% of proposals at Step One. This can be done, but with the expectation of a lot of unhappiness. A community participant suggested consulting the Heliophysics Division (HPD) for Lessons Learned on the two-step process. Dr. Rinehart commented that PSD used (the two-step process) once, but, tellingly, didn't do it again. Dr. Hurley noted that a “pretend down-select” study found no correlation between who was selected at Step One or at Step Two. Dr. Rinehart said he felt that a zero correlation was not possible in that case, but he did note that some others felt that the shorter Step One proposals weren't sufficient for determining which proposals should go forward. Dr. Schmidt said that given the format of current Step Ones, she could believe this. Exploring the triage concept would be to let people know to think of it more seriously. NSF's five-page proposal approach is another idea to try. Anything that gives people a chance is preferred. Dr. Schmidt added that she felt that it was still necessary to find out why people are proposing and why budgets are decreasing for scientists in the SMD budget, for planetary scientists in particular. Dr. Rinehart said he would seek more information on how these triage process suggestions might make sense. He noted that as part of the No Due Dates experiment, R&A is planning on triaging out 20% or so to simplify the reviewer's task. In answer to a comment, Dr. Rinehart reiterated that the money in R&A comes from Congressional numbers, and he was not sure where money is “disappearing” to, in this context.

Dr. Mainzer commented that understanding the causes of R&A funding issues will prove helpful. Turning to the question of how to get more people to review proposals: should it be required, like jury duty? Dr. Rinehart said that legally, NASA cannot require service of anyone; the only thing it can require is reporting. Also, he noted that there are people who simply do not excel on review panels, so a requirement would not help matters. There are other types of service, such as working for the AGs, doing outreach, etc., that can be encouraged. Everyone benefits when the community is engaged with itself. Dr. Glass suggested expanding ways to be on the review panels. External reviewers can submit one detailed review, e.g.; in addition, NASA should continue virtual options, post-COVID. Dr. Westlake suggested inspiring a culture of service by having senior management specifically address it in talks, and also by providing more opportunities to Early Careers as they are starting out. Dr. Diniega noted that when a task relies on volunteers, that is an impact felt differently by different people (Early Careers, institutional employees, etc.). It is still a draw on people's time. If NASA was able to incorporate a reviewing requirement into an award, this could be a way to “pay” someone for that time. Dr. Rinehart said that NASA does provide honoraria, but these honoraria don't mean the same thing to everyone: civil servants, for instance, cannot receive honoraria. How can these inconsistencies be leveled out, fairly and legally?

Anti-Racism Action Group and Inclusion, Diversity, Equity and Accessibility Working Group

Dr. Glaze introduced Dr. Meagan Thompson and the rationale for NASA's push to address inclusion and diversity. Over the last year there has been much social unrest, raising awareness of inequity throughout society. NASA has determined that it has a responsibility to look at its own organization in this light, in its responsibility to the community. The senior management at SMD is committed to this examination.

Dr. Thompson described the initial efforts in PSD to take a step back, listen, and talk a lot internally about what the division could do to address inequity. Inclusion is part of NASA's core values, and important to the missions. NASA wants to attract the best talent and to grow the capabilities of the entire workforce. As part of the NASA SMD Science Plan, inclusion is part of the strategy. Under Dr. Thomas Zurbuchen's leadership, the SMD Anti-Racism Action Group (ARAG) was created to propose and implement near-term tactical actions. The ARAG has identified three areas where the Agency has leverage: NASA itself,

the workforce, and the general public. ARAG gathered SMD input anonymously and through listening activities, held one-hour incubator workshops, and communicated through emails and PowerPoint presentations. After amassing 200 ideas, the ARAG began directly acting upon some, while passing other actions on to other working groups such as the Inclusion, Diversity, Equity and Accessibility (IDEA) Working Group.

Actions being undertaken right now include: collecting and publicizing demographics of SMD's current and past proposers and awardees to establish a baseline (data from ROSES 2013–2020); adding measurable outcomes in performance plans for improving inclusion; setting up a rotating, diverse SMD engagement group; developing a code of conduct to push to Divisions, and setting a goal for each Division to aim to increase the diversity of its demographics of reviewers. What NASA wants to try but doesn't know how to implement (these ideas have been pushed on to other IDEA groups): consider establishing SMD-wide postdoc fellowships hosted at HBCUs and MSIs; consider establishing a regional program for creating STEM cohorts & communities for future STEM leaders and NASA workforce; establish long-term, meaningful and growing partnerships with partners who have traditionally not been involved in NASA missions and research, centering on needs and desires of partners and NASA; and combining forces with existing successful programs at NASA and other agencies.

Next steps for ARAG are to address examples of ideas submitted by staff for desired SMD "End-States," such as: establishing a growth mindset culture always keen to ask "How can we innovate & improve?"; understanding and valuing non-traditional leadership styles; and in R&A at panels and in the PI pool, having the demographics reflect the nation at all levels of a project over the next xx years. In PSD, there is already high representation in the SMD-level IDEA Working Group. R&A has also done training and is continuing to train people in areas such as bystander intervention and microaggression.

Dr. Glaze commented on some of the actionable items, noting that there is an increased amount of accountability for all supervisors, based on explicit instruction from SMD AA, Dr. Zurbuchen. SMD is working to identify specific metrics for this accountability. Another major point is engagement; each member must be responsible to oneself and one's community. There are clearly roadblocks that need to be removed. NASA must also learn how to listen and engage with the BIPOC community so that NASA can offer opportunities that are more broadly accessible. Dr. Diniega asked how SMD has engaged social scientists in this effort. Dr. Thompson said that the SMD AA has hired a team that focuses on this issue; while ARAG was spun up rather quickly, SMD ultimately realized that it needed social scientists. Dr. Diniega said she was assuming there is actually engagement with the BIPOC community. Dr. Thompson confirmed that this was so, but that NASA recognizes that it needs to expand engagement, while being extremely cognizant to avoid "swooping in" with solutions. Headquarters does not yet have the representation to do this directly. Everyone knows that NASA needs to do better, especially in the proposing PI pool. Dr. Mainzer asked if there would be the creation of an Executive position, as a standalone office, for working on this issue. Dr. Thompson thought that NASA was ripe for such an idea. Dr. Glaze agreed and said she would suggest it to Dr. Zurbuchen and the IDEA group. Dr. Mainzer noted that the aerospace community is discussing expanding executive roles in addressing IDEA.

Dr. Diniega commented, in connection to the previous conversation on service in the community, on how to encourage people to serve, when service puts a lot of burden on people, who have many other responsibilities. One simply can't say it is a valuable idea; service needs to be seen as a vital part of being a scientist. How do we do it? Dr. Glass suggested using the NSF "broader impact" approach. Dr. Thompson said that the intent of incorporating broader impact at NSF was not to put money into it, it was to make sure proposals didn't end up in the wastebasket. The intent here was not to increase diversity. Dr. Rinehart noted that through the Solar System Exploration Research Virtual Institute (SSERVI), proposers are asked how they would improve diversity; NASA can certainly consider expanding that exercise

beyond the larger programs. The Astrophysics Division (APD) is also working on piloting an inclusion plan, asking proposers how they will improve inclusivity in their work. It will require extra money and there are many unknowns, but Dr. Rinehart thought it was worth it. If the community is okay with it, he would gladly pursue it. Dr. Glaze suggested Dr. Mainzer bring for a recommendation for an Executive position for IDEA; suggest to the full NASA Advisory Council (NAC). Dr. Mainzer agreed.

Dr. Diniega asked if the ARAG had looked into establishing codes of conduct. Dr. Thompson confirmed that these were being reviewed, and would probably come through SMD. Dr. Mainzer commented that codes of conduct go a very long way. Dr. Thompson agreed, although how to make these codes enforceable is always an issue. Dr. Hagerty thought that it would be helpful to see how progress is happening, and with regard to supervisory roles, it would be helpful to have some wording about how to place metrics on inclusivity, and setting the standard. Dr. Glaze agreed. Dr. Mainzer asked: to what extent can SMD include ARAG training as part of a grant? Dr. Thompson said this had not been discussed, but it's a good question. Dr. Glaze said she was not sure this could be required as part of a grant, but that NASA might be able to offer corollary opportunities for people to get such training if they are interested. Dr. Mainzer thought it could be handled perhaps like the institutional training that is required for International Trafficking in Arms Regulation (ITAR) work. Dr. Thompson said that some of this effort had been blocked by an Executive Order (EO) from the previous administration; although the EO has since been overturned, NASA is still dealing with the aftereffects. Dr. Schmidt suggested changes in eligibility for certain fellowships, such as EC awards, to try to include inclusivity within existing structures that won't be construed as discriminatory. This might broaden the number of people eligible for certain programs. Dr. Thompson acknowledged there was a general fear of engaging with the lawyers; anti-discrimination laws are great, but they can backfire. She said she would take an action to look at the legal boundaries to see where NASA can try to broaden eligibility. Dr. Schmidt said that anything can be done to get resources into underrepresented populations will be helpful, particularly for Early Careers. It's a resource game in the end.

General Discussion

Dr. Mainzer opened a general discussion, asking for ideas on how to make it easier for people to use PubSpace. Training sessions? Dr. Glass thought that was exactly right; people need to be reminded, and there should be a link to the PMC number in the annual report; it's a way to get more citations, so people should go for it. Dr. Rinehart said that there was no way to confirm a paper had been submitted to PubSpace without digging into the database itself. Dr. Glass suggested motivating people to submit their paper to the Program Officer. Dr. Rinehart thought that the first step should be to increase awareness of the requirement, and after the grant has ended, NASA needs a way to check. The community must be made aware that there is a hard requirement to make federally-funded data publicly available, i.e. to submit these papers to PubSpace. Dr. Thompson said that NASA has just come up with all-new annual and final reporting templates; this might be a place to include links to PubSpace? Dr. Rinehart said that those templates were created with the idea to make it as easy as possible and to give NASA the information it wants. Once the grant is over, should NASA issue a reminder? Would that be sufficient? Dr. Hurley said that if the language included why NASA wants the information and what is done with it, people might be more compliant. Dr. Carter noted that anything to simplify the process for people will help, such as a reminder six months before the end of the grant. Dr. Rinehart agreed, and added that one other incentive is to be represented via science nuggets for the SMD website. Dr. Diniega asked Dr. Rinehart if there were a code of conduct for AG meetings. Dr. Rinehart said that if it's in the TWSC call, it will apply. Dr. Diniega asked who is held responsible for coming up with the code of conduct. Dr. Rinehart said that NASA does not tell the AGs what to do in that sense; it would be out of place for NASA to impose a code of conduct. Dr. Diniega thought it would be helpful to establish a code-of-conduct baseline for a NASA-sponsored activity. Dr. Rinehart commented that enforcement will always be an issue; it is easy to create codes of conduct with panels, but it is more complicated for a public event,

and for grant-funding. While there are codes of conduct that apply to reviewers and group chiefs, he felt that everyone must have one to facilitate accountability and transparency.

Dr. Hurley asked Dr. Rinehart about the most common forms of noncompliance in proposal writing. Dr. Rinehart cited tiny font (8.5) when the requirement is 12 point, more than 15 pages, inclusion of appendices (forbidden), and unreadable captions. Noncompliance is inherently unfair to those who do comply.

Dr. Mainzer asked for ideas for findings on ARAG, IDEA, and codes of conduct. Dr. Glass suggested mining the existing white papers for specific action items that can be prioritized. Asked who would mine the papers and come up with the items, Dr. Rinehart thought this would be a good task for the Decadal Survey. NASA should look for quick wins and then let the Academies do the rest. Dr. Mainzer thought that codes of conduct were important in setting the tone, and while awaiting the IDEA presentation at the next meeting, supported a current finding to support the establishment of a code. NASA will be setting the standard.

Dr. Mainzer asked if there were any flexibility in the NASA budget to allocate more money to R&A. Dr. Rinehart reiterated process by which the Operating Plan influences the budget negotiations, and that in general, R&A funding flexibility is very limited. The PAC should keep in mind that the budget is not a zero sum game. Dr. Glaze said that PSD puts the highest priority possible to protect R&A from threats. In addition, the flexibility to change the Operating Plan varies a lot, depending on how strongly the appropriators feel about the Congressional language regarding the program lines. NASA must work to achieve the intent of the appropriators. Mr. Ianson noted that the Planetary portfolio tends to be very specific, but there is at times a little room to negotiate. Dr. Schmidt made an observation about the structure of programs; it seems there have been items pulled out of PSD and put in maybe more flexible funding lines; does this mean there is an increase in directed missions? Is that where much of that flexibility for R&A funding has gone? Dr. Glaze said that while it may seem that the overall topline budget has increased, she did not think there was a direct correlation with the R&A budget challenge. Mr. Ianson said that some budget elements are semipermeable, but the Office of Management and Budget (OMB) likes to specify how program and project elements are connected to budget lines. PSD tends to be very proscribed on where the boundaries are.

Analysis Group Reports

Mercury Exploration Analysis Group (MExAG)

Dr. Steve Hauck, Chair of the MExAG, the newest AG, described the group's Steering Committee of 11 members. MExAG had its first annual meeting in February of this year, with 230 registrants, (70% US), 100 participants each day, and 58 presentations. The MExAG has set up a code of conduct (CoC) for the Steering Committee, using the Lunar and Planetary Institute (LPI) CoC as a template. The meeting resulted in good feedback both in the US and internationally.

Dr. Hauck presented a MExAG response to Major Parameters, reporting that the MExAG is concerned that Mercury is not on the list for the New Frontiers 5 (NF-5) call, as it is the second New Frontiers call in a given decade that lacks a mechanism for incorporating new discoveries. Given the NF-4 precedent, MExAG feels that an important opportunity was missed in the Statement of Task for the Committee on Astronomy and Planetary Science (CAPS) [2020] report; an assessment of whether discoveries in the decade since the writing of Vision and Voyages merited other destinations being considered for NF-5.

MExAG issued a number of findings, including an appreciation for the creation of MExAG, and PAC support for including Mercury in the PMCS option. Finding 3 encourages NASA to enhance cross-divisional support for opportunistic mission science, such as the measurements undertaken during the

Solar Probe flyby of Venus. Finding 4 concerns ground-based (GB) observation support for Mercury, comprised of two elements. One element has to do with optical GB observations; the Mercury community tends to be hamstrung by allocation rules, as the planet is visible only around twilight hours, and optical observation is necessary for monitoring the exosphere. The other element is concern about radar observations for geology/geodesy, and volatiles. The loss of Arecibo is particularly significant for Mercury. Finding 7 concerns early career support; MExAG wants to add its voice to encourage NASA to expand upon existing opportunities for Early Career researchers to build a diverse and sustainable community for the future. Upcoming events include the LPSC, where there will be 12 talks and 24 posters dedicated to Mercury. Dr. Hauck noted that when ESA's BepiColombo mission makes its first flyby of Mercury, it will provide the first data from Mercury since 2015.

Venus Exploration Analysis Group (VEXAG)

Dr. Noam Izenberg reported on the latest VEXAG meeting. The AG has four new SC members, two who have come on immediately and two that are coming on in July. VEXAG 2020 marked the 18th meeting of the AG, which took place in November 2020. There were 100 + in attendance over two days; the meeting went well, and people are very excited about the upcoming Discovery selection process. The two Venus concepts are close to approaching site visit time. VEXAG has established a new six-month rotation (with 30% EC researchers required at all times), establishing the rules and ensuring equity and diversity, and has also been working with the SMD IDEA group on establishing standards. The AG is moving toward a new monthly presentation schedule for the Study/Science Analysis Workgroups (SAWs), considering a revision of the Venus Gravity Assist Science Opportunity (VEGASO) document, working on Venus science nuggets, and finishing up a Surface Platform Study. VEXAG has also been working with NExSS (Venus is the Exoplanet Next Door), the ExoPAG Science Interest Group, the Equity, Diversity and Inclusion Working Group (EDI WG), and the AG Chair Caucus; and also has a Venus Strategic Plan paper in review. VEXAG is not going to be part of the LPSC townhall, and plans its next meeting to be held live at Caltech in November 2021. VEXAG has great optimism for the Discovery selections, the possibility of a HOTTech2 program, and changes in AG budgeting.

VEXAG is finalizing its findings, including one that is similar to a MExAG finding, urging NASA to take additional data on any mission that flies by Venus. Dr. Izenberg briefly highlighted Finding 3 on HOTTech2, Finding 4 on leveraging the Long-Lived In-Situ Solar System Explorer (LLISSE) development effort, and Finding 6, in which VEXAG requests detailed statistics on proposal submission and selection rates in all ROSES program to better understand where Venus stands. Findings 9 and 10, combined, request that Venus-related proposals be included in the Habitable Worlds (HW) and Exobiology R&A programs. In response to the NF5 solicitation for input, VEXAG sent a letter to Dr. Curt Niebur and Dr. Glaze to encourage raising the NF5 cost cap to at least \$983M, and to propose new general language for NF5 AO.

Lunar Exploration Analysis Group (LEAG)

Dr. Amy Fagan, Chair of the Lunar Exploration Analysis Group (LEAG) presented, first offering huge congratulations to the Perseverance team on the rover landing, noting that this resounding success is a good way to get the public excited about exploration in the Solar System, and the Moon to Mars connection. It also helps to increase dialogue between the Moon and Mars communities. She noted, as an example of the increased dialogue, that an engineering talk given by Ashwin Vasavada at the latest Lunar Surface Science Workshop had been particularly well-received. LEAG also continues to be excited about the Artemis program and is happy to have the Biden administration's support, as it looks forward to seeing development of timelines for Artemis III and the establishment of an Artemis base camp. Dr. Fagan noted that there is continued interest and success in the Lunar Science Workshop series, despite the switch to all-virtual presentations, and indicated that reports from the workshops are available for two weeks after each one has concluded. LPI has been a strong supporter of these workshops, as have SSERVI, NASA and non-NASA chairs, and Early Career participants. The LEAG is also very excited

about CLPS, PRISM, and the VIPER rover, and continues to encourage the establishment of a Lunar Exploration Program Office similar to that of the NASA MEP. Recent LEAG activities include participation in a NF-5 Town Hall meeting in January of this year, for which there were 112 individual log-ins. In response to the NF-5 Draft Announcement, LEAG found much support for South Pole-Aitken (SPA) basin sample return, although LEAG notes it may not be possible to resolve the thorium anomaly, for instance, depending on Gateway's ultimate orbit. LEAG continues its EDI prioritization efforts through three main avenues, and is planning for its virtual annual meeting in August 2021; the theme will be lunar science and exploration over the next five years. The LEAG's Commercial Advisory Board (CAB), which started off with 11 member companies, now has 60 individuals and 38 companies. Chair Elizabeth Frank has been working on restructuring the Board and refining goals; Dr. Fagan stressed that the CAB is available to respond to requests from the PAC. Dr. Frank will speak at an LPR Seminar Series on 6 May. Dr. Diniega commented that LEAG's efforts to make Town Halls more inclusive should be shared across all the AGs.

Small Bodies Analysis Group (SBAG)

Dr. Bonnie Buratti, SBAG Chair, introduced her briefing by remarking that SBAG has been engaged in EDI for years. SBAG has a large portfolio of objects that include Kuiper Belt Objects (KBOs), dust, Phobos and Deimos, the Outer Irregulars, and objects surveyed by Planetary Defense. SBAG's last meeting was held in January, and the next one is scheduled for June. Its most recent focus has been aimed at supporting the Decadal Survey through presentations. SBAG revised its Goals document, now posted at lpi.usra.edu. At present, there are numerous current and approved missions to small bodies in the Solar System. SBAG strongly supports NEOSM, and is concerned about the delayed KDP-B milestone. SBAG has put together a white paper on radar recovery, with an emphasis on the loss of Arecibo, and continues to advocate that NASA continue to consult with NSF and other government agencies to get another radar facility up and running. SBAG applauds NASA's NF-5 efforts, and urges NASA to clarify language within the PDART (or other relevant) solicitation that explicitly indicates that development of software tools to work with Solar System data from the Rubin Observatory are within the scope of the program; or to add a solicitation specifically for Solar System science using Rubin data. SBAG encourages NASA on viewing Apophis at its next close flyby. SBAG also applauds NASA's approach to the COVID pandemic, especially with regard to its response to EC researchers. Dr. Buratti detailed some of the suggested improvements to the radar recovery effort from white paper, including recommendations for collaborations with foreign assets. The SBAG does not yet have a CoC for diversity, but Dr. Buratti reiterated that the SC is already diverse. SBAG continues to funnel its efforts to Arecibo and the need for new radar facilities. Prior to Arecibo's loss, the SBAG had been focused on the Decadal Survey, supervising target papers to make sure gaps were covered, and also to ensure that fundamental questions were being addressed. Dr. Filiberto noted that SBAG was the only group that put out a white paper (on scientific recovery due to the loss of Arecibo). Dr. Buratti enlarged on the comment, noting that SBAG did confer with OPAG, and that MEPAG had some interest as well.

Mars Exploration Program Analysis Group (MEPAG)

Dr. Aileen Yingst, MEPAG Chair, reviewed the programmatic of the Analysis Group. Both the SC and the Goals Committee have new members (SS Johnson and K Lynch), and also two representatives from NASA's EDI effort. MEPAG has been celebrating the three recent successful arrivals at Mars, and is hopeful that ESA's ExoMars will launch successfully in Fall 2022. The MSR IRB reported out its primary recommendation that MSR proceed, a result that has been welcomed by the community. The MASWG submitted its report to NASA. MEPAG held its last meeting in January, during which it considered the re-organization of MEP and MSR. The MEPAG is grateful to have had Messrs. Ianson, Gramling and Dr. Bobby Braun present to discuss the re-organization, and also to Dr. Meyer for being the glue that binds the two programs. MEPAG also discussed MIM, and the possibility of a communications satellite network, and is looking forward to the release of a white paper on a measurement approach and the possible formation of a Mission Design Team for MIM (also the subject of a MEPAG finding). The

MEPAG stands ready to stand up a SAG if requested. It has also discussed a change in the MRO orbit to increase the amount of operational time for Perseverance surface activity. This change might have an impact on MRO science. MEPAG has not yet heard detailed response from M2020 or MRO just yet on this issue.

Dr. Yingst presented the major findings from the January meeting:

- MEPAG commends the great effort between the Mars Exploration Program (MEP) and the Mars Sample Return (MSR) program to communicate smoothly and effectively.
- MEPAG is excited to see the significant progress on the highly complex MSR program. Although concerns of the Independent Review Board (IRB) regarding the schedule and funding profile are valid, the community is encouraged to see MSR move forward.
- MEPAG encourages NASA to address the important MASWG report requested by the mid-term Decadal review. MEPAG believes that the report defines the non-MSR aspects of the MEP and as a standalone report, it should be assessed on its own rather than waiting for the Decadal Survey report.
- MEPAG is encouraged by the news that the FY21 budget is sufficient to cover Mars priorities, and is appreciative of Headquarters hearing the community's recommendations to focus funding back into extended missions (as per the NASEM report). MEPAG looks forward to seeing the details of the approved operating plan.
- MEPAG is excited about the first stages of discussions regarding humans to Mars but is concerned regarding the lack of input the Mars community has had in the initial formation of science objectives for human exploration of Mars. Science community input into HEOMD architectures at the earliest stages will be crucial for coordination and better understanding of knowledge needed for a successful human mission to Mars.

Dr. Diniega asked if it were the MEPAG's desire to treat the MASWG finding as input to the Decadal Survey. Dr. Yingst said that the understanding was that NASA wanted to assess the MASWG report in the context of Decadal Survey output, but regardless, the MEPAG believes the MASWG is a standalone report.

Outer Planets Analysis Group (OPAG)

Dr. Linda Spilker, co-Chair of the OPAG, reported that the Group has welcomed three new members, as others are rotating off the Steering Committee. OPAG is a community-based forum that meets twice per year, its last meeting having been held in February. All OPAG documents are posted on the OPAG web page. OPAG has "joint custody" of Pluto and some other KBOs, along with SBAG. An OPAG-related meeting took place in a Town Hall at the American Geophysical Union (AGU) meeting in December 2020. The Summer OPAG meeting will be focused on the Decadal Survey. Dr. Spilker presented some highlights of OPAG's NF-5 feedback:

- OPAG concurs with excluding Phase E and launch vehicle costs from the NF-5 mission cost
- OPAG recommends that NASA maintain the cost cap at the same level (\$1.1B in FY22\$) for NF-5
- OPAG advocates that evaluation criteria for NF-5 proposals should include factors that consider how proposed missions would foster an interdisciplinary, diverse, equitable, inclusive and accessible community.

Full findings from the latest meeting are still be developed, but it is to be mentioned that one finding is well in line with SBAG's finding on Arecibo. OPAG does have some concerns about community involvement in the Decadal Survey, and is particularly concerned about Dragonfly's two-year launch slip, as it appears to imply that the mission is a lower priority than others. OPAG would like to explore ways to avoid a third launch delay. OPAG has other concerns about controlling cost growth on Flagships (such as the Europa Clipper and MSR), and how this might affect other Flagship priorities for the next decade. Asked about communication with the Decadal Survey, Dr. Spilker commented that OPAG has had some difficulty with Decadal Survey transparency.

Mapping and Planetary Spatial Infrastructure Team (MAPSIT)

Dr. Brad Thomson, MAPSIT Chair, noted the diverse nature of its SC, and reported that he MAPSIT community now has a roadmap. MAPSIT findings include an endorsement of a recent knowledge inventory of foundational data products in planetary science (Laura and Beyer, 2021); MAPSIT will interface with AGs to ensure gaps are addressed. There is also a big push in the community on the developing Planetary Data Spatial Infrastructure (PDSIs), including a preliminary one for Io, and the continued development of a Europa PDSI. MAPSIT encourages a PDSI for the Moon, while noting that the workload for a lunar PDSI will require some funding, and therefore should not be left to a voluntary effort. MAPSIT appreciates the establishment of an IRB for the Planetary Data Ecosystem, and looks forward to hearing IRB results.

The fifth Data Users Workshop, which has grown to several hundred people, will happen in June/July 2021 in Flagstaff, AZ. Dr. Diniega asked what sort of interactions MAPSIT has been having with the different AGs. Dr. Thomson said that members of the MAPSIT committee have presented at various AGs, and have come away from these encounters encouraged that data standards are getting "baked in" to data management plans. For example, there is much extant Venus data, some of which is being converted to stereo products based on the Magellan mission; it is not clear in this case where the data are going- is it going to PDS? These issues can be resolved through further discussions with the AGs on the status of foundational data products: How accurate is the data? Where is it archived?

Extraterrestrial Materials Analysis Group (ExMAG)

Dr. Barbara Cohen presented an update on ExMAG, formerly known as the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM). When the AGs went through their charter revisions, the dual role of CAPTEM as both an analysis and allocation body was examined in detail, and potential conflicts of interest were taken into account. As a result, the ExMAG was stood up. ExMAG is a community-based forum that holds Spring and Fall meetings and is comprised of 15 members. Sample allocations formerly governed by CAPTEM are now being run as NASA review panels, called Astromaterials Allocation Review Boards (AARBs), which are separate from the AG function.

ExMAG will soon be opening up a call for new members. In 2021, the AG is starting afresh, which entailed much housekeeping. The subcommittees, now free from allocation duties, have been able to expand their activities. NASA held a Town Hall during the last week of February to roll out ExMAG; the Town Hall attracted 214 registrants. The ExMAG Spring meeting will be held virtually on 7-8 April; the meeting agenda will include a NASA Headquarters briefing, NF-5 sample return mission language, some discussion of Chang'e's sample return, as well as Artemis curation planning and an Artemis III SDT. ExMAG is working on revitalizing the Fall meeting, planned for September/October, and also likely to be virtual. Potential topics for the Fall meeting may include sample handling systems and facilities, and Early Career contributions. Asked if there were still an informatics subcommittee, as under CAPTEM, Dr. Cohen said it had been combined with the Facilities subcommittee, and ExMAG is looking for a new chair to revitalize this combined subcommittee.

Exoplanet Analysis Group (ExoPAG)

Dr. Michael Meyer, the new ExoPAG Chair, reported that the ExoPAG now has representatives from Planetary Science, Earth Science, and Heliophysics. He noted that the ExoPAG has made a special effort to reach out to underrepresented populations as the AG expands further, and has been encouraging diverse nominations during its latest membership solicitation. Recent activities include the ramping up of a Science Interest Group (SIG-3), and cross-PAG activities including a special session at the AAS on Barriers to Participation in SMD APD Space Science, and a proposed cross-PAG SAG on this topic. Another cross-PAG initiative is to consider the upcoming Astrophysics Division (APD) Biennial Technology Gap Review, which will follow release of Astro2020, the decadal survey impacting APD mostly directly. The ExoPAG held its first Exoplanet Explorers events to benefit young scientists, which included 100+ participants, and which was targeted specifically to people who are interested in diversity and inclusion. ExoPAG also held a community forum in December 2020, to prepare business for its January 2021 meeting, including the review of a new finding that states the value of investing in interdisciplinary exoplanet science of scale over longer periods of performance (up to 5 years). In addition, the ExoPAG held a joint Solar System/Exoplanet Synergies Mini-Symposium, which included SIG3 updates, talks on Venus and the Ice Giants, and a Habitable Worlds Meeting Pre-Meeting Update. A business meeting scheduled for 6 January had to be cancelled, thus the ExoPAG conducted a virtual poll on the finding.

The ExoPAG is in the process of closing out SAG 19, *Exoplanet Imaging Signal Detection Theory and Rigorous Contrast Metrics*, and has stood up two new SAGs, SAG 21 and SAG 22, *Stellar Contamination on Transit Spectra* (which may be of interest to colleagues in PSD and/or Heliophysics) and *Exoplanet Host Properties Database*, respectively.

Initiatives under consideration for the future include ground-based vs. space-based direct imaging synergies, the status of debris disk knowledge for imaging planets, and a discussion of common standards for publishing and archiving exoplanet discoveries. ExoPAG also raised a question for the PAC to consider: Was the absence of PSD proposals for recent APD balloon programs an oversight?

General Discussion

Dr. Glass asked if there were any more detailed information on MIM and scientific engagement. Dr. Yingst said that while NASA intends to come to the community to solicit community feedback, the interaction has not yet been described. Dr. Filiberto, referring to serendipitous observations that could be collected during mission flybys, and citing Parker Solar Probe (PSP) as a good recent example, thought it would have been good to have been able to provide updated guidance and to have a discussion with the AGs well in advance of the latest Venus flyby opportunity. The VEGASO document is old; BepiColombo decided to turn on everything they could because they could, recognizing that the potential science is tremendous. Dr. Buratti commented that there are many similar opportunities for small bodies, and that it would be good practice to get the AGs involved in pursuing such “bonus data.” Dr. Hauck noted that PSD spacecraft frequently carry instruments (particle detectors, spectrometers) that prove relevant to Heliophysics, and supported the idea of thinking about these opportunities ahead of time. Dr. Glaze observed that BepiColombo had done a particularly good job in investigating what could be done during cruise phase, and NASA can learn from their example. She added that VESAGO had been pulled together to assess opportunities for BepiColombo, PSP, and Solar Orbiter (SO), but that in the early planning stage of these missions, the focus must be on mission scope, in order to avoid scope creep. It’s a bit of a trade-off. NASA can’t drive science beyond the Level 1 requirements for the missions. Dr. Izenberg reiterated that while each mission does not have the mandate or support to do these extra things, once the mission launches, and everyone can relax, that would be the time to request some support from Headquarters to investigate serendipitous science. Dr. Nixon asked if there were a cold technology development program that might support future icy sample return from a Europa lander, for instance, from drilling in Mars ice caps. Dr. Glaze said that cold technology development in PSD is more applicable to keeping cold samples from the Moon pristine, with relevance also to comet sample return. Cold technology work for a Europa lander relates to getting samples from through the ice. Dr. Carter asked about MEPAG issues surrounding

the changing orbit for MRO. Dr. Yingst noted that in the MEPAG's view, the community, ideally, should have at least some knowledge of what the trade-off is, or some buy-in to what a reasonable decision is regarding any changes in the MRO orbit.

Dr. Hurley asked, in reference to the LEAG finding on establishing a Lunar Exploration Office (LEP) at NASA, how ESSIO comes in. Dr. Glaze acknowledged the parallels between a LEP and an MEP, but said the programs are quite different. All the CLPS activity is run out of JSC, and that PSD also works closely with ESSIO, but PSD in fact runs the VIPER and Lunar Trailblazer projects. Dr. Noble said that ESSIO is there to be an integrating function across SMD. Dr. Glaze added that ESSIO's function is to integrate science and technology that can be done at the Moon, as there are many different aspects. Dr. Hurley said it seemed like it would be easy to have an LEP; perhaps a lot of those functions are being done through ESSIO? Dr. Glaze asked what functions Dr. Hurley felt were being omitted. Dr. Hurley said she had no specific functions in mind, beyond the benefit of having an office in terms of supporting a long-term strategy. Dr. Yingst added that because there is a Mars program focused on science, it allows the community to think about strategy long-term. It means that scientists can plan ahead, giving them the power to think and plan strategically, and build on the science. Dr. Glaze felt that this same concept speaks to the existence of MEP, which is run out of Headquarters; the MEP is a Headquarters program. SMD has Lunar Discovery and Exploration Program (LDEP), which is run by ESSIO. LDEP is quite analogous to the MEP at the Headquarters level. Dr. Glaze asked what Dr. Fagan was looking for in a Lunar Exploration Program. Dr. Fagan said was learning more about where ESSIO and LDEP lie on the organization chart, and how they were related overall within SMD. Dr. Glaze said that Dr. Kearns would be providing a lot of stability for LDEP, and explained how both LDEP and MEP are contained in the PSD budget lines, adding that both programs have Strategic Plans that carry into the future. LDEP is more than lunar science; it has cross-divisional and cross-directorate connections. The LDEP funding line is in the PSD budget, but the budget and the program is managed by ESSIO. Dr. Noble noted that the ESSIO website was in the process of development— eventually the site will provide a little more clarity. Dr. Glaze added that the core part of the lunar program is CLPS, which also provides stability for the program going forward. Dr. Fagan asked: does this mean ESSIO is at the same level as MEP? Dr. Glaze suggested that Dr. Fagan consult Dr. Noble off-line for more clarification of ESSIO's role in PSD.

Findings Discussion

Dr. Mainzer briefly sketched some draft findings:

- Congratulations on the Perseverance landing, and the work on all the other PSD missions.
- COVID impact on the future of the field: short-term things to mitigate, such as extending ROSES and encouraging NASA to look at other things, such as career advancement and mentoring, while longer-term, suggesting that NASA assess the impact with the help of social scientists.
- How to infuse Astrobiology expertise into mission definitions of requirements.
- R&A and the relative trades associated with biannual calls when rates are low

Dr. Glaze said that with regard to infusing Astrobiology into mission requirements, NASA was absolutely looking at this, but she did welcome more feedback on it could be done. Dr. Glass referenced a large Atlanta conference scheduled for the following year, that could infuse M2020 into the community. Dr. Carter suggested instrument development teams as another pathway.

With regard to an R&A finding, Dr. Glaze requested that the PAC provide a rationale. Dr. Mainzer said that there seemed to be an openness to trying a Step 1/Step 2 triage with a severe Step 1 criteria. Dr. Glaze noted that as R&A moves to NoDD, there will be an impact of significant triage. Dr. Mainzer said that PAC wants to understand why proposal costs are going up, and that perhaps there are professional societies that have data relevant to this phenomenon, that NASA might find useful. Dr. Westlake added that the PAC also wants to understand the fundamental reasons behind increasing proposal pressure: what

does this pressure say about the state of the community? Dr. Mainzer felt that the main question is how R&A might grow proportionately with the PSD budget. Dr. Diniega said that this finding might also include a comment on looking at health of the community in terms of diversity.

Dr. Mainzer enlarged on a PAC finding expressing concern about the cost of MSR, seeking assurance that the science community be involved in decision thresholds, and de-scopes. She added that controlling mission costs is partly based on understanding the fundamental science requirements. Dr. Glass also felt that the community should be engaged in building and designing a Sample Receiving Facility. Dr. Glaze said that a facility was not yet in planning stages. Dr. Westlake felt that the MSR approach was a little engineering-heavy. Dr. Glaze suggested that the PAC home in on what it think really needs to be done re: MSR, which may not necessarily call for a science team. Dr. Mainzer said the PAC's concern was more that the expertise be present to help with MSR's decisions. Dr. Schmidt observed that the goals of M2020 (Perseverance) and MSR are similar but not the same: how does MSR decide which samples to return, or how many samples to bring back? Dr. Glaze said that NASA has an entire science activity being spun up for sample return. Dr. Lindsay Hays added that MSR itself does not have science instruments, but that there is fundamental science at the heart of the program. Dr. Schmidt said that the usual structure is having a science team present with a decision-making ability. Dr. Glaze asked the PAC to reiterate upon and describe its specific concerns, and to refrain from prescribing the solution: the answer is not necessarily falling back on the "way we've always done it." Dr. Glass asked if the MSR mission extends to the ground-based analysis on Earth as well. Dr. Glaze said that in order to address cost, NASA wants to solely focus on getting the MSR hardware built successfully and on time, and on cost. MEP owns the science, which is being carried out by Perseverance. When the samples are returned, MSR is done, and MEP takes over.

Dr. Carter commented on the issue of changing the MRO orbit to support Perseverance, noting that the lack of transparency regarding this decision is what seemed to bother people. Mr. Ianson said that the intent of MEP is to work closely with anyone involved with MRO, and to look at it in the best interests of Mars science. No one is jumping into anything, and there has not yet been a meeting to discuss it. Dr. Glaze said the MRO orbit change is at present, simply a proposal from the Perseverance team, and not a done deal. Dr. Mainzer suggested deferring this finding pending further information.

Dr. Mainzer noted a proposed finding supporting NASA's work on encouraging diversity and inclusion, and a request for briefings from some of the white paper authors. Dr. Diniega's suggestion to issue a finding on Code of Conduct development was tabled until the next PAC meeting. Dr. Filiberto mentioned the loss of science stemming from the loss of Arecibo, as it had been mentioned by three different AGs, but with no coherent effort as yet. His other issue of note was to encourage support for making multiple observations from one mission, and to ensure that taking advantage of serendipitous opportunities continues. Dr. Diniega added a comment regarding the Decadal Survey and the State of the Profession discussion, calling for transparency while respecting the independence of the NAS process, and requesting continued updates on the Decadal Survey through the PAC.

Dr. Mainzer adjourned the meeting at 6:02pm.

Appendix A

Attendees

Planetary Science Advisory Committee Members

Amy Mainzer, University of Arizona, **Chair**

Lynn Carter, University of Arizona

Serina Diniega, Jet Propulsion Laboratory

Justin Filiberto, Lunar and Planetary Institute

Jennifer Glass, Georgia Institute of Technology

Justin Hagerty, United States Geological Survey

Dana Hurley, Johns Hopkins Applied Physics Laboratory

Conor Nixon, NASA Goddard Space Flight Center

Britney Schmidt, Georgia Institute of Technology

Joseph Westlake, Johns Hopkins University Applied Physics Laboratory

Stephen Rinehart, NASA Headquarters, **Executive Secretary**

Other Virtual Attendees

Aaron Burton

Aaron Gronstal

Abi Rymer

Adam Schilffarth

Adriana Ocampo

Alana Johnson

Alexandra Witze

Amanda Nahm

Amy Fagan

Andrea Hughes

Andrea Riley

Anne Verbiscer

Ashlee Wilkins

Azita Valinia

Barbara Cohen

Bill Knopf

Bo Trieu

Bobby Braun

Bonnie Buratti

Bonnie Meinke

Brad Thomson

Brent Archinal

David Smith

Cadrian Thompson

Caroline Diehl

Casey Dreier

Charity Phillips-Lander

Chris Nie

Christina Richey

Christina Viviano

Christopher Dateo

Cindy Schulz

Curt Niebur

Dana Burton

Daniel Evans

Danny Lentz

Dave Murrow

David Eisenman

David H. Smith

David Millman

Delia Santiago-Materese

Doris Daou

Edgard Rivera-Valentín

Elaine Denning

Emily Gulick

Eric Ianson

Flaviane Venditti

Francesco Bordi

Gale Allen

Gene Mikulka

George Tahu

Gina DiBraccio

Greg Ferko

Gregg Vane
Jake Robins
James Lochner
James Spry
Jason Callahan
Jay Bookbinder
Jeff Foust
Jeff Moore
Jeffrey Hollingsworth
Jeffrey Gramling
Jeffrey Grossman
Jennifer Kearns
Joan Salute
Joan Zimmermann
Joel Kearns
John Baker
John Rummel
Joseph Gasbarre
Joshua Handal
Julie Castillo
Julie Stopar
Kelly Fast
Krista Soderlund
Kurt Retherford
LaJuan Moore
Laura Ratliff
Lewis Groswald
Linda Billings
Linda Karanian

Linda Spilker
Lindley Johnson
Lindsay Hays
Lizabeth Montgomery
Lori Glaze
Louise Prockter
Lucas Paganini
Lynn Carter
Marchel Holle
Marcia Smith
Mary Beth Wilhelm
Mary Voytek
Maxime Devogele
Meagan Thompson
Megan Ansdell
Meghan Bartels
Melissa Kirven-Brooks
Melissa Lane
Melissa Morris
Michael Kelley
Michael Meyer
Michael R. Meyer
Monty DiBiasi
Nicolle Zellner
Niel Holt
Noam Izenberg
Patricia Rausch
Paul Byrne
Paul Steffes
Paul Voosen
R Aileen Yingst
Ramon de Paula

Rebecca McCauley Rench
Richard Rogers
Richard Ryan
Richard Zurek
Robert Fogel
Robert Tomes
Robins Mdoka
Rosaly Lopes
Ryan Watkins
Sarah Noble
Mitch Schulte
Scott Hovarter
Sean Marshall
Shoshana Weider
Stefanie Milam
Stephen Clark
Steve Mackwell
Steven Hauck
Steven Slaten
Sylvie Espinasse
Tammy Dickinson
Teresa Jensen
Thomas Statler
Thomas Thompson
Thomas Wagner
Thomy Reyer
Uma Verma
Ursula Rick
Van Kane
Ying Lin

Appendix B
Committee Membership

Amy K. Mainzer, **Chair**
University of Arizona

Lynn Marie Carter
University of Arizona

Serina Diniega
Jet Propulsion Laboratory

Justin Filiberto
Lunar and Planetary Institute

Jennifer Glass
Georgia Institute of Technology

Justin Hagerty
United States Geological Survey

Dana Hurley
Johns Hopkins Applied Physics Laboratory

Conor Nixon
NASA Goddard Space Flight Center

Britney Schmidt
Georgia Institute of Technology

Joseph Westlake
Johns Hopkins University Applied Physics Laboratory

Stephen A. Rinehart
Executive Secretary, NASA Headquarters

Appendix C

Planetary Advisory Committee (PAC) March 1–2, 2021 Meeting

VIRTUAL MEETING

Agenda

Meeting Information (both days)

Meeting link:

<https://nasaenterprise.webex.com/nasaenterprise/j.php?MTID=m1aafd71607930a725986be629a61990e>

Meeting number: 199 538 6929 **Password:** PAC_March2021

For audio, when you join the WebEx event, you may use your computer or provide your phone number to receive a call back. Otherwise, call the U.S. toll conference number: 1-415-527-5035 and enter the access code 199 538 6929.

Day 1: Monday, March 1

Time (Eastern)	Length (minutes)	Item & Speaker
10.25–10.30	5	Welcome/around the table Stephen Rinehart
10.30–11.30	60	Planetary Science Division (PSD) update Lori Glaze
11.30–12.00	30	Exploration Science Strategy and Integration Office (ESSIO) Update Joel Kearns
12.00–12.30	30	Astrobiology update Mary Voytek
12.30–13.30	60	BREAK (east cost/mid-west lunch)
13.30–14.00	30	Planetary Defense Coordination Office (PDCO) update Lindley Johnson/Kelly Fast
14.00–15.00	60	Mars Exploration Program/Mars Sample Return update Eric Ianson, Jeffrey Gramling, Michael Meyer
15.00–15.30	30	Decadal Survey Update

		David Smith
15.30–16.30	60	BREAK (west coast lunch)
16.30–17.30	60	Discussion time PAC members
17.30		Adjourn for the day

Day 2: Tuesday, March 2

Time (Eastern)	Length (minutes)	Item & Speaker
10.30–11.30	60	R&A Update Stephen Rinehart
11.30–12.15	45	Anti-Racism/Inclusion Diversity Equity and Accessibility Working Group Report Meagan Thompson
12.15–13.00	45	Discussion time
13.00–14.00	60	BREAK (east coast/mid-west lunch)
14.00–16.00	120	Analysis/Assessment Group Reports/discussion 14.00: MExAG 14.12: VExAG 14.24: LEAG 14.36: SBAG 14.48: MEPAG 15.00: OPAG 15.12: MAPSIT 15.24: CAPTEM/ExMAG 15.36: ExoPAG 15.48: Additional Q&A
16.00–17.00	60	BREAK (west coast lunch)
17.00–18.00	60	Discussion and findings
18.00		Adjourn

Appendix D
Presentations

1. Planetary Science Division Update; *Lori Glaze*
2. Exploration Science Strategy and Integration Office; Joel Kearns
3. Astrobiology Update; *Mary Voytek*
4. Planetary Defense Coordination Office; *Kelly Fast, Lindley Johnson*
5. Mars Exploration Program and Mars Sample Return; *Eric Ianson, Jeffrey Gramling, Michael Meyer*
6. Decadal Survey Update; *David Smith*
7. Planetary Science Division Research and Analysis Update; *Stephen Rinehart*
8. Inclusion Diversity Equity Accessibility (IDEA) Report; *Meagan Thompson*
9. Mercury Exploration Analysis Group (MExAG); *Steven Hauck*
10. Venus Exploration Analysis Group (VEXAG); *Noam Izenberg*
11. Lunar Exploration Analysis Group (LEAG); *Amy Fagan*
12. Small Bodies Analysis Group (SBAG); *Bonnie Buratti*
13. Mars Exploration Program Analysis Group (MEPAG); *Aileen Yingst*
14. Outer Planets Analysis Group; *Linda Spilker*
15. Mapping and Planetary Spatial Infrastructure (MAPSIT); *Brad Thomson*
16. Extraterrestrial Materials Analysis Group (ExMAG); *Barbara Cohen*
17. Exoplanets Analysis Group (ExoPAG); *Michael Meyer*

