

NASA ADVISORY COUNCIL
PLANETARY SCIENCE ADVISORY COMMITTEE

August 17–18, 2020

NASA Headquarters
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MEETING REPORT



Anne Verbiscer, Chair

STEPHEN RINEHART Digitally signed by STEPHEN RINEHART
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Stephen Rinehart, Executive Secretary

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August 17, 2020

Opening and Announcements, Introductions

Executive Secretary of the Planetary Science Advisory Committee (PAC), Dr. Stephen Rinehart welcomed members of the committee and held a roll call, noting that this is the last meeting for a number of members: Drs. Anne Verbiscer (PAC Chair), Timothy Lyons, Robin Canup, Rhonda Stroud, Francis McCubbin, Aki Roberge, and Chris German. New members coming on board are: Drs. Joseph Westlake, Jennifer Glass, Serina Diniega, and Conor Nixon. Dr. Amy Mainzer will become the new PAC Chair.

PSD Status Report

Dr. Lori Glaze, Director of the Planetary Science Division (PSD), presented an update on the division, tendered her thanks to the PAC members rolling off, and reported that the new PAC members are in their final phase of confirmation paperwork. Dr. Glaze announced newly arrived staff at PSD: Drs. Courtney O' Connor, Jeff Gramling, Christie Leighton (Program Executive for Dragonfly), Bo Trieu (Program Executive for VIPER), Megan Ansdell, David Smith, Lindsay Hays, Kenneth Hansen, Rich Ryan, Amanda Nahm, and Aaron Burton.

Of late, the impact of the COVID-19 pandemic on the health and safety for all staff has been the top priority at PSD. Ongoing challenges include the continuing adaptation to full-time telework, virtual work, balancing responsibilities at work and home, and building new relationships with colleagues. Looking ahead, PSD is addressing short-term issues to ensure diverse and representative input into proposal reviews and the Decadal Survey panels. Longer-term, Dr. Glaze felt more concerned about losing scientists due to the economic fallout associated with COVID-19. To this end, the Science Mission Directorate (SMD) is making efforts to augment existing grants, allow funding extensions, with priority for students, and soft-money, early-career scientists, and is considering expanding the NASA postdoctoral program. The Agency is also aware of the pressing social justice issues of the day, and has issued a Statement of Task to the National Academies of Science, Engineering and Medicine (NASEM) to help determine what kind of actions NASA can make to increase diversity, inclusion, equity and accessibility in its mission activities. Although in-person Principal Investigator (PI) Launchpad events have been suspended because of the pandemic, NASA has been looking for options on virtual workshops, with no firm plans as yet. There is an active website that hosts material from the first Launchpad event.

The Perseverance Rover launched successfully on 30 July, and is now on its seven-month cruise to Mars. The next Planetary launches will be the Double Asteroid Redirection Test (DART) and Lucy, a Trojan asteroid mission, in 2021. A total of 12 missions are in formulation and development, with 14 in current operation. Dr. Glaze noted that Perseverance had been aptly named, and that the virtual launch experience was highly successful, booking great metrics: 7.1M social media engagements, 5M views of launch across all platforms, and more than 66k virtual participants in the launch, with support from notable accounts including those of Octavia Spencer, Mae Jamison, and Peanuts. The rover is scheduled to land in the Jezero Crater in February 2021. The Ingenuity Helicopter, an exciting and unusual technology demonstration, is stowed on the rover. It will attempt five powered, controlled flights at Mars. The Origins Spectral Interpretation Resource Identification Security - Regolith Explorer (OSIRIS-REx) mission is scheduled to carry out a sampling event on 20 October at the Nightingale site on the asteroid (101955) Bennu. OSIRIS-REx carried out a flawless Matchpoint rehearsal test on 11 August, reaching 40 m above the surface of Bennu. The DART mission, the first to demonstrate an asteroid deflection technique, will be the first mission for the Planetary Defense Coordination Office (PDCO); its launch is scheduled for July 2021. DART will attempt to kinetically impact the smaller body of the double-asteroid system, Dimorphos-Didymos. DART's Assembly, Testing, Launch and Operations (ATLO) phase has started. The spacecraft is at the Johns Hopkins University Applied Science Laboratory (APL), awaiting the addition of the LICIAcube, to be delivered in March 2021. PSD released a Participating Scientist (PS) call for DART in June. Lucy, also launching in 2021, is the first mission to study the Trojan asteroids orbiting near Jupiter, and is coming up on its Key Decision Point-D (KDP-D) milestone in late

August, with ATLO beginning just afterward. Lucy will fly by seven Trojan asteroids, the first one in August 2027. The Volatiles Investigation Polar Exploration Rover (VIPER), has been transitioned to PSD for management; this lunar rover will characterize ice in cold traps and regolith on the Moon, and will provide a great feed forward to Human Exploration. VIPER is designed for a 100-day lifetime, and will be built and launched by Astrobotic, a provider for NASA's Commercial Lunar Payload Services (CLPS) contract vehicle—its Program Design Review (PDR) will take place in late August.

The Europa Clipper mission has many instruments that have gone through Critical Design Review (CDR); its flight system CDR has been scheduled for December of this year. Steps have been taken to inhibit the cost growth for three of its instruments. Following a risk assessment, some Level-1 requirements were altered to allow teams more flexibility in managing resources. Recently, PSD competitively selected seven members of a Gravity/Radio Science team for the mission. Clipper's Launch Vehicle (LV) remains a concern. Congress has mandated that Clipper use the Space Launch System (SLS), but SLS availability before 2025 is not clear. The mission is doing very well otherwise, and is well into the process of building hardware.

A Small Innovative Missions for Planetary Exploration (SIMPLEx) mission, the CubeSat Particle Aggregation and Collision Experiment (Q-PACE), will launch on Virgin Orbit's LauncherOne vehicle, possibly as soon as 30 September. The LunaH-Map orbiter, a lunar hydrogen mapper, is scheduled to launch on the Artemis-1 flight, no later than November 2021. In continuing progress for the Mars Sample Return (MSR) initiative, a Memorandum of Understanding (MOU) has been approved between the US and the European Space Agency (ESA), and the new MSR Program Office Director held a review of the MSR Program. As a result, a separate MSR Program Lead will be established at the Jet Propulsion Laboratory (JPL). Dr. Michael Meyer will serve as Lead and Chief Scientist for the Mars Exploration Program (MEP) and MSR Program at Headquarters. The Perseverance phase E leg will remain under MEP, reporting to the Mars Program Manager. The MSR Program will end with the initial containment of samples on the Mars surface, after which responsibility goes back to MEP. MSR continues to work toward two launches in 2026.

In preparation for the New Frontiers 5 Announcement of Opportunity (AO), PSD is looking for more community engagement as it develops the AO, to be released in Fall 2022. The SIMPLEx-3 AO is scheduled for no earlier than April 2021, and is facing budget challenges. The Discovery 2019 program remains on schedule. In preparation for the next Planetary Decadal Survey, the Committee on Astrobiology and Planetary Sciences (CAPS) has produced a report on potential destinations for New Frontiers 5. The report recommended retaining Enceladus in Ocean Worlds; removing Titan from Ocean Worlds due to the Dragonfly selection; removing the Trojan tour and rendezvous due to Lucy; removing the Io Observer if the Io Volcano Observer (IVO) is selected in Discovery in the current competition; and retaining the Lunar Geophysical Network. Dr. Glaze noted that SMD places great weight on the CAPS report and its role in the Decadal Survey process; there will be a community announcement coming soon.

The Office of the Inspector General (OIG) has been conducting an audit of the PSD science portfolio; it has already covered the Earth Science and Heliophysics Division, and is close to finalizing their report for PSD. The PAC will be briefed on the OIG's recommendations and the PSD response. In Research and Analysis (R&A), PSD is considering a provision of funds for grant augmentation in response to the COVID crisis. The Division is looking to have a fixed pot of money, which will have to come at the expense of other things. PSD is also piloting dual anonymous peer review (DAPR) in the upcoming Habitable Worlds selections; is undertaking an effort to raise Astrobiology's profile by interfacing with other divisions across NASA; and is defining and implementing a digital communications strategy, including highlighting individual faces and stories at NASA.

SMD is in the process of formalizing a Science Definition Team (SDT) to define science objectives for the Artemis III mission, to be chaired by Human Landing Systems (HLS) Lead, Dr. Renee Weber, at Marshall Space Flight Center. This is a short turnaround activity to provide immediate input to the requirements definitions for Artemis III, which will rely heavily on existing community documents, such as those produced by the Lunar Exploration Analysis Group (LEAG). In addition, SMD will release a public call for very short white papers (1–2pp), focused on science that can be accomplished with humans at the lunar South Pole. Papers are due 31 August.

Drs. Robin Canup and Phillip Christensen have been announced as co-chairs for the upcoming Decadal Survey on Planetary Science and Astrobiology. Eleven Planetary Mission Concept Studies (PMCS) were submitted to NASEM, including SDT reports for missions such as Venera-D (Venus), Ice Giants, and Europa Lander. New Terms of Reference (TOR) activities for the Assessment/Analysis Groups (AGs) have been completed, after having made some small changes to Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM), due to its responsibilities for sample allocation. The new Mercury Exploration Analysis Group (MExAG) has also been stood up. There will be several AG meetings coming up in Fall/Winter 2020.

Dr. Glaze addressed a number of PAC findings from its March 2020 meeting, and PSD's response to them. Regarding Finding 1 on the issue of the Europa Clipper LV, Dr. Glaze said that PSD shares PAC's concerns. PSD understands that there is a great risk of LV cost growth, and has been having many conversations with the Human Exploration and Operations Mission Directorate (HEOMD) on the issues surrounding the compatibility of Clipper with SLS, despite the Congressional mandate to use SLS. PSD is also considering an expendable LV (ELV) for Clipper. As to Finding 2 on the New Frontiers program, PSD recognizes that while methodologies were varied, the New Frontiers 4 call was written around the science objectives only; PSD expects use a similar approach for New Frontiers 5. Responding to Finding 3 on the Nancy Roman Telescope (formerly the Wide Field Infrared Space Telescope; WFIRST), PSD notes that there had been a concern about removing the moving-target tracking capability, but that the Roman telescope has been firmly capped at \$3.2B; the WFIRST Independent Engineering and Technical Review (WIETR) had exhaustively covered the reasons for this cap. In addition, a Solar System Working Group determined that little scientific gain would be accrued by simply restoring the tracking capability—it is a much bigger issue that remains under discussion in the community and at NASA.

Regarding Finding 4 on the Internal Scientist Funding Model (ISFM), Dr. Glaze noted that NASA has carried out the first external independent review on ISFM, which was largely positive. PSD is still digesting the results and will provide an overall summary to PAC soon. She noted that there had been, however, a substantial reduction in proposals from Centers. As to Finding 5 on the Planetary Data Ecosystem, SMD and PSD are highly supportive of improving data discoverability, and are seeking feedback from the community on how to do this. NASA is also setting up an independent review to provide actionable recommendations for PSD's long-term planning in this area.

Dr. Amy Mainzer asked whether the NASEM was incorporating findings on Diversity and Inclusion (D&I) for the next Planetary Decadal. Dr. Glaze said that APD is going through their own Decadal Survey process and it is obvious that an approach to D&I remains a struggle to define. PSD is trying to figure out what kind of questions to ask on the subject that will have SMD-wide relevance. Asked what sort of science objectives (lunar samples, e.g.) are being considered for the lunar program, Dr. Glaze said that currently, the real effort is in hardware and mass requirements; there will be a call for this information by the end of the week. She advised that interested parties contact Dr. Sarah Noble with additional questions on lunar science. Dr. Britney Schmidt asked how COVID-related award extensions would be funded. Dr. Glaze said the intent is that awards will be supported on existing grants in the program lines, to the tune of about 10–20% of funding for new research (R&A) awards. It's a trade in order to balance opportunities and retain young scientists. Asked if there were any plans to have members

of the Decadal Survey community undergo bias training, Dr. Glaze noted that this would be an appropriate question for the NAS's Dr. David Smith, as the Survey must remain an independent process; it's a good question and a great idea.

PSD Research & Analysis Status

Dr. Stephen Rinehart presented an R&A update. All of the ROSES19 applications are in. Overall statistics- (slide). Planetary Science and Technology from Analog Research (PSTAR) will not be solicited in ROSES20, and Habitable Worlds (HW) will not be solicited in ROSES 21. DAPR will be the pilot effort for HW, but not in ROSES 21. PSD will apply DAPR to all the Data Analysis Programs (DAPs) in ROSES 21. ICAR announcements will be made in the Fall (Slide).

Selection rates are generally low. Solar System Workings (SSW) is particularly low this year, (but all PSD programs have these challenges). Among the reasons behind the selection rates are: the average requested budget has risen by 40% in the last five years, while the total number of proposals has also risen. The total budget request for SSW has risen from \$125M/year to \$192M/year, a 53% increase. Selection rates have hovered around 20% (until this year), maintained only by extraordinary effort (such as borrowing against the future), and in addition, FY19 and 20 took more than \$10M hits in the final budgets. Nobody is happy about it, but PSD can no longer borrow from future, particularly in this era of uncertainty. Dr. Rinehart felt strongly that it would be critical to establish a long-term, sustainable R&A program, based on community guidance, particularly as PSD needs to reduce the outyear "mortgages." He added that Dr. Glaze had been extremely supportive in protecting R&A as much as possible, as PSD works to reverse R&A trends in future budgets.

In responding to the COVID crisis, PSD will continue to cooperate with mandatory work-at-home policies, and with challenges at home such as eldercare, childcare, and the additional stress and anxiety that family responsibilities overlaid on work regimens. In this area, R&A has been doing a remarkable job. All reviews are being done virtually, and largely successfully. Most Program Officers (POs) and reviewers seem to like the virtual approach very well, and have found it easier to recruit reviewers under this regimen. The virtual approach has also translated to reduced costs for running reviews, and reduced carbon footprints. PSD plans to continue virtual reviews for a significant fraction of programs even post-COVID, and this will be true across all of SMD. SMD will have a call opening in October for augmentations to existing awards meant to help with COVID-related issues; top priorities will be: students and postdocs, followed by early-career and soft money folks, and then everyone else. SMD has decided that funding will be coming out of R&A funds for new awards (beginning with ROSES 20), in order to ensure that there will be a well-defined pot of funds. Dr. Rinehart strongly encouraged anyone interested in augmentations to apply for them ASAP.

PSD is developing a Planetary Facilities call in order to address equipment that will be needed for sample return tasks and for other planetary science objectives and has brought in Aaron Burton to support this effort. While there is not enough funding in R&A to support a new \$10 to \$15M program, PSD will be advocating for overguides, with plans to roll out quickly should the money appear. PSD is also rolling back changes that had been made to the Planetary Major Equipment and Facilities (PMEF) call to essentially keep it as it was and has planned future year budgets to provide a better and more stable funding line for PMEF. All white papers have been received for addressing gaps in requests for information (RFIs), and a list of recommendations is being put together for SMD; Dr. Rinehart said that more information on these recommendations would be available at the next PAC meeting.

PSD is planning to implement a No Due Date (NoDD) Program within R&A. The National Science Foundation (NSF) does this, outside of the Astronomy and Astrophysics Program, as does the Department of Energy (DOE) and several other Agencies. Some advantages of a NoDD approach are: NoDD could address the COVID problem, which has resulted in many requests to shift due dates. Even with the

requested shifts, people have missed them. Second, the workload for Program Scientists has been even more stressed by COVID. Third, NoDD can help with budget flexibility, as changes in budget can disproportionately affect late-year programs. Fourth, submissions from small institutions can be helped; and fifth, NoDD can help to reduce proposal pressure, and have a beneficial effect on selection rates. Thus in ROSES21, PSD is planning to run some programs with no due dates. The details of implementation are being worked out now; seven programs are being explored as potential candidates for NoDD, including Exobiology, PDART, and SSW. All NoDD programs would have at least one review per year. For large programs, panels may need to be broader in scope, and PSD may need to work with reviewers more carefully to avoid conflicts up front. More care will also be needed in managing individual budgets, therefore there will be a one-year moratorium on the resubmission of a proposal. It is expected that the average time to notification will not change, but that some individual proposers may have a long wait.

Anticipated benefits for Principal Investigators are: provision of relief as COVID challenges (or challenges from other events such as natural disasters, illnesses, etc.) continue to arise; separation of inspiration from proposal cycles; PSD flexibility to respond when there is urgency; and removal of concerns about conflicting due dates. Benefits for PSD include allowing POs to spread out their workloads over the year, to better manage commitments to multiple programs; spreading out funding needs more evenly over the year, perhaps allowing for more risk acceptance; and anecdotally, the quality of proposals has been seen to increase under NoDD. Dr. Rinehart welcomed feedback from PAC and the community as soon as possible.

In PSD's consultations with NSF on the adoption of NoDD, NSF reported significant reductions in proposal pressure (20–50%). Anecdotally, increases in proposals from small institutions have been seen. Most PIs have had positive responses, as have POs. Possible down sides for PIs are that some people simply won't like the change, and unlucky timing could result in longer wait times for some PIs. Communication will be key here, to keep expectations reasonable. The down side for POs include concern for budget availability, and additional diligence required for recruiting reviewers, the latter of which may result in additional work load for POs (in anecdotal reports, this outcome appears to be 5% or less). Many POs say that the flexibility is worth the workload down side. PSD has just established a Implementation Working Group, and anticipates being ready to roll out NoDD with the ROSES21 call.

PSD is also in the process of carrying out its first review of the Planetary ISFM. Overall, reactions have been positive, but some challenges have been noted in the initial organization of the model. Early takeaways regarding its effects on programmatic have been largely around the management of the funds by some of the individual ISFMs. Last year's government shutdown, and this year's COVID impact, have also led to challenges in timely burn-down of available funds. However, fewer proposals are being received from Centers, and more participation is being seen in panels and other forms of community service. Compared with 2010–16, the past two years have seen reduction in the number of proposals from Ames Research Center (ARC) by 19%, from Goddard Space Flight Center by 24%, and from Johnson Space Center by 37%. An analysis of FY19 is coming soon. The target was a 10% reduction in Center proposals, and it is fantastic that the numbers are in fact larger. Across all SMD, Divisions are getting comparable numbers. It is expected that these numbers will go up somewhat this year, and perhaps through FY21. NASA expects to select new ISFMs in FY22, so Center scientists will need to prepare. Simultaneously, PSD and NASA have been looking hard at how to improve Diversity, Inclusion and Equity (DI&E). While the subject remains uncomfortable for some, PSD continue to treat it as a major topic, which is also reflected in PSD's newest hires.

Dr. Rhonda Stroud asked if there would still be notices of intent (NOIs) for NoDD programs. Dr. Rinehart thought it would be wise to have NOIs to identify conflicts, but that PSD would still have to think about how it all plays out. The apple cart has been upturned, and NASA needs to make changes to

help the community. To do so, PSD will have to throw out assumptions out and think about all of the implications. Dr. Chris German commented that, given the expectation that proposal pressure goes down, it might mean that R&A won't get increases in the future. Dr. Rinehart noted that as these changes are internal to NASA, he didn't see that as a real risk. At higher levels, he didn't think there was a discussion. Dr. Glaze commented that so far, increasing selection rates have not affected R&A total budgets, especially since the NAS weighs in heavily on the importance of R&A. Dr. Rinehart said that the real issue is providing community members the flexibility to get proposals submitted. Dr. Mainzer asked if it were possible to get a magnitude of the budget "mortgage" to the outyears. Dr. Rinehart said while he doesn't have an exact figure, probably around \$10M of next year's R&A budget has liens against it; the question is: will PSD have to do this every year? There are a whole bunch of programs that need more money. It's going to be an ongoing issue, and PSD will have to do things differently. Dr. Francis McCubbin asked: what would the selection rates have been if PSD had not borrowed money from outyears? Dr. Rinehart felt there would have been a slow slide in selection rates, about a 10% reduction in the number of selections each year. He said R&A can always do better with more money, but if proposers continue to ask for more money per grant, the selection rate will keep going down.

PSD Equity and Diversity

Meagan Thompson gave an update on PSD's efforts on improving DI&E, specifically as it relates to Black, Indigenous, and People of Color (BIPOC) communities. PSD wants to lean forward on addressing the issue, but remains open to criticism and correction. NASA already has a rich history in DI&E within PSD and across SMD. However, racism towards BIPOC is a reality, and science is not above it. None of this is news; the problem has been called out by many over the last months, and requires a different approach. Scientists and civil servants are representatives of their communities: gatekeepers, policy and rule makers, and setters of priorities. It is necessary to think proactively about being intersectional. The first thing is to recognize that racism is fractal, planted as seeds in the human mind, shaping concepts of legitimacy. Being anti-racist means confronting racism wherever it exists, beyond traditional outreach issues. The first step at Headquarters has been the establishment of training exercises in an effort to understand the issues, and identify inherent biases.

External communication and engagement are also under way via virtual seminars with MSIs, etc. NASA leadership is engaged in coordinating efforts, opening the conversation, and finding solutions. DI&E is a living problem and in a state of flux. PSD needs external ideas, and is asking PAC for specific recommendations. Dr. Glaze noted that PSD wants to work with others and share information, and consider new ideas. Dr. Stroud thought that a PAC Working Group on the subject would be timely, and asked if PSD had looked at processes to connect Historically Black Colleges and Universities (HBCUs) more directly to NASA, to get students more connected to scientists in R&A. Thompson said that the effort is really just starting, and that PSD is open to ideas.

Planetary Science and Astrobiology Decadal Survey Update

Dr. David Smith, NASEM Senior Program Officer, gave an update on the Planetary Science and Astrobiology Decadal Survey process. Co-chairs were appointed in May, and NASEM is now in the process of identifying committee members and getting them appointed. The Statement of Task can be accessed on the Decadal Survey (DS) website [<https://www.nas.edu/planetarydecadal>], outlining what NASA and NSF want the DS committee to do. The website contains other information like scope, considerations, approach, and suggestions to help the process along. As was the case with the previous Survey, this report will provide an overview of relevant disciplines, a broad survey of the current state of knowledge, and identification and ranking of (but not recommendations for) a variety of small to large missions. What is notably different this time: the Survey will give a higher profile to astrobiology and planetary defense; recommend activities that are clearly traceable to goals and objectives; give more prominence to decisions rules to accommodate significant deviations in budget; give a higher profile to human exploration; contain a discussion of multidisciplinary collaboration; and provide consideration of

issues relevant to the state of the profession. The co-chairs decided that the report would be organized around cross-cutting science themes and priority questions, thus there will not be individual chapters devoted to planetary bodies. The model for the new Decadal Survey will be based on the cross-cutting themes that were published in Table 3.1 in the previous Survey, *Vision and Voyages*. The Survey will draft its version of Table 3.1 very early in the deliberation process, so that it can be viewed by the community. Greater prominence will be given to engaging early-career professionals. NASEM has already held three events to discuss these issues, the content of which is also available on line at the NASEM website. The deadline for public nominations for the Survey committee (347 nominations, 300 unique) was 1 May. Deadlines for science and mission white papers were staggered; the deadline for all remaining white papers is 15 September. Steering Group members will be appointed throughout August and September. Panel members will be appointed in September. The Survey will be published in the late first quarter of 2022. The dissemination period, and the NASA contract, will run through 2023.

The Decadal Survey process, as currently envisioned, will determine cross-cutting themes and priority questions; identify promising additional concepts being studied by design centers at the Committee's request; assess how progress might be made in addressing priority questions over the next decade; assess all mission studies; identify the most promising concepts that are being assessed for cost and technical realism by contractor; assess results from contractor studies and determine priority missions. After a period of report review, and final adjudication and report approval, NASEM will release the report by roughly March 2022.

Nominees are identified and reviewed in a multi-step process. To date, the NASEM has identified 19 individuals who are ready to serve, and started the paperwork that will pass through the Space Studies Board to the NASEM Executive Office, after which final appointments will be made. The Academies will weigh factors such as geographical site, range of expertise for the task, and balance of perspectives, with a close look at diversity. Dr. Aki Roberge asked Dr. Smith to elaborate on how Planetary will handle state-of-the-profession issues. Dr. Smith said he could not discuss the subject yet; it is a matter for the Steering Group. Dr. Roberge said she would urge Planetary to take state-of-the-profession papers seriously and give them as much consideration as scientific papers. Dr. Smith agreed that this was a sound approach, and said there are typically subsets of reviewers tasked with looking at particular topics. The final adjudication process will also look at any gaps in every item that is a part of the Statement of Task. There are also other studies on the diversity of PIs—these will go on in parallel with the Survey—it is expected that these studies will end earlier than the Survey itself, and will be available for coordination. Dr. Hurley asked if there would be opportunities for the community to interact with panels, beyond those associated with white papers. Dr. Smith said, yes, members of the community will be invited to give presentations to address all manner of questions downstream. All information-gathering meetings will be open-forum. The only closed meetings are the deliberative ones for reaching conclusions and recommendations.

Mars Exploration Program

Mr. Jim Watzin presented, noted that summer has been a busy one for Mars, with a United Arab Emirates (UAE) launch of its Hope reconnaissance orbiter (19 July), a big first for the UAE. Hope will probe the Mars atmosphere in many different wavelengths, and will bring interesting science to the table. On 23 July, China launched Tianwen-1 to Mars, a lander/rover and reconnaissance orbiter mission. NASA's Perseverance launched on 30 July from Cape Canaveral. All these missions were launched in challenging times, yet all went very well. Preparing for Perseverance was quite an undertaking at the Cape. In January, the flight articles were shipped to the Cape by air, and other hardware was trucked in. When COVID hit in March, NASA switched to almost entirely virtual work, and had to re-plan operations cadence and techniques, as well as increase the working space to support social distancing requirements. NASA provided aircraft to transport teams. Mr. Watzin offered kudos to the entire team for doing a tremendous job in executing a flawless launch. Perseverance performed its first trajectory control maneuver on 14 August, and at the end of the winter will do the remaining corrections. The rover team is

now focusing on readiness drills to support Entry, Descent and Landing (EDL) at Mars, and commissioning the rover for operations on the Mars surface. The process is well on track; progress can be seen at [eyes.nasa.gov/apps/orrery/#/sc_perseverance].

The Interior Exploration using Seismic Investigations, Geodesy and Heat Transport, (InSIGHT) probe on Mars has catalogued more than 500 events, some of which were major seismic events, and is providing details on surface and magnetic measurements, while accumulating a detailed set of weather data (pressure, temp. and wind). Issues with the “mole” continue. The team is trying to recover its utility; the last activity will be to cover the mole with regolith and continue to try to hammer to a 3- to 5-meter depth. In summary, Perseverance is healthy and on a stable cruise to Mars, and MEP is moving ahead with MSR activities, and continuing to explore potential implementation models for a Mars Ice Mapper (MIM) mission. COVID has affected how MEP works, but not how well it works. MEP continues to be healthy and productive.

Dr. Michael Meyer presented science aspects of the Mars program. The Mars Architecture Strategy Working Group (MASWG) has produced a preliminary report, which it hopes to submit by late August/early September. A white paper containing key findings has been submitted to the Decadal process, just one of over 70 white papers that have been submitted. A NASA/ESA Mars Sample Return Planning Group was established in June of this year to address science and curation planning questions for analyzing samples returned to Earth from Mars.

The Mars Curiosity Rover continues its work, and celebrated its 8th anniversary on Mars on 6 August. The latest drilling sample at Gale Crater was taken at the beginning of August at the “Mary Anning” site; its color (yellow) is a little different, and may mark the last opportunity to drill into a major clay deposit. Currently, the sample is being assayed for organic compounds. The Mars Reconnaissance Orbiter (MRO) imaged a regional dust storm, which showed details of warming and upwelling/downwelling, and heating/cooling events in the atmosphere as the dust storm formed and traveled through the latitudes. MRO also saw some dust storm effects on the planet’s polar vortices.

MRO undertook a Context Imager (CTX) South Polar Residual Cap campaign, the goal of which is to get a full CTX mosaic of the south polar region in southern spring, to see what the differences are. This campaign, begun in 2007 and continuing through the present, has observed that in years following dust storms, the polar cap seems brighter. The current theory is that dust storms “clean” out carbon dioxide from the polar cap. Mars Odyssey (ODY) has provided some thermal observations of the Mars satellite, Phobos. In addition to its communication relay duties, the Mars Atmosphere and Volatile Evolution (MAVEN) orbiter has uncovered the structure of global electric currents at Mars. The inferred currents have been observed to couple the solar wind with the planetary atmosphere, one of the factors thought to be driving atmospheric escape at Mars. MAVEN has also revealed global wind patterns in Mars’ upper atmosphere. The wind structure seems to persist through the seasons, and reflects the nature of major surface features.

Perseverance is on its way to Mars, where it will explore Mars for signs of potential habitability at Jezero Crater, which has features of a delta deposit that contains smectite, magnesium carbonate, and olivine. The rover will also be caching samples for future retrieval and return to Earth. MSR challenges will include protecting the samples from terrestrial contamination, and protecting Earth from the samples. The MSR architecture includes a fetch rover that will bring samples to a Mars Ascent Vehicle (MAV). In preparation for the science, the MSR Science Planning Group is working to develop a number of guiding principles such as transparency, science maximization, and sample accessibility. A second Planning Group has been formed: diverse group of 29 people who will look at a Science Plan for the NASA/ESA effort, how to define interfaces, organizational relationships and communications pathways, and technical issues related to the science of MSR and how implementation impacts these questions. The Planning

Group will also develop high level requirements for a Sample Receiving Facility (SRF), and a list of key decision points. The group has an ambitious timeline, and aims to finalize its task in Spring 2021. There have been four teleconference meetings thus far, assigning people to focus groups, and the group will continue to meet regularly.

Dr. Britney Schmidt asked about the status of the Mars Ice Mapper (MIM) mission. Mr. Watzin said that MEP is continuing to pursue discussions with interested parties on implementing this mission. MIM is an exploration initiative, still in its exploratory stages, it is but moving ahead. The goal is to have a plan by the end of this calendar year. Dr. Justin Filiberto asked for a definition of “adequate funding” in the case of various Mars projects under consideration. Mr. Watzin said that the MEP considered them case by case, and was generally able to get close to each project for their funding requests.

Mars Sample Return

Dr. Jeffrey Gramling gave a presentation on the development of an architecture supporting MSR. As early as 2026, there will be one ESA and one NASA launch to Mars. The NASA launch will contain the capture modules. In 2026, NASA will also launch a sample retriever lander with a sample fetch rover and a MAV. MAV will take the samples to orbit around Mars, which will be rendezvoused with the sample return/Earth return vehicle. In progress to date, NASA conducted an Acquisition Strategy Meeting (ASM) in July 2019, and ESA obtained approval for MSR at its November 2019 Ministerial Council meeting. MSR is part of the President’s Budget Request (PBR) for FY2021. MSR architecture elements began with the M2020/Perseverance launch, which is carrying returnable sample tubes. There is an MSR Program Director at Headquarters, while system-level Project and Program offices are distributed across NASA Centers. ESA is responsible for the Earth Return Orbiter (ERO) Project (within which there is the capture and containment module, and Earth return module, both of which in turn are distributed across NASA Centers). Samples are scheduled for return by 2031. The Sample Retrieval Lander (SRL) is being planned to avoid the winter and global dust storm seasons, enabling an all-solar-powered SRL. The ERO will perform double duty as a communications relay asset, and will function as a part of the Earth return system.

Dr. Gramling described aspects of the Sample Retriever Lander, in comparison to Perseverance: the SRL has no science payload, but does have precision landing capability (part of Perseverance heritage). It has simpler operations activities (similar to those of InSIGHT). SRL is stationary, and upon landing will await the ESA fetch rover. A Capture, Containment and Return System (CCRS) will help “break the chain” for Planetary Protection requirements; its key function is to rendezvous with, and capture, the Orbiting Sample (OS) that is taken to orbit by the MAV. MSR will have its first Mission Concept Review (MCR) in Fall, followed closely by NASA KDP-A in late 2020. The near-term plan is to complete the NASA/ESA MOU to its final signature by the end of August. SMD has chartered an Independent Review Board (IRB) to review cost and schedule: this is an eight-week activity that began on 17 August, to be completed by MCR in mid-October, with KDP-A expected in mid-November. Dr. Schmidt asked for clarification on the goals of the review, and the timeframe. Dr. Gramling said the goals of the review are to ensure a firm technical foundation, and to look at the cost and schedule that is being proposed, to determine if MSR has the resources it will need to execute a successful mission. The eight-week timeline was the same that was used to good effect for the WIETR. Dr. Schmidt asked if there were a plan to have CAPS or another NASEM board to review those results, as this mission occurs between the Decadals. Dr. Glaze said that as of now, there is not an intent to do that, but that PSD could step back and think about it. The intent is to get the independent review as described in the presentation. Dr. Glaze took the point, but indicated that the NASEM will receive this IRB information, and there will be a published report.

Lunar Program

Dr. Brad Bailey presented an overview of the Exploration Science Strategy and Integration Office (ESSIO) at PSD. ESSIO’s vision is to define and lead the science strategy for the Artemis and Moon to

Mars programs; integrate efforts between divisions and others; and promote a lunar economy. Recent organizational changes include the move of Mr. Steve Clarke to the position of Deputy Administrator of Aeronautics. Dr. David Burns now serves as Acting Deputy Director of ESSIO; the Office has also added Drs. Zachary Pirtle and Debra Needham. Dr. Noble remains at 30% effort in ESSIO and 70% in PSD.

The Moon enables scientific exploration as a cornerstone for Solar System science and exoplanet studies, and serves as a training ground and natural laboratory. Valuable lunar science includes the study of planetary processes and volatiles, and the impact history of the lunar surface. The Moon provides a record of the ancient Sun, and the opportunity to carry out fundamental lunar science. The Moon can also serve as a platform to study the universe.

Overall, ESSIO seeks to advance beyond the Apollo paradigm, principally by extending the reach of lunar science by building in mobility; focusing on new samples; using state-of-the-art instruments that can be placed by human astronauts; and access to cold, permanently shadowed regions (PSRs). A bold new era of human discovery will be enabled by Artemis science objectives, including investigating and mitigating exploration risks to humans. ESSIO enables science coordination with HEOMD by acting as facilitator, promoter and strategist for science at the Gateway. The first instrument planned for Gateway is the Heliophysics Environmental and Radiation Measurement Experiment Suite (HERMES), which will study the lunar radiation environment. ESSIO is coordinating SMD Division participation in Discipline Working Groups as part of its strategizing function, and is working with many individuals both internal and external to NASA, to determine the needs for lunar surface characterization, identification of potential landing sites, and mapping. ESSIO is also integrated with all the major mission directorates involved in the lunar exploration effort, and has taken over the responsibility for the Lunar Reconnaissance Orbiter (LRO), which made its 50,000th orbit this month. LRO will continue to be used to provide input for landing site characterization for Artemis and CLPS landers.

ESSIO is working with HEO to define opportunities for Artemis III and beyond, such as developing handheld, walking-stick mounted sensors, Lunar Terrain Vehicle (LTV) mounted instrumentation, lander mounted instruments, and astronaut-deployed instruments. ESSIO is also looking at what kind of science can be done from surface architecture components (e.g., Foundational Habitat). The Office is heavily involved with PSD in the tools development process, and in planning science coordination with sample return and curation efforts. COVID has delayed the Apollo Next Generation Sample Analysis Program (ANGSA), an effort to examine unsealed lunar cores from the Apollo era. ANGSA 2.0 will likely fall under PSD, when or if funds are found for execution. NASA is looking to engage the community for more ideas for ANGSA. ESSIO is holding a variety of community engagement efforts to obtain feedback from the community on lunar research. The Lunar Surface Science Workshop, a joint effort by HEOMD and SMD, is ongoing and holding monthly sessions. Workshop meetings are recorded and available online (<https://www.hou.usra.edu/meetings/lunarsurface2020>). Nearly 700 unique individuals have been involved in these virtual meetings thus far. The Workshop is focused on innovative science deliveries to the Moon; the effort is schedule-driven, and science-driven, to provide Decadal-caliber science, as well as advanced technologies that can enhance science return.

The current CLPS vendor pool includes 14 companies, including Astrobotic, SpaceX, and Lockheed Martin. There are four deliveries on contract at present, to produce 25 instruments for less than \$450M. The Payloads and Research Investigations for the Surface of the Moon (PRISM) RFI, to produce a catalog of potential instruments, was released earlier this year, and received 238 stage 1 RFI responses. PRISM Stage 2 will state the location for each delivery, and feed the manifests for Task Order deliveries from late 2023 and beyond. International partners are permitted to participate in PRISM. The next delivery locations will be Reiner Gamma, a magnetic swirl site, and Schrodinger, a young, far-side impact basin. Provisional 2022 CLPS deliveries include some major investigative areas highlighted by DS.

ESSIO will continue to support other mission directorates, carry out its MOUs with SMD and HEOMD to enable maximum utilization, and evolve capabilities for Decadal-caliber science.

VIPER Mission Update

Dr. Anthony Colaprete gave a background on the VIPER lunar mission. The last decade has brought much information on water on the Moon, but surface access is still needed to definitively determine the water cycle and distribution, and the physical states of water. VIPER models itself after terrestrial resource exploration modalities. Its PDR is planned for 26/27 August, moving toward launch in November 2023. Lunar water research will provide critical information for planetary science and exploration, such as the distribution of resources for exploration, and a theory of water. Critical observations are needed for both science and exploration: where is the water, and how much material needs to be removed to get to it? How do we measure volatiles at the human scale (meters to 10s of meters to km), and at what depth? To do this, VIPER will utilize a smart-mapping technique with a neutron spectrometer (which gives hydrogen measurements to a depth of about a meter), and with periodic drilling to minimize the number of boreholes. The technique has been demonstrated in the field, in the Mojave Desert, with a roving spectrometer. Real-time data analysis will allow smart-sampling to influence real-time decision-making for drilling.

VIPER will use spatial proxies that are used to produce resource maps and models, in order to study Ice Stability Regions (ISRs) on the lunar surface. VIPER's required measurements include a determination of water distribution across PSRs with an uncertainty of less than or equal to 50%. The rover will also characterize water and water-equivalent hydrogen at concentrations as low as 0.5%. The current integrated rover design includes side-mounted solar panels, a thermal radiator pointing at deep space; its full height, including antenna, is about 2.5 m. VIPER is a Mars Exploration Rover (MER)-class vehicle, weighing about 450 kg. Its science payload includes four instruments: Neutron Spectrometer System (NSS), Near Infrared Volatile Spectrometer System (NIRVSS), and Mass Spectrometer Observing Lunar Operations (MSolo) will be on continuously during roving. The TRIDENT percussive drill (Honeybee Robotics) will be used intermittently. The launch to the lunar South Pole is planned for late 2023, and VIPER will be delivered by Astrobotic's Griffin Lander. The mission consists of surface operations running out to 100 days, delivering data to the Planetary Data System (PDS) over a period of six months, with hibernation periods during communication blackouts. There will be science stations in each leg of the mission, as the rover characterizes regions and identifies points to drill. Candidate locations for traverse studies include the Haworth, Nobile and Shoemaker sites, which will be considered at PDR.

Planetary Defense Coordination Office (PDCO)

Dr. Kelly Fast and Mr. Lindley Johnson presented a status of the Planetary Defense Coordination Office (PDCO). Dr. Fast summarized recent activities in various surveys and at follow-up sites. The Near Earth Object (NEO) survey is going well despite various challenges in Arizona and Hawaii. The NEOWISE satellite is operating nominally, and operations are being extended for another year. With the continued closure of Kitt Peak and other observatories, however, there is significant challenge to scheduling follow-up observations. There has just recently been a major accident at the Arecibo radar station, and interruptions at the Goldstone radar facility. The number of Near-Earth asteroids (NEAs) discovered is now more than 23,000, over 2000 of which are potentially hazardous asteroids (PHAs), and 901 of which are over 1 km in size. NEA discoveries by survey are on track to exceed the number found in 2019, and represents all known NEAs, most of which are in the small range. PDCO might be hitting the capability of what current assets can discover. Only one asteroid of over 1 km diameter has been discovered this year.

Mr. Johnson noted that skywatchers have been able to view the NEOWISE comet during the month of July. NEOWISE is the first naked-eye comet in some time; there may be another comet due to brighten to

visibility in the Fall. Reporting on the current situation at Arecibo, Mr. Johnson recounted that on 10 August, a cable came out of its socket in a support tower, causing great damage to the Arecibo radar dish, taking out a section about 100 feet in length. The accident happened in the early morning, and fortunately avoided a human crew that would have been working on the dish that day. The hole will take several months to repair. The University of Central Florida, the National Science Foundation (NSF), and Arecibo are doing safety repairs first, and have yet to assess the cost of a full repair. A new klystron for the Goldstone radar facility has been installed and is in the final stages of testing; the facility should be back up this Fall, hopefully by the end of August.

Much work has been going on in planning and coordination. On 18 August, there will be a meeting of a White House Committee on space weather hazards to discuss emergency protocols, and to streamline communications in the event of a major situation. DART is progressing well and is in the integration and test phase now, after a 1.5-month COVID delay. The schedule is about six weeks behind, and the team is trying to make up time to reach a launch readiness date (LRD) in July 2021. Delivery of solar arrays is about a month behind. DART could provide an area for Lessons Learned for new technology systems; the amount of testing that was needed before delivery could have been better understood. This will be a continuing challenge for DART over the next months. The NEO Surveillance mission is finishing phase-A work and getting ready for a September Mission Readiness Review (MRR); the schedule suffered a bit from COVID delays, but it is expected to meet a KDP-E milestone later this Fall, some time in November. Technically, the project is in good shape, and mature. The biggest challenge to launch readiness will be the budget; in the PBR for FY21, PDCO takes a hit after the DART mission. PDCO is working with PSD to resolve the issue. Dr. Schmidt asked about the budget numbers for the NEO Surveillance mission. Mr. Johnson reported that right now, DART is within its projected life cycle costs, and still has some Headquarters reserve, but it will be a challenge that can affect the rest of the program. As far as the future budget goes, PDCO is actively talking with SMD, recognizing it is a Decadal Survey priority to characterize as many PHAs as possible. The tasking from Congress has never been accompanied by a concomitant appropriation, which is a large part of the shortfall problem. However, NASA has a consensus on the best way to tackle the problem that has been approved by SMD and the Academies, and is now working on the FY22 budget to address it.

GPRAMA

Dr. Michael New gave a brief overview of the newest approach to the Government Performance and Reporting Act Modernization Act (GPRAMA) process. FY20 GPRAMA Science Goals are both quantitative and qualitative. SMD has decided, in order to better support interdisciplinary goals, to change the traditional process, and re-map nine goals so that they are not obviously tied to one discipline division. Each discipline advisory committee will now take a lead on assessing certain goals. PAC will have a leading contributor position on three goals (1.1.3, 1.1.5, 1.1.7) and a supporting contributor position on three goals (1.1.1, 1.1.2, 1.1.4), with some overlap with the Astrophysics Division. Dr. New said that Meagan Thompson would be collecting inputs, and that the PAC would need to schedule an interim meeting to do the GPRAMA assessment. A subset of PAC members could be identified to hold a meeting at some time in October or November, and hold a vote. Chris German suggested ESAC be added to 1.1.5, and HPD be added to 1.1.8 and 1.1.9.? Dr. New said this change could be considered for new FY21 goals.

Discussion

Dr. Verbiscer asked Dr. Glaze about planning for the next Planetary Senior Review. Dr. Glaze, noting that the Review had been postponed a bit, said the next one will focus on InSIGHT and Juno, after which the hope is to have the remaining eligible missions to get synced up for 2022. One of the key lessons for the last review was to use the contracted independent review approach, which is what will occur for the next Review. Other topics raised for potential findings included the budget for R&A, a position on NoDD, the Europa Clipper LV, DI&E in the Decadal process, proposal risk postures in R&A, and

communication between study teams and independent contractors (an issue that plagued the last Decadal Survey).

August 18, 2020

ExoPAG

Exoplanet Analysis Group (ExoPAG) Chair, Dr. Michael Meyer, gave an update to the PAC. The ExoPAG is an interdisciplinary, community-based forum that reports to the APD, and is meant to articulate and prioritize key science objectives of Exoplanet Exploration research, and evaluate capabilities of Exoplanet missions. ExoPAG is composed of a diverse cohort, with members across disciplines; it is now in the process of bringing on liaisons to PSD and ESD (Doris Daou, and Dr. Richard Eckman), and has started a new process of developing and voting on findings at annual meetings to bring to the APD leadership. ExoPAG had its first virtual meeting in June 2020, whose agenda included the PI Launchpad, Planetary Discovery studies, ARIEL/CASE mission of opportunity (NASA/ESA), first science results from ESA's CHAracterizing ExOPlanet Satellite (CHEOPS) mission (a characterization transit mission, as opposed to a discovery mission such as TESS), James Webb Space Telescope, and the Nancy Grace Roman Telescope coronagraph instrument. The ExoPAG also heard recommendations from the EPRV initiative report, early career scientist presentations, and had discussions about institutional racism. Dr. Meyer offered examples of findings given to APD, including a finding on the utility of assembling target catalogues for future NASA missions; sharing ExoPAG reports with, as well as receiving more input from other divisions; and low selection rates that merit closer monitoring of the Exoplanet Research Program (XRP). A current status of Science Analysis Groups (SAGs) and Science Interest Groups (SIGs) was also heard. SIG2, on the subject of Exoplanet demographics, held a thematic symposium. SIG3, meant to facilitate cross-division discussions between APD ExoPAG and PSD (an example of which is the Exoplanets in Our Backyard conference), and is now trying to coordinate input into the Planetary Decadal Survey by populating a "list of lists" for paper submissions. SAG21 is studying the issue of stellar contamination, a phenomenon that can hamper transit signals. SAG22 is seeking to define the properties of priority stellar samples relevant to NASA exoplanet studies (triggered by the above finding). ExoPAG's future activities may include investigations of zodiacal dust and future ground-based high-contrast imaging initiatives. It will also revise the "Science Gap List," which will hopefully inform research calls. ExoPAG is continuing to collect community input to develop findings for discussion at the next meeting, ExoPAG 23, planned for 5–6 January 2021. ExoPAG will continue monthly telecons, review what ExoPAG can do to dismantle barriers for BIPOC, and initiate a junior scientist speaker seminar, and update its website.

Dr. Roberge raised the subject of a mentoring program, pointing to many discussions at APAC about promoting a diverse community. The ExoPAG is making this a central point of the junior scientist speakers bureau. Asked if ExoPAG would report regularly to PAC, Dr. Meyer said he would be happy to keep the lines of communication open.

CAPTEM

No presenter was available for CAPTEM.

LEAG

Dr. Samuel Lawrence, departing Lunar Exploration Analysis Group (LEAG) Chair, (Dr. Amy Fagan to succeed as Chair in September), presented. Dr. Lawrence said he would continue as Emeritus Chair, while the LEAG reorganizes to meet new challenges, and highlighted Dr. Elizabeth Frank as the new Chair of the LEAG Commercial Advisory Board. LEAG is soliciting, for the first time, a DI&E representative and an astrophysics/heliophysics liaison. Recent LEAG events of note include the participation of 1300 attendees in the all-virtual Lunar Surface Science Workshop series. LEAG also formed a Special Action Team (SAT) by request of PSD in response to some questions from the

Committee on Space Research (COSPAR), to undertake a limited (two-week) assessment of planetary protection in response, in the context of human activities in the lunar polar regions. The SAT's main finding was the inarguable need for a balance between exploration objectives, economic development, and narrow science goals. Another SAT was chartered by the Deputy Associate Administrator for Exploration (DAAX) of SMD, to assess the abilities of existing instruments towards achieving Decadal science goals in the context of a polar exploration campaign. Its final report will appear on the LEAG website.

LEAG issued an August finding on white paper deadlines, and praised the NASEM for deadline lenience due to the COVID pandemic. LEAG issued another finding on the Lunar Discovery and Exploration Program (LDEP), strongly supporting PRISM, Trailblazer, and encouraging a conversation for developing a next-generation LRO, as well as finding stating that the Artemis program will advance or even redefine Decadal Survey objectives through orbital, lander, robotic, and human exploration. LEAG explicitly calls out the value of the Artemis Base Camp—a permanent field station at the Moon's South Pole, humanity's first permanent presence on another world, a profound advance for human civilization—as being transformational for all of planetary science with a clear societal value. LEAG also noted its approval of the progress made in the VIPER program, as well as the continuing value of LRO, which vividly demonstrates that planetary scientists are trailblazers for human exploration. LEAG strongly encouraged a VIPER PS program. LEAG continues to support the Korean Pathfinder Lunar Orbiter (KPLO) PSP, and requested an update, and also welcomed the NASA Plan for Lunar Sustainability.

Findings from LEAG Commercial Advisory Board (CAB) include the following:

C1—The CAB supports an integrated campaign approach to lunar exploration, including prospecting, orbiters, surface science, and sample return.

C2—The CAB finds that a sustainable cis-lunar economy requires sustaining CLPS providers and other companies that are building up internal infrastructure, staff, and institutional knowledge. NASA can address this by expanding the number of funding opportunities available to commercial companies across all NASA directorates (this finding includes implementation suggestions).

LEAG 2020 will be held 14–16 September; its theme will be Value of Sustained Human Presence at the Artemis Base Camp. LEAG will be trying some innovations to make the virtual meeting more engaging. A Program Officer for KPLO noted that the PSP program had been held up briefly in review, after it was found that there might be major changes to mission. The review process has now restarted and selections should be made by the end of the calendar year. The PIs have been updated with relevant information.

MAPSIT

Dr. Brad Thomson gave the briefing in Dr. Jani Radebaugh's stead, to provide an update on the Mapping and Planetary Spatial Infrastructure Team (MAPSIT). The main activity of late has been the submission of a white paper to the Decadal Survey describing strategic priorities for Planetary Spatial Data Infrastructure (PSDI). Spatial data contributes to NASA endeavors if they are correctly acquired, accessible and usable. PSDI is a plan and a structure to provide such data. MAPSIT feels that a PSDI should be built around user needs, which influences how data should be obtained, organized and prioritized, and which technologies are necessary. As an example of what such an infrastructure could improve, Dr. Thomson noted that Mars Express had been underutilized for many years until its data were made more accessible to users.

To build a PSDI, one might envision a planet with missions past and future, and a committee of users, as explicated in a Europa case study (*Laurel, et al.*), that can help to develop a combination of policy and standards, determining what products are needed, what data exist, and how to collect and integrate new data, formats, and access. In the case of Mars Global Surveyor, for quite a while it was difficult to agree on basic concepts of geodesy; this process would have benefited from earlier community input. The next

community meeting will be held on 14 October, and will discuss PSDI plans and efforts, as well as the Planetary Data Ecosystem review that is in progress at NASA. MAPSIT is looking forward to executing its Roadmap [www.lpi.usra.edu/mapsit/roadmap/] by building PSDIs, perhaps by starting with Europa, or the Moon, as a case study. Dr. Mainzer asked if there had been an effort to get people to include mapping considerations in their proposals. Dr. Thomson said he had seen improvement, but thought that standards and policies will help; he didn't feel the current program is formalized enough—that's the charge for the Planetary Data Ecosystem (PDE) review. The concept of a data management plan in proposals has matured in the last few years, but it could be better. Dr. Verbiscer asked how PSDI and the PDE are meant to work together. Dr. Thomson said the recently announced PDE was intended to be an *ad hoc* framework of activities; PSDI and PDE encompass parallel ideas, which are similar but not the same. PDE is meant to tackle the issue in a targeted way.

Asked if there were a preferred place to archive Decadal Survey white papers, Doris Daou sent out a NAS URL to PAC members, commenting that the NAS archives all submitted white papers.

SBAG

Dr. Bonnie Buratti reported on the output of the Small Bodies Assessment Group (SBAG), and gave an accounting of Steering Committee membership, which appointed four new members for those rotating off. The SBAG has a liaison at Headquarters, Dr. Thomas Statler, as well as HEOMD liaisons. SBAG seeks broad community input on small bodies and missions to small bodies. Its Terms of Reference (TOR) include Main Belt Asteroids, Comets, Near-Earth Objects, Meteoroids, Interplanetary Dust and Meteors, Trojans (of all the planets), Centaurs, Trans-Neptunian Objects (TNOs), Dwarf Planets, small planetary satellites (including Phobos, Deimos, and the irregular satellites of the Giant Planets), and Meteorites, and returned samples from any of these objects. SBAG holds open meetings twice per year, and maintains a Goals document (recently modified). SBAG reviews and advocates for small bodies missions, such as OSIRIS-REx, and Hayabusa-2, the New Horizons extended KBO mission, NEOWISE, DART, Psyche, Lucy, and the NEO Surveillance Mission. Other missions are ESA's Hera, JAXA's Destiny+, and JAXA's MMX missions, as well as NASA's Trident, a Discovery mission downselect focused on Triton and a possible Centaur fly-by. SBAG held its last meeting in June, has supported some early career talks, and has held two workshops on Decadal Survey white papers.

SBAG issued some major findings on including Ceres as an Ocean World; a formal PSP process for international missions; and the utility of planetary radar. SBAG encouraged NASA to keep at least one radar facility operational at all times (given that at present Arecibo is damaged, and Goldstone is still off-line). SBAG, as well as LEAG, are also concerned about a lack of small bodies and lunar missions in the latest Discovery selection, and by a statement from Headquarters after the selections that these missions were not considered.

SBAG curated five broadly supported white papers for submission to the Decadal Survey, and intends to endorse a DI&E white paper. SBAG's Big Questions for the Decadal Survey are:

- What do small bodies tell us about the formation of the Solar System and the conditions in the early solar nebula?
- What do the distribution, composition, and sizes of small bodies tell us about the evolution of the Solar System, including its dynamical history, cratering processes, and the influx of volatiles and organics into the inner Solar System?
- Do sustainable habitable environments exist on any of the small bodies?
- What are the main geological processes that determined the evolution and current state of the small bodies and are they similar to those on larger bodies?
- What threat do Near-Earth Objects pose to civilization and life on Earth, and how can we quantify and mitigate that threat?

The five main white papers reflect these questions.

In addition to the curated papers, SBAG considered a portfolio of objects through a SBAG-led questionnaire, to which 121 people responded; the highest priority Flagship mission to be identified through this exercise was a comet sample return. Dr. Buratti noted that findings were based on community input, wherein SBAG tries to emphasize persistent problems that need attention at the highest level. Asked whether SBAG consider cold vs. ambient return for its high-priority comet sample return mission, Dr. Buratti indicated that this was so: a cold return would be a Flagship-class mission, and an ambient return would be a New Frontiers-class mission. The next SBAG meeting will take place 26–27 January, 2021.

MExAG

Dr. Steven Hauck II, the Mercury Exploration Analysis Group (MExAG) Chair, noted that this was the first presentation for MExAG as a formal AG, which was created in response to a February 2018 PAC finding. The AG attracted strong interest, with 28 nominations for 9 positions. The final membership represents a range of institutions. Near-term priorities for MExAG are providing support for Decadal Survey white papers; building the MExAG community through a Communications Working Group; preparing for the first MExAG annual meeting; and development of the first Goals document through an Operations Working Group. Efforts are currently focused on building the machinery for an active and sustainable AG. A recent review of white papers reveals six that are clearly Mercury-focused, and an additional 37 include some discussion of Mercury. MExAG notes that a holistic approach is essential when developing an exploration strategy, as opposed to a “keyword search” approach. Next issue—how do we build and sustain the community. As a new group, MExAG is focused on an equitable, diverse, inclusive, and sustainable approach to serving the needs of the community and NASA. Among the AG’s first actions were to become an engaged participant in the NASA Equity, Diversity and Inclusion Working Group (EDIWG), and creating a code of conduct for the Steering Committee, including accountability mechanisms, through a Steering Committee Code of Conduct Working Group (CoCWG). This CoCWG will serve as a jumping off point for the new MExAG. Upcoming Mercury events include the Europlanet Science Congress in September; MESSENGER to BepiColombo session at the 2020 American Geophysical Union (AGU) meeting. Mercury 2021 has been rescheduled for June 2021, and already has 93 registrants. The first annual MExAG meeting is yet to be scheduled. A final report on a Planetary Mission Concept Study (PMCS) for a Mercury lander was submitted in early August, addressing a full Mercury year of surface operations (88 days), with a cost estimate in the New Frontiers range. Early MExAG observations include an expression of concern for low funding rates in Solar System Working from ROSES19, as these low selection rates disproportionately impact small communities like the Mercury community. Asked if there were a PSP for the BepiColombo mission, a PSD Program Officer commented that ESA ran its own program, which is not an official NASA PSP; however, three US investigators were selected and will be funded by NASA. There may be another ESA call for guest investigators as BepiColombo approaches its target in late 2025.

OPAG

Dr. Jeffrey Moore gave an update on the Outer Planets Analysis Group (OPAG), essentially a comparative planetology group, and introduced members of the Steering Committee. OPAG’s charter is to be NASA’s community-based forum for planning and prioritizing OP exploration over the next several decades. OPAG documents serve as input to Decadal Survey; OPAG and SBAG “co-own” the Pluto system. In February of this year, OPAG held a joint meeting with the Venus Exploration Analysis Group (VEXAG) and ExoPAG, which Dr. Moore said he found exceptionally helpful. OPAG is now investigating having a Town Hall meeting at the December AGU. OPAG meets twice a year; at its next meeting in September, OPAG will receive a Headquarters briefing on PSD, a Planetary Decadal Survey update, and will hold a white paper discussion, including PMCSs on a Neptune-Triton mission; an Ice Giant pre-Decadal Study; Pluto Orbiter mission; a KBO Exploration mission study; and a Europa Lander

mission study. On the last day, OPAG will discuss Io Volcano Observer (IVO) and CAPS-recommended mission concepts; Dr. Alan Stern's Planetary Protection Independent Review Board (PPIRB) report, and data analysis programs. Dr. Moore strongly encouraged PAC to interface with the EDIWG leaders, Drs. Richey and Milazzo.

Some recent key activities in the Outer Planets theme are: IVO was selected for further study in Discovery, as well as Trident; Juno completed its 28th orbit of Jupiter; and Europa Clipper completed its PDR. The New Frontiers program continues to be very good for exploration, as evidenced by the Juno and New Horizons missions. OPAG has also produced a white paper targeted to the next Decadal Survey that is organized around big questions, including a cross-divisional theme. The paper contains a strong statement on importance of R&A and international partnerships, and enabling technologies, and an updated diversity statement. White paper conclusions about large directed missions include support for a completed Europa Clipper mission, a new start for an Ice Giants mission (Neptune preferred), as no new technology efforts needed in the latter case. OPAG supports a new start for Ocean Worlds mission in the second half of decade, such as a search for biosignatures at Europa or Enceladus, supports opening competition to all Solar System destinations, as recommended by the NASEM in 2008, and supports inclusion of Enceladus and Titan. All of this is wrapped up in a proposed timeline for a robust Outer Planets Program spanning three decades. Preliminary OPAG-relevant white paper statistics are: 51 on giant planets, and 61 on outer worlds and small bodies. Dr. Mainzer asked how a Europa Lander might fit into the proposed timeline. Dr. Moore said that he hoped that the Decadal Survey considers the proposal and includes the possibility in its architecture, however it is up to the Academies to decide. OPAG concerns about the Participating Scientist Program are aired in some of the papers that have been submitted to the NASEM website. OPAG has never been pleased with the PSP, as it always seems small, and would like to see improvements.

VEXAG

Dr. Darby Dyar, Chair of the VEXAG, presented an update. She reported that the AG was happy to welcome a new *ex officio* member, Dr. Megan Ansdell of NASA Headquarters, but was sad to see Dr. Adriana Ocampo leave. The Venus community at present can be described as happy but exhausted. A new 6-month rotation has been established for VEXAG, with the goal of having 30% early-career members on the AG Steering Committee at all times. The AG would also like Headquarters to think about a formal succession plan for Chairs, and is also trying to formalize what the VEXAG does by populating a schedule and meeting once a month. VEXAG also has a number of subcommittees: Nugget Officers (bringing Venus science to the attention of the wider community), a Committee Organization Document Committee; a Working Group for the next off-season VEXAG meeting in 2021, which is essentially an "Exoplanets in our Backyard 1.5" meeting, to take place at the December AGU; VeGASO, a Venus Surface Platform Study; and a newly created Venus Technology Group. The Technology Group is considering monthly or quarterly virtual seminars, possibly to be held jointly with other AGs. Other VEXAG commitments include NexSS (Nexus for Exoplanet System Science), an ExoPAG Science Interest Group, and representation on the EDIWG.

VEXAG is excited about the Deep Atmosphere Venus Investigation of Noble Gases, Chemistry and Imaging Plus (DAVINCI+) mission, a probe and an orbiter (2026-29) planned for the Goddard Space Flight Center. A decision might be made in April 2021; the prospect is keeping the Venus community very busy. The other proposed mission is Venus Emissivity, Radio Science, InSAR, Topography, & Spectroscopy (VERITAS), to study surface geology and perform radar topography (2025). Optimism is high in the overlooked Venus community. VEXAG recently completed a Flagship Mission Study, and the process has been unifying for the community. The mission design is inclusive: orbiters, smallsats, probe, balloons, and long-lived lander, with a cost target of about \$2B. New ideas came via the inclusion of scientists beyond the usual suspects.

A Venus Surface Platform Study has been written and submitted; VEXAG is now in the process of revision and is circulating the draft; the hope is to have it finalized by the next PAC meeting. The next VEXAG meeting is planned for 16–17 November. The agenda includes the VEXAG year in review, VERITAS, DAVINCI+, Envision, Venera-D, Akatsuki, and a series of lightning presentations, which are groups of small talks, six or seven minutes long, with questions at the end. Planning is also underway for VEXAG 2021 at Caltech. VEXAG white papers for the Decadal Survey are at 35 and counting. There will be a mini-Zoom conference 31 August to 3 September on the subject of Venus Science Today.

MEPAG

Dr. Aileen Yingst, Chair of the Mars Exploration Program Analysis Group (MEPAG), gave an update, pausing briefly to honor the memory of Dr. Nadine Barlow. MEPAG currently has a vacancy in the Steering Committee. Recent activities include the March 2020 release of a Goals Document, which is also associated with a white paper. The MEPAG 38th meeting was held in mid-April, where it addressed Decadal Survey preparations and Mars program architecture, with findings forwarded in a letter to the PAC. MEPAG held another virtual meeting in June where the Mars Architecture Strategy Working Group (MASWG) reported on a strategy for Mars, the nearest habitable world (i.e., what happens after MSR?). The MEPAG Steering Committee authored three white papers and endorsed white papers on crucial topics. Metrics as of 14 August include 76 papers marking Mars as a category, with eight additional having just come in. The makeup is about right, with cross-over topics, life/habitability foci, atmospheric evolution and climate, surface and geological evolution, and technology. MEPAG-authored papers include (1) a paper outlining the MEPAG Goals Document, (2) Mars as a compelling target (emphasizing the point that the MEP has proven that the way to do science is through a program—allows steady accumulation of data, allows researchers to plan ahead); and (3) Mars as a candidate for the New Frontiers. July saw a record three launches to Mars, Mars2020 Perseverance, the UAE’s Hope mission, and the Chinese Tianwen-1 probe. The community is disappointed that ExoMars has been delayed to 2023.

Regarding the FY21-25 budget, the Mars 2020/Perseverance phase E budget is short; the mission overran its development budget, but launched on time due to heroic efforts by the NASA team. Mars Odyssey has received a full year of operations funding. MRO and MAVEN are working with a reduced science budget despite good marks in the Senior Review. None of these choices is easy, but the community needs to be aware of the consequences. Congress does have a markup for ODY and to get on with MSR, but everyone expects a Continuing Resolution.

The latest MEPAG summary findings are as follows: MEPAG is excited about the ongoing technical progress in MSR, but MEPAG is concerned about the lack of transparency for MIM, and wants to understand how it fits in the Mars portfolio; therefore MEPAG is calling for a more formalized and rigorous understanding. MEPAG also notes an apparent disconnect between Senior Review rankings and subsequent funding of certain continuing Mars missions. Finding #7 applauds international missions to Mars, and encourages NASA to leverage these missions through support for PSPs. MEPAG Finding #5 concerns the fact that the Mars communications infrastructure is old, and encourages innovative solutions like smallsats and commercial ventures. Finding #6 notes good news about R&A augmentations. Dr. Schmidt asked if the MEP had provided any clarification on MIM. Dr. Yingst said not much had been addressed beyond the official finding—the main concern is about scope, and science intent. Dr. Schmidt commented that MIM seems like a submitted Discovery proposal. Dr. Glaze noted that all the discussion points were well taken. Dr. Carter said that another issue is that there are funding challenges to the MEP, raising questions about how MIM will be funded. Dr. Mainzer asked if there were a PSP for Akatsuki. Dr. Yingst said there had been, but she was not sure if it had been renewed; only a small number of people were selected for the original. Dr. Glaze noted there had in fact been two rounds of selections for Akatsuki.

Findings and Recommendations Discussion

Dr. Verbiscer enumerated potential findings, starting with NoDD and DAPR in R&A. Dr. Mainzer commented that, especially with the COVID situation, it would be critical to get proposals reviewed in a timely manner. However, beyond NoDD and DAPR, the fundamental problem is money. Dr. Schmidt asked if there were a way to shift priorities to avoid cuts to the R&A program. Dr. Rinehart said he agreed that the single biggest problem is money, but felt that DAPR and NoDD are entirely separate from the funding issue. Dr. Glaze acknowledged the funding challenges, and said she had been pushing mightily to increase funding for R&A. The amount of funding requested by the community is substantially more than is available, and it is increasing faster than the program can keep up with it. Dr. Glaze felt the PAC could help the situation by providing guidance in identifying areas where funding can be cut in order to ameliorate the R&A situation. It's a matter of prioritization—anything that needs money means cutting elsewhere. Dr. Rinehart added that PSD can easily move money within R&A, but not beyond. Dr. McCubbin asked how the proportion of funds is divided between Flight and Research in SMD. Dr. Glaze said that Congress specifies earmarked funds, such as for the Europa Clipper, apart from which is an unspecified amount of money for the rest of the program, for which NASA uses the Decadal Survey to guide prioritization. Dr. McCubbin asked if it was appropriate for the PAC to address the balance of these funds. Dr. Glaze said yes, keeping in mind the recommendations of the Decadal Survey. Dr. German asked how NASA determined its latest funding prioritization; e.g., delaying PSTAR for one year. Dr. Rinehart said he didn't know the exact decision process behind making the Planetary Science and Technology from Analog Research (PSTAR) program a biennial call, but that because selection rates had been so low, it was decided it would be better to run PSTAR every other year. These are specific program issues. Dr. Rinehart said he would welcome the PAC's discussion on how to make those value judgements.

Dr. Dana Hurley commented that it appears that selection rates for data analysis programs (DAPs) are higher than, for example, the instrument program. Is that a conscious decision by NASA, or is it a matter of not having people trained for data analysis? Dr. Rinehart said that the DAPs are funded out of mission lines, a different pool that is separate from R&A, and that the PAC should probably not comment on specific programs, due to potential conflicts of interest. Dr. Mainzer said she could agree that when selection rates are below 10%, it's not worth having a call, but beyond that, she asked what could be done to improve selection rates. Dr. Roberge commented that there should also be some thought to lowering the burden on the community in areas where there are low selection rates, making the cost/benefit ratio better when it comes to triaging proposals. Dr. Schmidt suggested PAC make a finding that states that an extra \$10M per year (that does not come out of R&A budget) could help support more scientists. The funding problem is coming to a head at a particularly bad time—the community is in flux, and there are a greater number of people vulnerable to economics, and the impact of COVID.

Dr. Roberge noted that on the APD side, in addition to science teams and PSPs, the Roman telescope mission has at least once put out a call for preparatory science as another way of giving out funding. Asked how this is different from the DAPs associated with mission lines, Dr. Roberge said these calls were broader, and could be done before the mission flies. Dr. Richey commented that it would be good to know what the ROSES21 funding pot will be. Dr. Glaze noted that the augmented call came out before COVID. Dr. McCubbin asked how many other ROSES programs were likely to see 10% selection rates. Dr. Rinehart said that some programs have seen slow declines, but because SSW is so large, it was prioritized. Some programs won't be significantly affected. The real issue is that there are no real increases in the outyears, and no one knows what the Congressional budget will look like. Dr. Glaze pointed out that Dr. Rinehart has really been digging in to the R&A program to understand the situation, and to get the program on a strong footing. Dr. Mainzer asked if partial awards could be made to grantees. Dr. Rinehart agreed that this could be done, but it is a stopgap solution, and people will need to ask for more in the future. The researcher must ask for the full funding needed to do the work. Dr. Rinehart felt it would be far better to fund five awards and do them right, rather than 10 awards that result in a half-

hearted effort. Dr. Justin Hagerty asked if the decision for NoDD marked a permanent change. Dr. Rinehart said he was seeking Directorate support for NoDD; if people don't want it, PSD won't do it. Personally, he thought NoDD would have positive effects for Program Officers and the community, across the board, and that PSD is starting the experiment because PSD thinks it will work. A meeting participant commented on his experience with NoDD at NSF: there are no cutoff dates for panels, which can lead to tremendously long wait times. He thought that could be a problem, especially for early careers. Dr. Rinehart said that none of the NoDD programs being considered is an every-other-year program. The single biggest implementation challenge will be how to figure out latency between receipt of proposal and response. Another participant commented that a rolling review schedule might help reviewers be more objective in assessing proposals (i.e., comparing them to an ideal proposal, rather than to other proposals). Dr. Rinehart added that virtual reviews can be held more often, which also helps reduce conflicts by increasing the numbers of eligible reviewers. Dr. Roberge thought NoDD was a good idea and should be tried, while Dr. Tim Lyons thought it could have real problems. Dr. Rinehart said the system in place is already biased against certain communities—at worst, the NoDD would change the bias. PSD has to try to do better than that.

Asked if the PAC would have direct involvement with the EDIWG, Dr. Filiberto noted that the chairs of the WG were on the chat, and could be tapped for a future presentation. Asked if the PAC were making efforts to improve diversity, Dr. Rinehart said that the PSD was trying, but one of the challenges to this effort is a White House memo directing the reduction of the number of committees and committee members. Next year, PAC will be soliciting members again, and he encouraged the PAC to make suggestions. Dr. Mainzer thought it might be useful to have a panel dedicated to diversity and inclusion on the Decadal. Dr. Glaze noted that once the Statement of Task has been turned over to the NASEM for the Decadal Survey, NASA must step back and allow them independence. At this point, it will be up to the Academies to decide how to incorporate DI&E. Dr. New commented that there are two other studies currently being spun off on diversity, and one on the state of the profession, but NASA is not allowed to collect the type of data valuable to diversity metrics, as yet.

Dr. Verbiscer spoke to Dr. Schmidt's previously aired points on the impact of ISFM. PAC has issued findings on ISFM to 2018, asking what the impacts are (dollars from R&A to cover ISFM? what have the contributions been to the community?). ISFM seems to be related to R&A funding problems. Dr. Rinehart said that PSD is in the middle of the review now, and noted that ISFMs were started with new money, and that the ISFMs are sharing the pain like everyone else: last year they took a significant cut across the board, and they will again next year. PSD has been seeing more panel participation, so it looks like it is getting what it wanted out of the program, but the final report is yet to be written. Asked if there were any plan to solicit input on NoDD, Dr. Rinehart said there was not; however, PSD plans to socialize NoDD long before ROSES21 comes out, maybe through some sort of an R&A virtual Town Hall associated with a major conference like AGU. Dr. McCubbin asked where one might get instrument funding above \$5M. Dr. Rinehart said that ideally, the answer would be Planetary Major Equipment and Facilities (PMEF). The real answer is nowhere. There would have to be a compelling case to fund such an instrument nothing else. A meeting participant asked if NASA would bring back the PMEF program back some time in the future. Dr. Rinehart said there would be a Facilities call, which is different from PMEF, but said he felt that PSD was getting back on track after skipping one year of PMEF.

Public Comment

No comments were noted from the meeting's audible feed. There were some questions written in the Webex chat section about encouraging diversity in the Decadal Survey panels, and asking if there were any effort to standardize diversity guidelines for the AGs. Dr. Mainzer said the PAC could support the idea of furthering the topic in future discussions with NASA, and support PSD's efforts in diversity and inclusion.

Findings and Recommendations Discussion

Dr. Hurley commented that the main issues for the PAC at present were the matters of inadequate funding in R&A lines that are not associated with missions, and potential redirection of funds. An associated issue is that there are improvements to be made to the proposal process; it may be beneficial to have more fundamental research aligned with the better-funded mission lines, which could also help to improve diversity. Dr. Stroud said that a potential problem of tying preparatory science funds to mission lines is that this may inhibit ground-breaking science. These are unintended consequences; PSD could ultimately cut off the Venus community if a Venus mission were not to be in the works. Dr. New noted that in the cases of the Lucy, Psyche, and Dragonfly missions, a preparatory science grant could have the effect of delaying money. An alternative could be a Lucy DAP, or a Discovery DAP. M2020/Perseverance and Europa Clipper were both cost-capped via negotiations with the Office of Science and Technology Policy (OSTP). Dr. Glaze commented that there is a difference between PSD and APD funding schemes in terms of preparatory science and science teams. Dr. Roberge said a preparatory science call could give a awardee a chance to do a one-off; there are places this is already happening, as in MSR. Dr. Rinehart warned that the scales of the budgets in different programs and divisions are very different. Dr. Schmidt felt that preparatory science grants were different in that they are flexible, but they won't solve the issue that there is more need than there are dollars, which leads back to re-prioritization. Can PSD talk to Flight projects and ask them to re-allocate some of their science money? Dr. Rinehart said the implication of such a move would be the slowing down of the cadence of calls. Dr. German suggested a finding or recommendation asking how PSD decides to its allocate monies. Dr. Schmidt didn't think there was an R&A program that can fix the fact that selections are going down; she felt a general finding should state that NASA find x amount of dollars (outside of the current R&A budget) to contribute to the R&A budget. Dr. Rinehart said telling NASA to "find money" would not be helpful. Dr. Schmidt felt a finding might precipitate some activity to give money to R&A; or even if that doesn't happen, it gives outside groups ammunition to use for lobbying purposes. Dr. Rinehart said that this would require a very concrete finding or recommendation. What should PSD do? Is SIMPLEX a higher priority than R&A? Should NASA pull money from small missions? Dr. Schmidt commented that it's always worth considering program balance; small cuts to big missions represent big money for R&A. Dr. Roberge said that missions are struggling with the COVID impact also. Dr. Glaze said that delaying an October SIMPLEX AO might save a little, but not much. Dr. Roberge asked: is it too late to pull back on or reduce mission concept studies to support the Planetary Decadal Survey? Dr. Glaze said that while having priorities is helpful, the issue remains the increased number of proposals, and how to feed an ever-growing community.

The PAC returned to the issue of funding R&A and discussed ways that might make existing funds go further. Dr. Glaze cited increasing the cycle time. Dr. Roberge agreed that PSD should reduce the cost and effort to propose to Headquarters. Dr. Glaze suggested triaging the science mission proposals, to winnow down the number of mission concept studies, and to reduce the cost associated with multiple mission concept studies. Dr. German thought triaging was a good way to go, and that data on relative success rates would help the PAC make a better decision on what programs could be cut. The community is not in a steady-state, and it can't recruit people if there is no real career opportunity for them. Dr. Schmidt suggested a finding to simply move \$10M into R&A, or to simply get rid of programs and let people submit proposals based on what they actually want to do. A meeting participant commented that such a move would not be helpful; PSD would have done it if it could have, and it has already scraped up the "easy money." Drs. Glaze and Rinehart agreed with this comment. Dr. Schmidt suggested delaying MSR by two years, or eliminating MIM. Dr. Glaze noted that if MIM goes away, so does the money.

Dr. Mainzer felt that the community will have to consider the relative importance of R&A, in the current COVID pandemic. Asked how the adoption of NoDD affect selection rates in other programs, Dr. Rinehart said that in some cases it doubled, and in most cases increased selection rates by about 30%. This is not the main reason for proposing NoDD, however. In addition, there has been a general

recommendation to continue virtual meetings post-COVID to increase participation in review panels, and that converting most meetings to virtual could reduce unnecessary travel and therefore cost. There is no general agreement on this, and there were some refutations by anecdote. As to grant extensions and the effect on R&A, PSD wants to make sure it doesn't create gaping holes in the pipeline. Dr. New stated that in his responsibility for dealing with extensions across SMD, there have about 120 submissions for extensions, at about \$100K per request, on average. There are three levels of priority: funding graduate students and post-docs first, soft money second, followed by everyone else. Program Officers will ultimately make the decision on what science would be lost should an extension not be obtained.

Dr. Verbiscer cited a recommendation from the Decadal mid-term assessment that called for evaluating the role of space-based astronomy through a community workshop, and asked if there were plans to do this. Dr. Rinehart recommended consulting Dr. Kelly Fast on this matter. Dr. German commented that the AGs did not seem to be bringing up the Astrobiology profile very well, and wondered if there were another way to deal with it. Dr. Glaze noted the point and asked if there should be an Astrobiology AG. Personally, she wanted to bring Astrobiology into the science community, and thought a future Chair could start to explore how the situation can be improved. Dr. Mainzer commented, in light of the MAPSIT presentation, that it sounds like there is no standardized coordinate system for the bodies NASA explores. Dr. Schmidt said that she wasn't sure standards development could be done within the AO system; however, it could come up in proposal reviews. Dr. Hagerty felt it might be helpful to have a finding on coming up with language to ensure consistency and standardization at the beginning of a mission, to facilitate more accessible products on the back end. Dr. Mainzer asked if PAC could request NASA tackle the problem in AOs, using such language as "Use IAU standards." Dr. Verbiscer agreed that adhering to a standard will be beneficial in the long run. Dr. Mainzer commented that NASA might be able to come up with a solution that is broadly applicable, after which it could encourage people to use the standards.

Dr. Schmidt expressed concern that the Planetary Defense budget might cause some ripples that could ultimately affect Small Bodies exploration. Dr. Glaze clarified the issue, pointing out that while all programs are experiencing impact from COVID, Psyche and Lucy are still the highest priority missions, and PSD is focused on getting them to launch. There is no imminent danger to funding levels. While the President's Budget Request (PBR) does not contain the funding to move forward as desired, PSD is moving forward nonetheless. Dr. Glaze said she would appreciate any and all support on that front.

PAC expressed general, but guarded, support for the NoDD experiment, and discussed a finding on PSP, given potential opportunities arising from Juno, JUICE, and extended Mars missions. Dr. Lynn Carter suggested a finding on transparency about MIM. A meeting participant noted that MEPAG has issued a good finding on MIM that the PAC could point to. Dr. Mainzer recommended that a finding on the Europa Clipper LV remain on the backburner until the next meeting.

Dr. Verbiscer thanked Doris Daou for her service to the PAC, as her duties will henceforth be performed by Dr. Shoshana Weider. Dr. Verbiscer thanked all participants and adjourned the meeting at 6:01pm.

Appendix A

Attendees

Planetary Science Advisory Committee Members

Anne Verbiscer, **Chair**, University of Virginia
Justin Filiberto, Lunar and Planetary Institute
Justin Hagerty, United States Geological Survey
Dana Hurley, Johns Hopkins Applied Physics Laboratory
Timothy Lyons, University of California, Riverside
Amy Mainzer, Vice Chair, University of Arizona-Tucson
Francis McCubbin, NASA Johnson Space Center
Aki Roberge, NASA Goddard Space Flight Center
Britney Schmidt, Georgia Institute of Technology
Rhonda Stroud, US Naval Research Laboratory
Stephen Rinehart, Executive Secretary, NASA HQ

Virtual Attendees

Aaron Burton, NASA
Aaron Lewis, Ariane Space
Abigail Rymer, JHU APL
Adam Fleisher, NIST
Adrian Brown, NASA
Adriana Ocampo, NASA
Al Witkowski, Kata Basis Engineering
Alan Harris, U Colorado
Alana Johnson, NASA
Alba Meang
Alberto Fairen, Cornell University
Alfred McEwen, LPL Arizona
Alper Yilmaz, OSU
Angela Stickle, JHU APL
Arnold Evergreen, USC
Athanasia Nikolaou
Bill McKinnon
Amanda Arh, PSI
Amanda Nahm, ASRC Federal
Amy Chaput, Stellar Solutions
Andrea Riley, NASA
Andrew Garza, NASA
Angela Stickle, JHU APL
Anthony Colaprete, NASA
Aurore Hutzler
Awal Rau, SWRI
Azita Valinia, NASA
B Harvey
Barbara Cohen, NASA
Bo Trieu, NASA
Bradley Thomson
Bradley Zavodsky

Brent Archinal, USGS
Brett Benevi, JHU APL
Brian Paczkowski
Bob Grimm, SWRI, Boulder
Bonnie Buratti, NASA
Bonnie Meinke, Ball Aerospace
Brad Bailey, NASA
Brandon Eden, ULA
Brett Denevi, JHU APL
Brian Warner, Minor Planet Observer
Candy Hansen, PSI
Carl Gelderloos, LASP
Carolyn Mercer, NASA
Casey Dreier, Planetary Society
Catherine Hofacker, AIAA
Catherine Johnson, PSI
Catherine Walker, NASA
Cesare Grava, SWRI
Charles Edwards, NASA
Charles Schambeau, UCF
Chase Chivers, Georgia Tech
Chris German, Woods Hole Oceanographic Institute
Chris Glein, SWRI
Christina Richey, NAS
Christina Viviano, JHU APL
Christophe Sotin, NASA
Christopher Dateo, NASA
Conor Nixon, NASA
Cynthia Dinwiddie, SWRI
Dan Scheld, NSCI Corp
Danica Remy, B612 Foundation
Daniel Glavin, NASA
David Concha, La Institución Universitaria
David Draper, NASA
David Eisenman, La Institución Universitaria
David Gaba, Stanford University
David H. Smith, National Academies
David Lackner, L-M
David Liebhart
David Millman
David Senske
Dimitri Veras
David Traore, Orbit Zone
Delia Santiago-Materese, NASA
Dimitri Veras
Doris Daou, NASA
Doug McCuiston
Douglas Isbell, NASA
Ronald Freeman
Dylan Cohen
Ed Rivera-Valentin, LPI USRA

Eileen Stansbery, NASA
Eldar Noe Dobrea, PSI
Eric Christensen, LPL Arizona
Eric Ianson, NASA
Erik Edwardson, NAS
Erin Leonard, NASA
Eva Lilly, PSI
Evan E Shelman
F. Venditti, University of California
Federico Gasperini, AstraSpace
Fran Bagenal, U Colorado
Francesco Bordi
Gene Mikulka
George Tahu, NASA
Gernot Langle
Gordon Bjoraker
Grace Hu, OMB
Hadi Madanian, SWRI
Haje Korth
Heather Meyer, JHU APL
Heather Smith, NASA
Heidi Haviland, NASA
Henry Throop, NASA
Horton Newsom, U New Mexico
Hunter Waite, SWRI
Hunter Williams, Honeybee Robotics
Insoo Jun, NASA
Jack Mustard, Brown University
James Green, NASA
James Head, Brown University
James Lochner, USRA
James Tuttle Keane, Caltech
James Watzin, NASA
Jamie Cook, NASA
Jason Kalirai, JHU APL
Jaya Bajpayee, NASA
Jeff Foust, Space News
James Tuttle Keane (Ext)
Jaya Bajpayee
Jeff Moore
Jeffery Hollingsworth, NASA
Jeffrey Gramling, NASA
Jeffrey Grossman, NASA
Jeffrey Johnson, JHU APL
Jeffrey P. Morgenthaler, PSI
Jess Barnes, LPL Arizona
Jim Rice, PSI
Joan Salute, NASA
Joan Zimmermann, Zantech IT
Joe Westlake, JHU APL
Joey Roulette

John Grunsfeld
Jonathan Munetz, GAO
John Whithead,
Jose Baca Garcia, NASA
Jose Hurtado, UTEP
Joseph Lazio, NASA
Josh Handal
Josie Anderson, MSU
J Stopars, LPI USRA
Juan Lora, Yale University
Juan (Tony) Castilleja, Boeing
Juliane Gross, Rutgers University
Julie McGeoch
Julie Rathbun, PSI
Justin Hagerty, USGS
Kat Volk, LPL Arizona
Kate Craft
Kathy Mandt, JHU APL
Kaveh Pahlevan
Kelly Fast, NASA
Kelsey Young, NASA
Kelsie Krafton, AAS
Kennda Lynch, LPI USRA
Kim Reh, NASA
Kris Zacny, Honeybee Robotics
Krista Soderlund, U Texas
Kurt Retherford, SWRI
Kynan Hughson, Georgia Tech
LaJuan Moore, NASA
Larry Matthies, NASA
Lauren Jozwiak, JHU APL
Leonard David
Lin Yi
Linda Billings
Linda Spilker, NASA
Lindley Johnson, NASA
Lindsay McHenry, UWM
Lisa Danielson, LANL
Lisseth Gavilan
Lori Glaze, NASA
Louise Prockter, JHU APL
Lucas Paganini, NASA
Luisa Fernanda, Arecibo Observatory Space Academy
Lynn Carter, U Arizona
Madeleine Bronstein, ULA
Marcia Smith
Maria Lima
Marion Nachon, TAMU
Mark Elowitz
Mark Fonda, NASA
Mark Hofstadter, NASA

Matthew Koehler, Technology Service Corp
Matt Fillingim, UC Berkeley
Mark Salvatore
Mark Sykes, PSI
Marufa Bhuiyan, University of Hawaii
Mary Sladek, NASA
Mary Voytek, NASA
Matt Tiscareno, SETI
Matthew DeRosier, UTC Aerospace
Meagan Thompson, NASA
Megan Ansdell, NASA
Melissa Kirven-Brooks, NASA
Melissa Morris, NASA
Mike Combi
Mike Veto
Moses Milazzo
Mia Brown, National Academies
Michael Meyer, NASA
Michael New, NASA
Michael Phillips, U Tennessee, Knoxville
Michael V Elbel, MSU
Michelle Tang, MIT
Miguel Rima, JHU APL
Monty Dibiasi
Nancy Chabot, JHU APL
Nicholas Castle, PSI
Nicole Figueroa, ULA
Noam Izenberg, JHU APL
Parvathy Prem, JHU APL
Pat McGovern, LPI USRA
Patricia Beauchamp, NASA
Patrick Taylor, USRA
Paul Byrne, NCSU
Paul Mahaffy, NASA
Pete McCallum, Aerospace
Peter Doms, NASA
Prajakta Mane, ASU
Heeralal Janwa, UPR
P Schenk, LPI USRA
R Aileen Yingst, PSI
Ramon de Paula, NASA
Rebecca McCauley Rench, NASA
Rebecca Williams, PSI
Renee Weber, NASA
Rich Zurek, NASA
Richard Rogers, Stellar Solutions
Richard Ryan, NASA
Richard Mattingly, NASA JPL
Rob Seaman, U Arizona
Robert Fogel, NASA
Rob Landis

Robert Pappalardo, NASA
Robert Stephens, Fox and Stephens
Robin Canup, SwRI
Rosaly Lopes, NASA
Ryan Watkins, PSI
Sherry Smith, Boeing
Salvatore Scipione
Samuel Howell, NASA
Samuel Montez, NASA
Sarah Noble, NASA
Scott Anderson, SWRI Boulder
Scott Smas
Sergio Parra, Caltech
Serina Diniega, NASA
Shoshana Weider, NASA
Soumya Ray, ASU
Stephanie Getty, NASA
Stephen Clark, Spaceflight Now
Stephen Larson, LPL AZ
Steve Elardo, UFL
Steve Hauck, Case Western
Steve Mackwell, AIP
Tammy Dickinson
Taylor Duffin
Tehare Grava, SWRI
Teresa Jensen, SDL
Terik Daly JHU APL
Thomas Statler, NASA
Tim Gouge, U Texas
Tim Lister, LCO Global
Tom Gardner
Tom Prettyman, PSI
Tommy Thompson, NASA
Tracy Becker, SWRI
Trevor Graff, NASA
Ujjwal Raut, SWRI
Van Kane
Walter Kiefer, LPI USRA
Will Thomas, AIP
William Bottke, SWRI Boulder
William McKinnon, U St. Louis
William West, NASA
Zachary Torrano, ASU
Zhengwei Hu, XNano

Appendix B

Committee Membership

Anne Verbiscer, **Chair**
University of Virginia

Lynn Marie Carter
University of Arizona

Justin Filiberto
Lunar and Planetary Institute

Chris German
Woods Hole Oceanographic Institute

Justin Hagerty
United States Geological Survey

Dana Hurley
Johns Hopkins Applied Physics Laboratory

Timothy Lyons
University of California – Riverside

Amanda K. Mainzer
Jet Propulsion Laboratory

Francis McCubbin
NASA Johnson Space Center

Aki Roberge
NASA Goddard Space Flight Center

Britney Schmidt
Georgia Institute of Technology

Rhonda Stroud
US Naval Research Laboratory

Stephen A. Rinehart
Executive Secretary, NASA Headquarters

Appendix C Agenda

Planetary Science Advisory Committee Meeting

August 17 – 18, 2020

VIRTUAL

Monday, August 17, 2020, 10:00 a.m. – 6:00 p.m. EDT

10:00 Opening, Announcements, Around the Table Identification (S. Rinehart)

10:05 PSD Status Report (L. Glaze)

11:05 PSD R&A Status (S. Rinehart)

12:00 BREAK

12:30 Equity & Diversity (M. Thompson)

12:45 Planetary Decadal Updated (D. Smith)

1:15 Mars Program (M. Meyer & J. Watzin)

2:00 BREAK

3:30 Mars Sample Return (J. Gramling)

4:00 Lunar Program (B. Bailey)

4:30 VIPER Mission Update (T. Colaprete)

5:00 Planetary Defense Coordination Office (L. Johnson & K. Fast)

5:30 GPRA-MA (M. Thompson & J. Kearns)

6:00 ADJOURN

Tuesday, August 18, 2020, 10:00 a.m. – 6:00 p.m. EDT

10:00 ExoPAG (M. Meyer)

10:20 CAPTEM (K. McKeegan)

10:40 LEAG (S. Lawrence)

11:00 MAPSIT (J. Radebaugh)

11:20 SBAG (B. Buratti)

11:40 MEXAG (S. Hauck)

12:00 BREAK

1:00 OPAG (J. Moore)

1:20 VEXAG (D. Dyar)

1:40 MEPAG (A. Yingsht)

2:00 Findings and Recommendations Discussions

3:00 BREAK

4:00 Findings and Recommendations Discussions

6:00 ADJOURN

Appendix D Presentations

1. Planetary Science Division Update; *Lori Glaze*
2. Planetary Science Division Research and Analysis Status; *Stephen Rinehart*
3. Planetary Decadal Survey Update; *David Smith*
4. Mars Exploration Program; *Jim Watzin, Michael Meyer*
5. Mars Sample Return; *Jeff Gramling*
6. Lunar Program/ESSIO; *Brad Bailey*
7. VIPER Mission Update; *Anthony Colaprete*
8. Planetary Defense Coordination Office; *Kelly Fast, Lindley Johnson*
9. GPRAMA Update; *Michael New*
10. Exoplanet Analysis Group; *Michael Meyer*
11. Lunar Exploration Analysis Group; *Samuel Lawrence*
12. MAPSIT; *Brad Thomson*
13. Small Bodies Assessment Group; *Bonnie Buratti*
14. Mercury Exploration Analysis Group; *Steven Hauck, II*
15. Outer Planets Analysis Group; *Jeffrey Moore*
16. Venus Exploration Analysis Group; *Darby Dyar*
17. Mars Exploration Analysis Group; *Aileen Yingst*