

PLANETARY SCIENCE ADVISORY COMMITTEE

December 5–6, 2022

MEETING REPORT

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Dr. Stephen Rinehart, Executive Secretary
NASA Headquarters

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December 5, 2022

Welcome & Introductions

Planetary Science Advisory Committee (PAC) Executive Secretary, Dr. Stephen Rinehart, opened the meeting. Dr. Rinehart welcomed four new members: Brent Barbee, Dr. Kandis Jessup, Dr. Shannon Curry, and Dr. John Grant. Dr. Rinehart introduced Dr. Serina Diniega as Chair and Dr. Hope Ishii as the new deputy chair of the PAC. Two members were recorded as not being present for the meeting, one unable to attend and another to arrive late. He addressed the PAC regarding the report of any conflicts of interest to either himself or Dr. Diniega.

Dr. Serina Diniega, Chair of the PAC, welcomed all members of the PAC and those attending the meeting. She gave brief instructions regarding communication throughout the meeting.

Dr. Lori Glaze, Director of the Planetary Science Division (PSD), welcomed returning and new PAC members. She thanked all members, speaking on the value of their person and their interactions within the committee. Dr. Glaze discussed the virtual delivery of the meeting and the hopes that the next one would be hybrid.

Planetary Science Division (PSD) Update

Dr. Lori Glaze discussed Science Mission Directorate (SMD) leadership changes. She stated that Dr. Thomas Zurbuchen, the current SMD Associate Administrator (AA), is stepping down from said position by the end of December 2022. Dr. Zurbuchen has been the longest serving AA in NASA history. Dr. Glaze voiced appreciation for his years of leadership and wished him luck in his future endeavors. Ms. Sandra Connelly, Dr. Zurbuchen's Deputy, will be fulfilling the role of Acting AA until a new administrator is appointed. Mr. Eric Ianson will be serving as the Acting Deputy AA during this time. Dr. Glaze reported that the process could possibly take months and encouraged patience.

A quick view of the fleet chart reveals 32 PSD missions associated with the Moon, Mars, or within the solar system. There are six current operating missions and eleven extended missions. Also shown are ten missions in various stages of implementation and five within the formulation stages. Seven missions include international partnerships.

Dr. Glaze discussed highlights since the last PAC meeting, including the Double Asteroid Redirection Test (DART) impact that occurred on September 26, 2022 and the activities of the Mars 2020 Perseverance Rover.

DART was a spacecraft that was navigated to crash into Dimorphos, a Moonlet of asteroid Didymos, at approximately 6.1 kilometers (3.8 miles) per second, all while supplying high-resolution images. One of the Asteroid Terrestrial-impact Last Alert System (ATLAS) telescopes in South Africa witnessed the moment of impact and provided images of vaporized rock. The Hubble Telescope provided a side-on view of the ejecta curtain and a long trail of debris a few days following impact. The Italian Space Agency (ASI) provided images from the Light Italian Cube Satellite (Cubesat) for Imaging of Asteroids (LICIACube), which included the change in brightness of Dimorphos before and after impact, as well as a view of the plumes of ejecta

streaming from Dimorphos following impact. The objective of this mission was to change the orbital period of Dimorphos around Didymos. Prior to impact, the orbit of Dimorphos was 11 hours and 55 minutes, following impact it was 11 hours and 23 minutes which constitutes a 32-minute change. This was the first successful attempt to divert the path of an interplanetary object by humans.

The Perseverance Rover has been continually samples from the surface of Mars in paired sets. As of the meeting, there are 15 paired core samples. There is diversity in the types of rocks collected including volcanic rocks from the crater floor, fine- and large-grained igneous rocks, mudstones, and sedimentary rocks from the lakebed and the ancient river delta. A workshop was held to identify the readiness and scientific worthiness of initiating a cache depot for future retrieval. It was determined that the creation of the cache depot should begin within the month of December and the sample tube location would be the “Three Forks” area near the base of the ancient river delta. This location was chosen due to the flatness of the terrain which creates a safe future landing space for the Mars Sample Return (MSR) Sample Retrieval Lander (SRL). The cache would contain one set of each sample, while the other is to stay on the Perseverance rover. The baseline architecture is for Perseverance to deliver the sample tubes it is carrying directly to SRL, but if unable to do so, samples would be retrieved by Mars Helicopters to the landing space of the MSR Lander from the sample tubes’ locations.

Dr. Glaze then presented information on challenges facing the PSD including budget considerations, the Psyche Independent Review Board (IRB), the Jet Propulsion Laboratory (JPL), the Venus Emissivity, Radio science, Interferometric Synthetic Aperture Radar (inSAR), Topography and Spectroscopy (VERITAS) status, and Psyche and Janus.

The first challenge addressed was budget considerations. Dr. Glaze stated that the PSD had absorbed significant COVID-related costs that ranged upwards to a few hundred million dollars purely on missions that were in development. The PSD did not receive any additional funding to offset any of the COVID impacts. Dr. Glaze stated that she was proud of the PSD’s ability to keep many of the missions on schedule despite the COVID impacts. She stated that as missions move from the development phase to the operational phase (Phase-E) there appears to be significant increases in budgetary needs. This could be due to mis-estimation of operational costs. For new missions in formulation and development, there is a need to accommodate increased costs due to inflation, materials, labor rates, work-force costs, and long-lead-time (rephasing) issues. In addition, the appropriation for the 2022 fiscal year (FY22) was \$80 million less than expected and the FY23 that is currently being reviewed is also lower than the estimated planning budget.

The second challenge addressed was the Psyche IRB. It was co-chartered by NASA SMD headquarters and JPL and had two main sections that focused on Psyche and the JPL Institution. The final report and responses are published online. The forward plan for Psyche includes recommendations, per the IRB, which are to be considered as part of the continuation/termination review that cover a myriad of topics including management and communications, staffing, COVID-19, project metrics, Standard Review Board (SRB) review, the JPL/MAXAR relationship, and other general logistics. The IRB made the recommendations

to develop a launch plan to meet the new Launch Readiness Date (LRD) of October 2023; to establish and implement processes to improve communications at all levels within the Psyche project and at JPL; provide additional, experienced leaders at all levels of the project, as well as sufficient project staffing; re-establish informal communications at JPL and minimize hybrid/remote work on Psyche; develop an adequate and verified schedule for remaining work; strengthen the SRB process; and understand that the Psyche experience provides an excellent opportunity to document best practices for future NASA and commercial spacecraft provider collaborations.

As a continuation of the IRB review of JPL, many Psyche issues identified are not unique to Psyche and are indicative of broader institutional issues. Institutional issues that presented themselves during the review consist of inadequate flight project staffing-number of personnel and experience; erosion of line organization technical acumen; insufficient JPL senior management engagement with flight projects; and the post-pandemic work environment. Urgent corrective action recommendations include no new flight projects until workforce balance is achieved; cancel, redirect, or delay a flight project; transfer required talent from non-flight projects within JPL to flight projects; focused personnel training and development in key areas; significantly increase use of industry prime and support services contractors; increase use of and collaboration with other NASA Centers; aggressive recruitment and hiring; and accept the risk of layoffs.

The third challenge addressed was the status of VERITAS. The decision was made to delay the VERITAS launch, one of the Discovery missions chosen last year, to no earlier than 2031, with PSD providing FY23 funding for orderly stand down and continued funding for science team support. Restart of the mission would be contingent on funding and progress on IRB issues. PSD and SMD will pursue funding to support both VERITAS and the next Discovery Announcement of Opportunity (AO) through the FY2025 budget process. Dr. Glaze reinforced to attendees that the decision was not made lightly and that they are acutely aware how difficult of an impact this will have on PSD.

The fourth challenge addressed was the actual Psyche launch. The launch period is scheduled for October 10–30, 2023, with an arrival to the asteroid Psyche in August of 2029. This trajectory was chosen because it does not require any new operational activities or processes and it does not stress the spacecraft design. The Assembly Task Launch Operations (ATLO) 1.0 was completed and the spacecraft was placed in maintenance mode until ATLO 2.0 begins in June of 2023. This would be the final assembly and test before launch. JPL is working closely with the project to maintain the level of needed experienced staff to complete the remaining work prior to its launch. A Directorate Project Management Council (DPMC) meeting is planned for the February and March 2023 timeframe to monitor progress relative to the IRB recommendations and to ensure launch readiness for the planned date.

The last challenge addressed was from the Small Innovative Missions for Planetary Exploration (SIMPLEX-2) program, Janus. Janus was removed from Psyche's 2023 launch manifest as it would not be on a trajectory to meet science requirements. The spacecraft resides at Lockheed

Martin. The remaining funding for this project is useable and the team is to assess potential other objectives, missions, and/or uses of the spacecraft.

Dr. Glaze then presented information on mission updates associated with the Europa Clipper, the SIMPLEx missions, and The Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission.

Europa Clipper whose mission is to be inserted into Jupiter's orbit in April 2030 is steadily moving toward its target launch in October of 2024 with delivery of five of the nine science instruments including the Plasma Instrument for Magnetic Sounding (PIMS), Europa Imaging System Wide-Angle Camera (EIS WAC), Europa Thermal Emission Imaging System (E-THEMIS), Europa Ultraviolet Spectrograph (E-UVS), and the Surface Dust Analyzer (SUDA). More of the hardware and science instruments are expected by the end of February 2023. There is live feed available for viewing of the progress of the Europa Clipper from the JPL High Bay where it is being constructed.

The Lunar Polar Hydrogen Mapper (LunaH-Map) from SIMPLEx-1 is a small CubeSat successfully launched with Artemis I on November 16, 2022. On November 17, 2022, the propulsion system powered on, but thrust was not achieved. The team assessed that the propulsion system may be partially stuck. In an attempt to free the propulsion system, they are having the spacecraft heat the propulsion valve. If thrust is achieved within the next few months, the mission may still recover some, if not all, of the original science mission. Despite setbacks, the compact neutron spectrometer collected data during its November 21, 2022, lunar flyby demonstrating that the spectrometer is operating as expected. The Lunar Trailblazer (SIMPLEx-2) is set to launch on Intuitive Machines-2 (IM-2) Polar Resources Ice Mining Experiment-1 (PRIME-1) Commercial Lunar Payload Services (CLPS) delivery. Following the cost review in November 2022, the decision was made to continue with the launch. The mission goal of the Lunar Trailblazer is to understand the form, abundance, and distribution of water on the Moon and the lunar water cycle.

The InSight Mars Lander is continuing to map Mars seismic activity which includes more than 1,300 'Marsquakes' to date. This is a solar-powered craft and dust has settled over the past four years onto the solar panels which has affected its ability to operate. There was a partial restoration of power following a dust storm in late September, early October but the expectation is that communication with the craft will cease within the next 6 to 8 weeks. Until then, the plan is to maximize the number of seismic measurements by operating 8 hours on followed by 3 Mars solar days (sols) off for recharge. InSight has detected seismic waves from various meteoroid impacts.

Dr. Glaze shared that the Fifth Community Announcement to solicit New Frontiers Program mission investigations was released September 1st of 2022 and shared some policies under consideration for the AO and invites public comment to NASA. Work is being done to release the draft AO by December 2022 with an estimated release of the final AO for next fall and proposals being due by March of 2024. Draft mission themes include Comet Surface Sample Return, Lunar South Pole-Aitken (SPA) Basin Sample Return, Ocean Worlds (only Enceladus),

Saturn Probe, Io Observer, and Lunar Geophysical Network. Any comments and questions should be addressed to Curt Niebur, the New Frontiers Program Scientist.

Dr. Glaze introduced the new Planetary Exploration Science Technology Office (PESTO) manager, Dr. Erica Montbach from NASA Glenn, who is replacing Dr. Carolyn Mercer. Dr. Glaze expressed excitement about working with Dr. Montbach. Dr. Glaze reported that Dr. Mercer is organizing and planning the Technology Showcase for Future NASA Planetary Science Missions for January 9–11, 2023, in Galveston, Texas.

Dr. Glaze then reviewed responses to the June 2022 PAC eight findings that include the Decadal Survey, workforce information, code of conduct, the National Science Foundation (NSF) collaboration and the Antarctic Search for Meteorites program (ANSMET), ground-based radar, R&A with No Due Date (NoDD) and Dual-Anonymous Peer Review (DAPR), the Here to Observe (H2O) program, and the Advancing IDEA in Planetary Science conference (IDEAcon).

The finding of the Decadal Survey was as follows: The PAC thanked the committee members of the Planetary Decadal Survey for their significant contribution in researching and generating the consensus report, “Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032” (OWL). While the PAC was still digesting the full content of the OWL, they expressed their support for the excellent roadmap it provided for NASA in the coming decade. In particular, they expressed strong support for the OWL recommendations regarding the following: minimum R&A funding as a percentage of PSD total budget; the Recommended Program; actions to benefit the state of the profession; development and timely launch of Near-Earth Object (NEO) Surveyor; Uranus probe development start by FY24; development of sufficient Radioisotope Power Systems (RPS) supply for the Recommended Program; and expanding commercial providers for CLPS and taking CLPS beyond the Moon. The PAC looked forward to NASA’s upcoming response to the OWL. NASA’s official initial 90-day response to the 2023-2032 Planetary Science and Astrobiological Decadal Survey is available online. A full written response to the National Academies of Sciences, Engineering, and Medicine (NASEM) is posted, along with presentation materials from the public community townhall that was held on August 18, 2022. The Decadal Survey is to be further discussed.

The finding regarding information of the planetary science community workforce was as follows: The PAC endorsed the recommendation from the Decadal Survey State of Profession chapter for the collection of information about the planetary science community workforce. The recommendation was as follows: The PAC encouraged PSD to explore creative ways to obtain and analyze these data, within NASA’s legal confines; for example, working with professional societies and cross-AG forums. Such efforts should also be done in collaboration with social scientist with expertise on writing and administering such information collection. In future PAC meetings, the PAC requested to hear presentations from those who have successfully run past planetary science workforce surveys and other relevant information collections, to explore potential solutions and collaborations to fulfill this need. The response was as follows: SMD will be issuing its first annual “Research Program Yearbook” early in 2023. It will contain demographic and other information about SMD proposal Principal Investigator’s (PI’s), Co-Is, awards, and reviewers. It will also have division-specific sections on these data. Currently, the

Office of Management and Budget (OMB) will not allow changes to the NASA-posed demographic questions, therefore, working with professional societies, cross-AG fora, social scientists, etc. will not provide changes to the data obtained. It is noted that although professional societies are not bound by the same constraints of the Paperwork Reduction Act and Privacy Act as NASA the constraints extend to any study NASA asks a third-party to perform.

The finding regarding the Code of Conduct (CoC) is as follows: The PAC recognized the need for inclusion of a CoC in all NASA-supported activities and encourages CoC standardization to ensure that the best practices are being following, which include a reporting and accountability structure – as also recommended by the Decadal Survey. The PAC commended the Astrobiology program for now requiring a CoC-type policy for field site use and the AGs for implementing CoCs for their steering committees and events. The recommendation was as follows: The PAC recommended that NASA provide a CoC template for all NASA-supported activities, which included a reporting and accountability structure. For each activity, the CoC should be introduced at the beginning of the event and posted where appropriate, to encourage all participants to be both mindful and accountable. The response was as follows: SMD is developing several approaches in improving the climate of science terms. SMD has been developing a template for a mission team CoC but, by its prescriptive nature, it could be viewed as interfering with the employer-employee relationship. A new approach is therefore being developed in which a team would develop an “Agreement on Acceptable Behavior” that would cover broad topics stated and reviewed by SMD. With this approach, NASA would not be interposing itself between faculty and their universities, for example. Moreover, it would be expected that an “Agreement on Acceptable Behavior” would incorporate the resources and processes of the participating institutions.

The finding regarding the NSF Collaboration and ANSMET was as follows: The PAC recognized the critical role of NASA’s interagency collaboration and coordination with NSF. For example, over four decades, the U.S. has annually performed meteorite recovery through ANSMET. The meteorites recovered by ANSMET are vitally important for planetary research, providing scientists from around the world with samples of planetary bodies not easily obtainable by other means and at relatively low cost compared to sample return missions. Meteorites motivate and provide key information to preparations for, analyses during, and context following current and planned missions to small bodies, Moons, and planets. ANSMET is funded by NASA but relies on logistical support of Antarctic field activities by NSF. Due to the ongoing COVID-19 pandemic, the 2020–21, 2021–22, and 2022–23 ANSMET field seasons have been canceled, halting meteorite collection and field work on analogs in Antarctica. The recommendation was as follows: The PAC encouraged NASA to pursue conversations with NSF to prioritize support for critical work funded by NASA but requiring NSF coordination and support. In particular, the PAC encourages resumption of ANSMET field seasons as soon as practical. The response was as follows: NASA thanked the PAC for the finding and recommendation. NASA is planning to hold a meeting of the Meteorite Steering Committee (MSC) (with members from NASA, NSF, and the Smithsonian Institution) in 2023, during which the ANSMET program will be discussed.

The finding regarding ground-based radar was as follows: The PAC recognized the importance of ground-based radar observations for both planetary science and planetary defense and continues to recognize the impact of the loss of the Arecibo Observatory planetary radar system. The PAC supports ongoing cross-divisional discussion to replace the capabilities lost at Arecibo Observatory and supports the Decadal Survey recommendation, highlighted by many AG findings, to “develop a plan for ground-based planetary radar capabilities comparable to or exceeding those of the Arecibo Observatory necessary for achieving planetary defense objectives.” The response was as follows: NSF, NASA, and U.S. Space Force are participating in an NSF-led study, possibly also supported by other entities, to establish the context of the broad national needs for a next-generation planetary radar capability and possible technology concepts for addressing those needs. This study has taken longer than expected to initiate but is now on track to kickoff in January 2023 and is expected to provide preliminary input for the FY25 budget planning cycle in the spring of 2023.

The finding regarding R&A with NoDD and DAPR was as follows: The PAC commended the PSD for their general successes in R&A trials (NoDD and DAPR), and related community presentations, intended to improve equity, efficiency, and transparency. Such transparency continues to build support and trust in the community for the R&A program. The recommendation was as follows: The PAC recommended continuation of the NoDD and DAPR programs in the future. The PAC also recommended including a line in the selection letter to “selectable” proposals in NoDD programs with targeted response time. The PAC encourages PSD to continue to provide detailed communication about the R&A program to the planetary science community, specifically the high-fidelity data on proposal pressures, selection rates, community statistics, and assessments of the NoDD and DAPR programs presents to the PAC. The response was as follows: NASA concurred with the recommendation. An anticipated timeline for a final decision on “selectable” proposals is now standard practice in notification letters. The PAC and the planetary science community will continue to be apprised of developments within the R&A program.

The finding regarding H2O was as follows: The PAC commended the accomplishment of the organizers and student participants for the first year of the H2O program. They were very impressed with the activities and level of inspiration and passion displayed, as well as the great ideas from the student participants for improving the program. The recommendation was as follows: The PAC recommended continuing to develop this program, especially in directions that will lead to lasting and authentic connections with the partner universities and following the advice of the student participants. This development should also include definitive ways to assess impact of the program. Additionally, the “co-creation” premise of this program was key for its success and should be continued, and perhaps should serve as a model for other NASA IDEA and outreach efforts; the importance of relationship building was also discussed in Planetary Science & Astrobiology Decadal Survey white papers. The response was as follows: NASA thanked the PAC for the positive feedback. The H2O program has been extended for an additional pilot year, with two participating institutional partners, the University of Puerto Rico and Virginia State University. The second pilot year will allow the incorporation of more student-suggested events, activities, and engagement opportunities with PSD missions and

mentors. Student participant surveys will remain a core aspect of H2O as they prepare for broader participation and will continue to include H2O ‘alumni,’ to allow tracing of science, technology, engineering, and mathematics (STEM) education and career outcomes.

The finding of IDEAcon was as follows: The PAC commended NASA’s support for the recent IDEAcon and the usefulness of the detailed report of recommendations from IDEAcon. The PAC emphasized that there remains a need for improved and intentional coordination for IDEA efforts within and outside of NASA SMD. While the Cross-AG IDEA working group helps with some for this coordination outside of NASA, the coordination is not yet sufficiently happening with the efforts inside NASA and between internal and external efforts. The recommendation was as follows: The PAC endorsed the recommendations from the IDEAcon report and requested from NASA a response to the report’s top recommendations for funding agencies at the next PAC meeting. The PAC urged further coordination between NASA and community efforts, with one option being the outward-facing IDEA-coordination position as well development of a centralized repository of relevant resources, as recommended in the IDEAcon report. An existing model that may inform efforts to address this is the Planetary Data Ecosystem (PDE), where a paid, non-civil servant Chief Scientist has a mission to engage the community, is supported by an internal NASA group, and provides institutional support for a central information repository. The response was as follows: NASA thanked the PAC for the finding and recommendation. A detailed response to the findings from IDEAcon will require additional time and effort, but initial commentary will be provided during this meeting.

Dr. Glaze announced that NASA had approved the Near-Earth Objects (NEO) Surveyor mission last week.

Dr. Glaze concluded her presentation and was present for clarification questions.

Dr. Diniega inquired about Janus and possible launch opportunities. Dr. Glaze responded that they are currently not actively looking for another launch opportunity as there are other challenges with the spacecraft. She stated that the associated team is researching other options that may be viable and that they have been instructed to bring back any new ideas but that would qualify a new initiative.

Dr. Diniega inquired about workforce survey restraints and the communication associated with the recent SMD internal climate survey and efforts made at the NASA Advisory Council (NAC) meeting in June. Dr. Glaze stated that with that survey only civil servants were able to respond to the survey. She further stated that efforts to approve outside organizations for use was not approved but does not reflect a lack of desire of the SMD to gather information, just that it is very difficult.

Dr. Diniega inquired if the Artemis delay played a role in the issues developed for any of those small satellites. Dr. Glaze stated that she believes that the delay did play into some of the issues. She did indicate that there are challenges associated with rideshares. She stated that the landscape is changing from large missions to much smaller vehicle with newer launch capabilities. She stated that lessons are being learned regarding these missions. Mr. Ianson stated that although the sample size is small, data points exist, and evaluation needs to occur so

that recommendations can be made for future missions. Dr. Glaze stated that the Lunar Trailblazer is an example where the PSD is learning as it was originally manifest on the Interstellar Mapping and Acceleration Probe (IMAP) mission, but that mission was delayed. The Lunar Trailblazer project team got resourceful and is now purchasing the service from the Intuitive Machines to get a ride. Every single one of these situations is unique and different.

Psyche Independent Review Board (IRB)

Mr. Tom Young, former Director of NASA's Goddard Space Flight Center, President and Chief Operating Officer (COO) of Martin Marietta and Chairman of Science Applications International Corporation (SAIC) was introduced. Mr. Young commended Dr. Glaze's introductory remarks on the Psyche IRB and stated he would compound on her statements and then address any questions.

The Psyche IRB Charter was created to determine project, institutional, and all other issues that were responsible for the Psyche launch delay; to determine why there was a lack of visibility into the factors driving the launch delay; to review Psyche's path forward to maximize the probability of mission success; to identify lessons learned with utilizing the MAXAR commercial bus; to determine if Psyche issues were unique to Psyche or indicative of broader JPL institutional issues; and if broader institutional issues are identified to determine corrective actions appropriate for current and future missions.

Mr. Young reinforced that Psyche is a major mission and of significant scientific importance during the Psyche overview. Psyche is a competitively awarded, cost-capped, PI-led Discovery class mission selected for implementation in 2017 with a total mission cost of approximately one billion dollars. Its scientific objective is to study the unique metal-rich Psyche asteroid. Project management is performed by the JPL, as proposed to NASA by the PI, Lindy Elkins-Tanton from Arizona State University. The program management is provided by the Planetary Mission Program Office at Marshall Space Flight Center for NASA's Planetary Science Division.

Psyche General findings and recommendations were discussed. The IRB agreed that the late Guidance, Navigation, and Control software delay and lack of testbed maturity are the proximate causes of the Psyche launch delay. The assessment also concluded that additional issues could have led to a launch delay on their own and include the following: open flight software issues, incomplete verification and validation (V&V) most significantly in fault protection, and operational readiness. The IRB recommends developing a plan forward that prioritizes and completes development activities, establishing a new launch date with sufficient margin to have high confidence in success, reviewing work performed in the last several months before the launch delay to assure it is at the required level of excellence with no embedded problems, and conducting a detailed review and assessment of "use-as-is" problem dispositions and "unverified failure."

Psyche management and communications findings and recommendations were discussed. Findings by the IRB included the following: Major communication failures on Psyche resulted in project management not recognize the seriousness of issues until too late to resolve them in time for a 2022 launch; Psyche team members raised alarms but felt their concerns were not being

heard and/or acted upon at multiple levels of management; no formal Independent Technical Authority (ITA) dissents were raised on Psyche; a culture of “prove there is a problem” led to important issues raised by team members being disregarded; senior management changes in JPL’s Planetary Science Directorate, including three leadership changes and reorganization within the last two years, had an adverse effect on Psyche; senior and Line management did not recognize Psyche development problems in time to take corrective action to prevent the launch delay; senior management did not penetrate project execution sufficiently to recognize seriousness of the development issues; and high demands on management’s time to continually balance staffing requirements contributed to the launch delay. The IRB recommends establishing and implementing processes to assure open, credible, and responsive communications both vertically and horizontally throughout the Psyche Project; that the JPL Director, senior management, and Line management must establish and implement processes that assure significant insight into flight-project execution and participation in resolution of problems and risks; that the role of the Line management function in elevating concerns needs to be emphasized and strengthened; and that the workforce should be trained that the ITA should be used for elevating unresolved issues of any nature, including programmatic.

Psyche staffing findings and recommendations were discussed. The IRB found that multiple staffing issues resulted from JPL having more project work than can be supported by the available workforce including inexperienced managers and technical personnel in multiple project positions, worker burnout, inadequate staffing, excessive number in stretch assignments, lack of mentoring, and high turnover. It was also noted that key project positions were not staffed including a Project Chief Engineer and that the lack of a Guidance, Navigation, & Control (GNC) Cognizant Engineer (CogE) contributed to late GNC subsystem technical definition, development, and testing. The IRB recommends providing an additional 10 to 12 full-time, experienced leaders at all levels of the project, adequately supplementing and maintaining project staffing to support the replan, and that special attention should be given to assigning and maintaining a Project Chief Engineer, GNC CogE, and Fault Protection Lead Engineer.

Psyche COVID-19 related findings and recommendations were discussed. The IRB noted that COVID-19 was a contributing factor to the issues that led to a launch delay and the lack of visibility of these issues within JPL; that the resulting remote work substantially reduced information communications including “walking the floor” and “drop-in discussions” that did not happen which allowed various teams within Psyche to become more isolated; that remote and hybrid work arrangements persist and pose a high risk to remaining Psyche Project development. The IRB recommends reestablishing information communications, and that remote and hybrid work must be minimized on Psyche to give the team the best opportunity to coalesce in a short time.

Psyche project metric findings and recommendations were discussed. The IRB discovered a lack of meaningful progress metrics and risk assessment hindered visibility into, and the ability to highlight and elevate, issues. This included an inadequate and unrealistic Integrated Master Schedule that minimized the value of traditional “actuals vs plan” metrics to assess progress. Risk assessments did not accurately communicate project health (i.e., many yellow risks, no red

risks). Based on interviews completed, there was an aversion to “going red” by project management. Project schedule and progress-tracking metrics masked true development status. The project was also found to have focused on hardware development and problem resolution, and neglected software and other non-hardware areas of activity. The IRB recommends developing a detailed, integrated, resource-loaded, and adequately margined and verified schedule for all remaining work that includes sufficient task completion milestones in key areas like V&V, system integration and test (I&T), and mission ops preparations, such that progress in these areas can be readily tracked; establishing and implementing a management information and reporting system that produces a credible and timely assessment of status, risk, and issues against the described integrated baseline.

The Psyche Project summary and conclusions were discussed. Psyche is a project with significant scientific merit, which can greatly contribute to the knowledge of a unique class of a metallic asteroid and add to our understanding of the solar system. The PI set a commendable tone of collaboration from the project’s outset and continues to prioritize relationship building with project team members at all levels. Psyche’s issues are much more extensive than originally understood when the launch was delayed. These include but are not limited to significant staffing shortages and insufficient personnel with relevant experience, communication issues, hybrid work schedules, software and system testbed development, V&V which includes the fault protection system, operational readiness, and shortcomings in programmatic metrics. Psyche issues require significant corrective action, including the addition of new, experienced personnel at all levels of the organization. Many Psyche issues are the direct result of JPL institutional issues and COVID-19 was a contributing factor in the various Psyche issues. The IRB has reviewed the go-forward plan and believes JPL has established an executable plan for a 2023 launch.

Because many Psyche issues are not unique to Psyche and are indicative of broader institutional issues the IRB reviewed the JPL.

The JPL flight project workload findings and recommendations were discussed. The IRB discovered that the JPL currently has an unprecedented workload with the concurrent implementation of six large spaceflight projects, plus numerous small missions and scientific instruments that include two Flagship class projects (Europa Clipper, MSR), two Discovery class projects (Psyche, VERITAS), and two significant payload development effort projects (Surface Water and Ocean Topography (SWOT), NASA-Indian Space Research Organization (ISRO) Synthetic Aperture Radar (SAR) NISAR). A large imbalance exists between workload and available JPL resources which is demonstrated by an acute lack of experienced managers, system engineers, and GNC, Flight Software (FSW), and Avionics engineers. This imbalance represents a root cause for the Psyche issues and adversely affects all flight project activity at JPL. The IRB recommends that flight projects be fully staffed with appropriately experienced personnel from the beginning, particularly in Systems Engineering, GNC, FSW, and Avionics; that balance must be achieved between the workforce needs of flight projects and the available JPL workforce. The IRB stresses that timing of achieving this balance is critical and that Psyche is an example of the major problems this imbalance is causing today. The IRB believes that by the end of March

2023, significant corrective actions must be implemented to achieve balance and for any corrective actions requiring more time, a detailed plan of action must be developed and approved by JPL, California Institute of Technology (Caltech), and NASA. Options to achieve workforce balance within JPL include no new flight projects until balance is achieved; to cancel, redirect, or delay a flight project; transfer required talent from non-flight projects within JPL to flight projects; focused personnel training and development in key areas; significantly increase use of industry prime and support services contractors; increase use of and collaboration with other NASA Centers; aggressive recruitment and hiring, and to accept the risk of layoffs.

The JPL Line organization findings and recommendations were discussed. The IRB asserts that significant erosion of technical acumen in the Line organization prevents line organization from adequately engaging with flight projects, independently assessing status, identifying problems, working with projects to develop solutions, and providing mentorship. Technical leadership was found to have migrated from the Line organization to the flight projects. This represents the loss of a critical safety net and that without this Line organization's capability and safety net, Psyche issues will become the norm and not the exception. The IRB recognizes the institutional need for more experienced managers and lead engineers is a primary cause of the erosion. Division 31 (Systems Engineering) and Division 34 (Autonomous Systems including Avionics, FSW, GNC, and Robotics product areas for JPL) issues were identified. Modern space systems are complex, highly integrated, and rapidly evolving, especially in the domains of these two divisions and that the magnitude of responsibility in these technical areas has necessitated the partitioning of their work into two divisions. Ambiguity and confusion exist between the two divisions in terms of roles, responsibilities, and accountabilities. The hybrid work environment has exacerbated these issues. Both divisions are critically understaffed, especially in terms of engineers with flight project experience. The IRB recommends repopulating the Line organization with experienced leaders and engineers to reestablish the Line organization as an equal partner with flight projects during implementation; adding experienced people and including them in effort to achieve balance; addressing the Division 31/34 staffing, accountability, and coordination issues; and continually examining the issues between and within Divisions 31 and 34 because of the importance of these Divisions to the execution of flight projects.

The JPL senior management engagement findings and recommendations were discussed. The IRB reported that JPL senior management did not adequately penetrate the Psyche Project status. The large number of small projects, instrument developments, etc., dilutes JPL senior management's attention, contributing to a lack of appropriate levels of engagement in the execution of major flight projects. It was also found that JPL's management review process and tracking metrics during the critical prelaunch period are inadequate. The IRB recommends that senior management must establish regularly scheduled meetings, formal and informal communications, and "drop-in" visits to facilitate necessary engagement on major flight projects, communicate priority, and maintain cognizance of status; prioritize the large number of activities competing for senior management's attention to focus on those in greatest need and importance such that commitments to NASA and the various stakeholders are met; and that senior management develop and codify in JPL's Flight Project Practices the metrics that will be employed for tracking progress, especially during system I&T and V&V.

The JPL hiring and retention findings and recommendations were discussed. The IRB observed that JPL is experiencing difficulty attracting and retaining necessary experienced workforce, especially in critical areas such as Systems Engineering, GNC, FSW, and Avionics. Local competition and aggressive hiring from commercial space firms and start-up firms have changed the position of JPL and its competitiveness in hiring, including compensation and remote work options. It was noted that the incoming workforce has different expectations about career opportunities and mobility. The IRB recommends developing the capability to successfully hire and retain mid-level people in this new environment, developing approaches for the career growth and retention of critical and high-potential personnel, characterizing problems with retention, and developing incisive and decisive actions to address the identified problems.

The JPL hybrid work environment findings and recommendations were discussed. The IRB determined that the current JPL policy for remote and hybrid work will have an adverse impact on flight projects because remote/hybrid work heightens barriers between sub-teams which impeded communication and integration. This means that without appropriate in-person interaction, remote/hybrid work can increase miscommunications and create reporting problems up the chain. The IRB recognizes that physical access to shared resources, i.e., testbeds, helps build team rapport and familiarity with the spacecraft. They also acknowledge that at this time, it is difficult to estimate the impact of remote/hybrid work on the flight project schedule and budget planning. The IRB recommends immediately revisiting the policy for hybrid work to make it more effective and more reflective of the evolving needs of flight projects in different mission phases; carefully considering which tasks, project phases, and circumstances permit hybrid and remote work arrangements; and that any hybrid work arrangements should recognize the need for in-person interactions. In addition, it is critically important that early-career employees work alongside seasoned employees for their long-term development. It is also recommended that inefficiencies in productivity and communications associated with hybrid work must be included in the workforce, cost, and schedule plans for flight projects.

The JPL CalTech Governance findings and recommendations were discussed. The IRB found that there are deficiencies in Caltech's awareness of flight project status and progress and that Caltech has not been sufficiently engaged in helping JPL address its workforce challenges. The IRB recommends that Caltech should have a better understanding of the JPL institutional issues and play a supporting role; that JPL should strengthen the quality of flight projects status presentations to Caltech; and that Caltech should develop a more rigorous annual review and evaluation approach for the performance of the Laboratory Director.

The JPL Institution summary and conclusions were discussed. The JPL Institution's issues include inadequate flight project staffing, in both number of personnel and experience; erosion of Line organization technical acumen; insufficient JPL senior management engagement in flight projects; and the post-pandemic work environment. These issues are having a significant adverse impact on the implementation of JPL flight projects. Many of Psyche's issues are a direct result of the JPL Institutional issues and that corrective actions are urgently needed, and failure to act will result in more "Psyches" and potentially in-flight failures. It is expected that the IRB will

review recommendation implementations within JPL and for the Psyche project in the latter part of March and the early part of April 2023.

Mr. Young concluded his presentation and was available for clarification questions.

Dr. John Grant inquired about recruitment and attainment plans for senior management. Mr. Young acknowledged that there is no easy solution. He stated that less than 50% of people within JPL work on flight projects, meaning that out of 6500 employees nearly 3000 are working on other things (administration/security). World class science and engineers are working on other activities. Mr. Young stated that they are not trying to minimize the importance of their work but in this critical situation diverting them to Psyche may be imperative. Secondly, a long-term solution is to create a comprehensive training program. Thirdly, diverting needed workforce personnel from current projects by delaying said projects. Fourthly, taking advantage of industry and support services from other NASA centers. Dr. Young admits that these options may not solve the totality of the problem but addresses current critical concerns.

Dr. Ishii inquired about what NASA may do in the future to prevent surprises that were identified through this review. Mr. Young described how the IRB approached the issues and how to most effectively open dialogue within the working level of the program. He goes on to state that they implemented five panels of the working-level people with approximately 6 to 10 people on each panel. They met each panel independently. Mr. Young insisted that JPL is an honest, open organization and that people willing to share their experiences. Panel members explained that they were trying to communicate concerns but were not able to do so. Mr. Young says that managerial inexperience with such a major program and project played a critical role. Mr. Young explains that the review was striking and emotionally moving.

Dr. Ishii inquired if there was anything NASA could have done to review or catch these issues sooner? Dr. Glaze responded by addressing the SRBs. She stated that there were many items of concern that were identified as “yellow” not “red” as they should have been, and so key components were overlooked. She further discusses how they need to address the structure of the review boards so that they can identify issues sooner and address appropriate levels of concerns. Mr. Young also addressed the SRBs. He explains that often concerns are averaged together. For example, a single issue is identified as “red,” and another is identified as “green” and as it is reported up the line the colors are averaged to “yellow.” Mr. Young vehemently stated that “reds” should not be offset and that they should be resolved on its own merits. He stated that this clearly happened with communications and concerns between the SRB, JPL, CalTech, and NASA HQ. He also stated that there was a tendency for this to occur across the board throughout NASA. Dr. Glaze agreed and reiterated that there was too much time between SRB reviews. As a tool used for success, they should be successfully set up.

Dr. Ishii relayed a member’s inquiry regarding any disconnect between the mission PI expectations and JPL practice. Mr. Young stated that the mission PI appeared to have communicated properly but that extenuating factors created communication barriers and breakdowns throughout the project management organization.

Dr. Jennifer Glass inquired regarding the lack of qualified personnel, the plan to move nonflight/mission personnel to flight/mission work, and how to avoid potential exacerbation of the same issues with the lack of necessary skills and morale issues? Mr. Young stated that organizations deal with high priority activities in a crisis environment and that sometimes “you do things that you must do, and not necessarily what you want to do.” He acknowledged that there might be potential issues with moving but as organizations must respond, so do the individuals. Mr. Young stated that his instincts are that JPL people understand that concept and would be supportive while they may express some dissatisfaction at the process.

Dr. Glaze expressed thanks to Dr. Laurie Leshin, the Director of JPL, for her part in the IRB process with developing the approach and response. She stated that Dr. Leshin was diligently working with HQ and JPL leadership to take challenges head on. Dr. Glaze reiterated that none in SMD can be successful unless JPL is successful. She further expressed that the support from NASA and JPL was extraordinary and that all were honestly looking to solve the problems.

Mars Exploration Program (MEP) & Mars Sample Return (MSR) Updates

Dr. Michael Meyer, lead Mars Scientist, was introduced. Dr. Meyer explained that Mr. Eric Ianson, Mars Exploration Program Director, and Ms. Tiffany Morgan, Mars Exploration Program Deputy Director, would not be in attendance. He also introduced Mr. Jeff Gramling, MSR Program Director.

Dr. Meyer began his presentation by explaining that Perseverance has done an excellent exploration of the crater floor and has concluded the Delta Front exploration. He stated that the Mars Helicopter Ingenuity has been operating extremely well and providing reconnaissance for Perseverance.

Perseverance is set to deploy the Three Forks Cache. It has been pairing samples in anticipation of leaving one of the pair on the surface of Mars, forming a cache depot at Three Forks. After completion of the depot, Perseverance will discontinue paired sampling and retain all acquired samples onboard after the initial depot is placed. Following the Three Forks cache deposit, the rover plans to ascend the delta front and begin the Delta Top Campaign. Perseverance Prime Mission ends January 6, 2023. In 2024, Perseverance would begin the Crater Margin Campaign, as part of Inside Jezero, which is likely to encounter possible lake shoreline carbonates, then maneuver to the crater rim of Jezero with expectations that it would encounter possibly deep crustal rocks with hydrothermal systems and alteration, and then move to ascend the rim. Between 2025 and 2029, Beyond Jezero would have the rover encountering fundamentally different geologic environments from the crater interior. Nili Planum would include impact megabreccia from both Jezero and Isidis, with possible encounters with ancient crustal rocks within an aqueously altered basement.

The Mars 2020 Ingenuity helicopter has completed 34 successful flights as of November 29, 2022, with a total of 7,392 meters flown with an approximate 59 minutes of flight time in its lifetime. Ingenuity survived 101 Martian sols of winter. It was grounded because the solar power was not getting enough sunlight to keep the batteries charged both day and night. It also needed installation of new software capabilities that included hazard avoidance when landing and use of

digital elevation maps to help navigate up and out of the crater. Flight 34 validated the installation and operation of the new major software upgrade with an 18 second flight with a 5-meter hover.

Dr. Meyer reviewed the Sample Receiving Project (SRP) status. This is the process that would occur once the Mars samples return to Earth. The SRP is the final element of the MSR Campaign that has a defined mission to recover, contain, transport, assess safety of, curate and scientifically investigate the samples returned to Earth by MSR. The primary goal of the SRP is to enable safe and rapid release of the returned samples to world-wide labs for science investigations. The sample receiving facility modality study shows that 30% of draft reports from Architecture and Engineering contractors optimized strategies for utilizing existing biosafety level (BSL)-4 facilities, 80% of draft reports are due in December of 2022, and the study will be undertaken in 2023. Per the National Environmental Policy Act (NEPA) Environmental Impact Statement requirement, the project is developing a work scope and scheduling dependencies as necessary. The program personnel are working with scientific teams, policy, and the Office of Planetary Protection (OPP) to establish implementation of sample safety assessment framework that ensures safety and enables expeditious distribution to the scientific community. Integration of the European Space Agency (ESA) science and curation of personnel into the SRP team is occurring in a collaborative attempt with the ESA. A sample and facility governance model assessment is currently in progress.

Dr. Meyer discussed the success of the Mars Science Laboratory (MSL) Curiosity as it celebrated its 10th year on Mars on August 5, 2022. It has driven over 17.5 miles (28 kilometers) and gained over 2,000-foot (600 meters) elevation. All of the Curiosity's instruments are performing as well as they did the day it landed. It has analyzed 41 rock and soil samples, drilled 36 holes, and determined that liquid water as well as the chemical building blocks needed for supporting life were present for at least tens of millions of years in Gale Crater. Recently, Curiosity navigated treacherous terrain of sharp rocks and sand to reach a "sulfate-bearing unit" at Mount Sharp, which is a scientifically compelling region enriched with salty minerals. These residual salty minerals could indicate streams and ponds that dried up billions of years ago. Dr. Meyer introduced Kathya Zamora-Garcia of NASA's JPL as the new MSL Project Manager.

Dr. Meyer presented information regarding the MEP orbiters. The MEP is successfully managing network activities with aging orbiters that are well into their extended missions. The Mars Relay Network (MRN) Health Assessment study conducted in July 2022 found that only one asset, the ESA's Trace Gas Orbiter (TGO), is expected to be viable into mid-2030. Odyssey which began its 9th extended mission in October 2022 is expecting depletion prediction, the results of a propellant investigation, in early December 2022. The Mars Atmosphere and Volatile Evolution (MAVEN) which established scientific collaboration with the United Arab Emirates' Emirates Mars Mission (EMM) Hope Probe to exchange data between the two orbiters contributed significant value to missions and scientists performing analysis. MAVEN began its 5th extended mission in October of 2022. ExoMars/TGO is continuing to support relay operations for MEP and returns more than 50% of relay data of landed assets. The Mars Reconnaissance Orbiter (MRO) experienced two recent safe mode events in October and November of 2022 and

successfully recovered. MRO has experienced approximately three safe mode events per year since 2020 with no root cause but events are associated with Galactic Cosmic Radiation maxima. MRO began its 6th extended mission in October 2022.

Dr. Meyer reviewed the MEP International Collaboration. NASA is considering potential collaboration on ESA's ExoMars Rosalind Franklin Rover Mission. The ESA Ministerial approved a 17% increase overall for the ESA 2023-2025 budget. This approved ESA budget includes funds to implement a renewed ExoMars/Rosalind Franklin mission and assumes NASA participation although NASA participation is subject to the availability of U.S. funding. NASA and ESA are currently holding key conversations on the potential collaboration.

Dr. Meyer shared MEP challenges. Budget constraints must be considered as NASA: executes the MSR, the highest science priority in the next decade; supports the ESA's ExoMars/Rosalind Franklin Mission; and considers its commitment to Artemis a central near-term strategy in the nation's Moon to Mars ambitions. The MRN orbiters are aging, and are not expected to live past approximately 2030, having already lived far past their original estimated lifetimes. Steeper requirements for the next steps in Mars exploration include replenishable networks of orbital and landed assets for systems science and closing strategic knowledge gaps to support planning for a sustained human-robotic presence on Mars.

Dr. Meyer presented the MEP strategy. The MEP is developing a strategy that considers revalidating and updating MEP Science Objectives; refreshing communication and imaging infrastructure at Mars; defining technology investment priorities that map to science objectives; utilizing low-cost initiatives to meet science priorities; exploring airborne missions (helicopters, balloons, etc.) to advance science; leveraging collaborations with commercial and international partners; capitalizing on rideshare opportunities; establishing synergies with human exploration of Mars (preparing for and science operations); and inspiring current and future generations to explore space. The program science goals are to search for past and present microbial life and habitable environments, to discover dynamic Mars (system science of geologic and climatological processes), and to advance human exploration of Mars.

Strategy development events since December 2021 included the Mars Exploration Program Office (MEPO) and HQ Strategic Planning Retreat #1, a Low-Cost Science Mission Concepts for Mars Exploration, a Science Objectives for Human Exploration of Mars Workshop, a MEPO and HQ Strategic Planning Retreat #2, an In-Person International Mars Exploration Working Group, an Industry Day, a Mars Concurrent Exploration Science Analysis Group (MCE-SAG) Report to MEP, and a MEPO and HQ Strategic Planning Retreat #3. The future MEP strategy development timeline for 2023 includes a draft Strategy overview in January, a draft MEP Strategic plan in February, a stakeholder review and comment in March, and finalization of said Strategy while building it into the MEP budget by the end of Spring.

Mr. Gramling described the MSR mission architecture as designed to safely bring scientifically selected samples to Earth for study using the most advanced laboratory instruments – those that will exist in the coming decade and those in the decades that follow. The campaign is designed around the ability to go where the science takes “us,” to facilitate bringing back the most

valuable samples. The architecture is complex and optimized to reduce development risk while ensuring scientific integrity of the samples. The Decadal Strategy Plan endorsed the continuance of the MSR. Mr. Gramling expressed appreciation in that recommendation.

Mr. Gramling explained that MSR is valuable because there are four powerful technical advantages that allow for great scientific study that would not be possible in space or on Mars. The access to sophisticated sample preparation reduces detection limits, improves precision, allows for greater accuracy, and is required for many instruments. Multiple, diverse, and large instruments that cannot be miniaturized offer an opportunity to make confirming measurements using multiple methods and analysis by future instruments can potentially occur. Discovery-responsive investigation pathways can be affected by changes in the choice and/or design of later experiments due to answers to early questions. Greatly improved spatial focus and resolution for evaluating microbial life on a microscopic scale and access to small grains are crucial.

Mr. Gramling chronicled the MSR Campaign and Program. The MSR Campaign spans multiple launches and one ground element. Element 1 is the Mars 2020 Sample Caching that encompasses the collection of samples of rock and caching on the surface for retrieval. Element 2 is the Sample Retrieval Lander (SRL) which retrieves the cached samples and launches said samples into orbit around Mars. Element 3 is the Earth Return Orbiter (ERO) which is to capture and contain the samples from Mars' orbit and safely return the samples to Earth for recovery at a landing site. Element 4 is the SRP that is responsible for the recovery and transportation of contained samples to a receiving facility, the safety assessment and sample containment, and the initial sample science and curation. The MSR Program manages development and operations of elements 2 and 3 and interfaces to elements 1 and 4. The MSR Program concludes after the recovery, containment, and transport of samples to the designated sample receiving facility. The MEP manages Mars 2020 Phase E operations and the SRP and would assume responsibility for recovery and containment of samples upon Earth landing.

Mr. Gramling gave an update on the program architecture. Pictured was a timeline that illustrated the deployment of Mars 2022 Perseverance in 2020, the ERO with Capture, Containment, and Return System (CCRS) in 2027, the SRL with Sample Transfer Arm (STA), Mars Ascent Vehicle (MAV) and Sample Recovery Helicopter(s) (SRH) in 2028, and the ERO with the Earth Entry System containing the samples reentering the Earth's system by 2033.

Mr. Gramling discussed the SRHs. Draft top-level requirements include accommodation of two helicopters on SRL to be used if Perseverance is unable to deliver samples directly to the cache depot location. The planned helicopter use case can accommodate 10 samples from the Three Forks surface cache. The helicopters must be capable of operating at elevations up to the Jezero crater rim including planned regions for Perseverance's extended science missions. The proposed approach would be to maximize Ingenuity's rotor and airframe heritage and add the capability for sample recovery and transport to SRL. Key challenges associated with the SRH include their mass which is being tested in Winter 2022/2023 to validate that the flight envelope will be capable of accommodating the new capabilities of the mobility and grippers. The SRH had a Mission Concept Review in June of 2022 and has a Systems Requirement Review and Implementation Review in the Spring of 2023.

Mr. Gramling described an overview of the MSR Depot Strategy. The initial depot is intended to be a risk mitigation against possible Perseverance catastrophic failure or major degradation (e.g., loss of mobility, loss of ability to drop tubes). Guidelines established in MSR-MEP/Mars 2020 Conops Agreement included establishment of the initial depot prior to reaching Perseverance qualified design lifetime (1.5 Mars years; 20 km traverse distance). The initial depot must be scientifically return-worthy (SRW). A science community workshop was conducted on September 28th and 30th to help establish what constitutes a scientifically return-worthy (SRW) sample cache. The expected sample suite for the initial cache is 10 sample tubes consisting of 7 core samples, 1 regolith, 1 atmosphere, and 1 witness tube; from each core sample pair, one sample will be placed in the initial depot, with the other samples retained onboard Perseverance. After placement of the initial depot, Perseverance will discontinue paired sampling and retain all acquired samples onboard until delivery to the SRL. In the event of degradation in Perseverance's state of health that threatens the ability to directly deliver samples to SRL, establishment of a second surface depot would be considered. A change in the final landing location can be accommodated as late as two to three months prior to landing, allowing for possible diversion to a surface cache in the event of a Perseverance failure.

Dr. Meyer explained that no formal science group was previously in place for the MSR campaign. An open competition was held in the Spring of 2022 and persons were jointly selected to be members of the Joint ESA-NASA MSR Campaign Science Group (MCSG). The MCSG will be implemented in two phases as the Campaign transitions from ensuring sample integrity to planning and guiding the Investigations of the samples. The Phase one focus is on Campaign science and sample integrity planning, developing ground-based infrastructure, and science community engagement. The Phase two focus is on the implementation of the objective-driven science. The NASA-ESA Science Memorandum of Understanding (MOU) is an agreement between agencies codifying the intended science collaboration and was signed on November 7, 2022.

Dr. Meyer discussed the Mars 2020 and MRS Sample Depot Science Community Workshop. The workshop solicited input from the science community on the potential for the samples in the proposed depot to meet MSR's science objectives. The workshop was organized by the MCSG. Pre-workshop information was sent out September 21, 2022. The workshop was held over two non-consecutive days, September 28 and 30, 2022. A maximum of 189 individual and group attendees were present although the total unique individuals were not tracked. Feedback, facilitating participation and inclusion, was accepted throughout the workshop. During the workshop, the initial cache was judged to be SRW and recommended the MSR depot formation at Three Forks. The workshop anticipated ten sample tubes deposited containing core samples, regolith, atmosphere, and witness tube(s). For each core sample pair, the shorter sample would be placed in the initial depot and the other sample will be retained onboard Perseverance. The workshop recommended that samples in the first depot should include Roubion (atmospheric sample), WTA2 (witness tube WB3), Montdenier, Coulettes, Malay, Atsah, Skyland, Hazeltop, Amalik (to be determined (TBD)), and Regolith (TBD). All findings of the workshop were accepted by the scientific community.

Dr. Meyer described the ten samples to be used in the cache. Stating that this sample suite is better than they had reason to expect to collect in the prime mission. It contains both igneous and sedimentary rocks, plus at least two and possibly four or even more distinct styles of aqueous alteration. Samples represent the full diversity of the rover's explorations and includes the following: four samples of igneous rocks from the crater floor including unaltered igneous minerals and aqueous alteration products such as subsurface water; three samples of sedimentary rocks from lake Jezero including mudstone that allows for the examination of clay minerals and sulfate cement and abundant organic molecule detections, silty sandstone that allows for the examination of serpentine minerals and heavy mineral concentrates including zircons, and medium sandstone that allows for the examination of rock fragment and grain diversity along with carbonate sediment; Regolith sample; atmospheric sample; and a witness tube. All of the science objectives for returned samples could be addressed by the samples already cached. These include igneous rocks that allow for dating of rocks, sedimentary rocks from the delta front that provide a target for the search for evidence of life, evidence of aqueous alteration allowing for insights into the history of water in this region of Mars, and organic compounds from which origins (e.g., biogenic versus abiogenic) may be deduced. These samples address major gaps in our knowledge of concern related to future human exploration.

Mr. Gramling explained that NASA's SMD Associate Administrator recently approved the Mars 2020 project to establish an initial cache at the Three Forks location in Jezero Crater. The proposed sample cache represents the full diversity of Perseverance exploration to date and is deemed SRW. The Mars 2020 project and MSR Program determined that the Three Forks location meets all site certification criteria. Mars 2020 is ready to proceed and construct an initial sample depot demonstrated by completion of an operational readiness review that included the full operational plan, process, procedures, and products in place, definition of traverse plans and sample tube drop zones, and construction of depot that is expected to take less than two months to complete.

MSR accomplishments of FY22/FY23 include the Mars Ascent Vehicle (MAV) System Requirements Review (SRR)/MDR completed in November 2021, the SLR SRR completed in March 2022, the MSRP SRR/MDR completed in July 2022, the program entering Phase B: Key decision point (KDP)-B Agency Program Management Council (APMC) in September 2022, and the ESA STA preliminary design review (PDR) in November 2022. MSR upcoming events include the NEPA public comment meetings on November 30 and December 6 to 7, 2022, CCRS PDR Part 1 in December 2022, CCRS PDR Part 2 in February 2023, ERO Mission PDR in January-February of 2023, SRH SRR in February 2023, MAV PDR in March 2023, SRL PDR in April 2023, and Program PDR in June 2023.

Mr. Gramling concluded the presentation by discussing the look forward. Now is the time as Perseverance continues to collect samples which increases the value of the cache on board, orbital relay assets are in place around Mars, and Mission and Science MOUs are in place for a joint NASA/ESA mission. Key program focus areas include technical developments, schedule execution, Planetary Protection implementation and verification, and coordination of complex multi-program partnerships. As a result of the success of Perseverance, the Campaign has

compelling samples ready to return and an establishment of initial cache retires substantial Campaign risk.

Dr. Meyer and Mr. Gramling concluded their presentation and were available for clarification questions.

Dr. Diniega inquired about the SRHs and their ability to independently retrieve the tubes from Perseverance. Mr. Gramling explained that the SRH would be able to obtain the tubes once Perseverance placed them on the ground and retreated to allow for room for retrieval.

Dr. Grant inquired about the International Mars Ice Mapper (I-MIM) report update? Mr. Eric Ianson explained that the international partners are continuing to work on the formulation of a concept and that they reached out to NASA for support. Open dialogue is happening regarding a potential means in which NASA can participate as, at this point, no funding exists to support. Possible potential participation with sponsors would not be dismissed.

Dr. Diniega, thinking about the Psyche IRB, inquired about any challenges or changes that are having to be incorporated into the planning of MSR. Mr. Gramling stated that there are staffing issues at both JPL and Goddard that they are having to work through. He indicated that they are actively participating in better communication with staff and international partners. He implied that they have work to do to ensure that all those contributing feel heard and involved.

Dr. Diniega directed an inquiry to Dr. Meyer regarding the timeline of the Mars Program Strategy's between the meeting of stakeholders and the planning budget. She stated that it did not leave much time to be able to communicate between those events and how do they plan to incorporate communication with the community. Dr. Meyer stated that there is already communication within the community and that the timeline demonstrates a finalization of what is already occurring through discussion. Mr. Ianson made a statement that working backwards in the budget cycle allows for better preparedness. Mr. Ianson stated that he agreed to take on the new role but wanted continued involvement in the Mars Strategy. He stressed the importance of engagement with the community.

Dr. Diniega stressed the importance of the science community's engagement in MSR. Dr. Meyer expressed hope regarding how the MCSG held the workshop and that it's model may be used for future engagement.

Deep Space Network (DSN) Update

Mr. Philip Baldwin, Network Operations Manager of the Space Communications and Navigation Program (SCaN) was introduced. He began his presentation with an overview of the DSN.

NASA's DSN was established in December 1963 to provide a communications infrastructure for all of NASA's robotic missions beyond Low Earth Orbit (LEO). The NASA Headquarters Space Operations Mission Directorate (SOMD) oversees the DSN through the SCaN Program.

Responsibility for development, operations, and management of the DSN is assigned to the JPL Interplanetary Network Directorate (IND). The DSN's prime responsibility is telecommunications for NASA missions, but it also supports many international spacecrafts as well as scientific investigations through radio astronomy, radio science, and radar activities. The

DSN has three sites: Goldstone, Madrid, and Canberra. Within the last decade, DSN has changed their operations paradigm to support missions using a process called “Follow the Sun,” which in 1963 involved a full complex of 24-hour shifts of plugging and unplugging wires, but now automation allows for remotely controlling sites during the day period. He explains that he will give an overview of the DSN, review DSN demand and loading, discuss DSN sustainment of current assets, and present DSN future assets and upgrades.

The DSN consists of three deep-space communications facilities placed approximately 120 degrees apart, hosting 34- and 70-m antennas and operates, maintains, and upgrades the three tracking complexes around the world along with a centralized operation at the JPL. The DSN was designed to communicate with spacecraft located 16,000 km (10,000 miles) from Earth to beyond the edge of the solar system. It’s poised for support of interplanetary spacecraft missions. It provides radio and radar astronomy observations. Currently, key missions that involve the DSN include Artemis, James Webb Space Telescope (JWST), Juno, New Horizons, Mars Rovers and Orbiters, Mars Perseverance, Mars Science Laboratory, and Voyager. Mr. Baldwin stated that Generally DSN focuses beyond the Moon, but in the future they will be supporting human exploration at the Moon and beyond (to Mars). Mr. Baldwin explained NASA’s communications networks. The Near Space Network (NSN) is a collection of direct-to-Earth ground stations and it also includes the Tracking and Data Relay Satellites (TDRS). Previously, there were two networks, but Goddard combined the Near Earth Network and the Space Network to form the NSN at the end of 2020. NSN has a collection of government and commercial stations, but is moving towards a more commercial model. Along with the NSN, the DSN is also looking at partners and commercial options.

The DSN is looking forward and they see a need for more antennas. The DSN have a project to expand the number of 34-meter Beam Wave Guide (BWG) antennas over the next ten years, which is called the DSN Aperture Enhancement Project (DAEP). Mr. Baldwin explained that multiple antennas were in various stages of build and expressed that the DSN knows progress is happening and needs for the DSN are growing.

Mr. Baldwin discussed DSN loading and utilization studies as it applies to the importance to the Agency. NASA has a strategic and tactical interest in understanding upcoming demand for deep space communications and tracking services and if, or when, this demand will exceed its capacity in future years. The DSN regularly conducts capacity and loading studies to quantify projections for future “supply” from networks versus “demand” for services from missions using the following data: number of antennas and tracking hours available versus requested; uplink frequencies, data rates, and data volume capacity; downlink frequencies, data rates, and data volume capacity; antenna gain-to-noise-temperature (G/T) and Effective Isotropic Radiated Power (EIRP) metrics to characterize the capabilities of antennas for downlink and uplink. Additionally, SCA and the DSN complete ad-hoc studies to investigate any concerns with support and/or services. Most recently it completed a study to investigate communication issues discovered with key missions. That study recommended that SCA and DSN increase network capacity at each complex beyond the current DSN DAEP plans, which is in line with the overall regular loading study that was conducted.

A graph was presented that demonstrated the projected DSN use by sponsor including the SMD, SOMD, Exploration Systems Development Mission Directorate (ESDMD), Space Technology Mission Directorate (STMD), commercial, and international. Mr. Baldwin describes how the downlink count more than triples in the next fifteen years and how the SMD remains the dominant beyond-GEO (Earth) customer in these projections. A second graph displayed count of downlinks by band with the 2021 Best Guess Mission Set Scenario. Bands include S-Band NE and DS, X-Band NE and DS, K-Band NE and DS with different frequencies. The Human lunar exploration and operations will drive a substantial increase in X-band and Ka-band utilization while S-band use is projected to decrease over time if NASA adopts the Interagency Operations Advisory Group (IOAG) Lunar Communication Architecture recommendations. X-band deep space use increases substantially as the number of deep space robotic users increases as well. A third graph reviewed downlink antenna hours and excess demand based on the 2021 Best Guess Mission Set Scenario. A 50% steady-state excess demand during the 2030's is projected and a 100% steady-state excess demand during Artemis in the 2030's is projected. The average data rate increase in 10 years is six times the downlink and 690 times the uplink with a data volume increase in 10 years being 36 times the downlink and 1600 times the uplink. While the DSN has never been able to meet the historical excess demand max, it has found solutions to assist partners and organizations to help meet their needs. Causes of the excess include but are not limited to unparalleled growth in robotic and crewed missions, unparalleled growth in uplinks and downlinks, and especially demanding human exploration missions.

Mr. Baldwin explains how the DSN can meet excess demand needs and mitigate capacity constraints. Present-day loading studies project large increases in DSN demand in the 2020's and 2030's that, at times, will significantly exceeds the supply of DSN antennas. Possible mitigations being investigated include the following: enhanced DSN tracking, telecom, or operational techniques internally, i.e., minimize setup/teardown times, how can the DSN maximize the time a spacecraft is communicating with the DSN; equip DSN antennas with more frequencies, i.e., can each antenna be maxed on all capabilities; engage missions to move towards higher radio frequency (RF) as Ka-band is more accessible and easier to downlink; utilizing additional antennas, DSN or non-DSN, including other agencies; relay assets at Moon (and Mars) with crosslinks so that all local data can be sent through a single relay to one Earth antenna versus individual antennas on the ground; and optical communications.

In addition to studying the assets and capabilities needed to meet future mission demand, SCA_N and the DSN are taking steps to improve current network assets. SCA_N began the "Road to Green" Initiative in September 2020. This included an examination of the current state of health of the DSN. The DSN then determined concrete steps SCA_N could implement to improve the DSN's reliability and robustness including sparing, fiber security, and fire suppression. Additional funding allowed Scan to prioritize areas directly related to health and safety, information technology (IT) security vulnerabilities, facility infrastructure, and antenna vulnerable components. Mr. Baldwin assured the PAC that there are no near-term plans to retire the 70m antennas, instead transmitter modernization efforts will take place as there appears to be a foreseeable future need. The "Road to Green" Initiative addressed the holistic view of the DSN sites.

The 70-meter Transmitter modernization project revitalizes the 70m antennas by addressing the highest risk subsystems, the transmitters and associated power and facilities while retiring a DSN “red risk” associated with Deep Space Station (DSS)-43 High Power S-Band Transmitter, the only uplink capable of supporting Voyager-2 commanding. Goals include modernizing the designs in the 20kW workhorse transmitters, adding wideband 80kW X-Band capabilities, improving reliability and removing obsolete components, improving maintainability by replacing multiple transmitter designs with one transmitter design throughout the DSN, replacing obsolete Power Distribution equipment and Cooling Equipment, replacing cooling towers and retiring the risk regarding the Madrid Deep Space Communications Complex (MDSCC) cooling towers, and replacing and updating transmitter, servo and hydrostatic bearing cooling equipment.

The first of three 70m sustainment activities have been completed on DSS-433 in Canberra, Australia. The antenna downtime was originally scheduled for February 2, 2020, through January 17, 2021. DSS-43 is the only antenna in the world that can communicate with Voyager 2 which means that the downtime was closely monitored. The start was delayed six weeks due to a Voyager 2 spacecraft emergency. The DSN Service Readiness Review successfully completed in February 2021. The DSS-43 was operation as of February 12, 2021, and supported early uplink with Voyager 2 in October 2020, after a delay due to COVID-19 during the downtime. DSN 70m upgrades are planned to take place at Goldstone from approximately 2025 to 2026 and in Madrid, beginning 2028.

SCaN has a 3-Part Network Capacity Plan for Artemis and Lunar Science. The first part of the plan was the 34m antenna upgrades which required upgrades to two DSN antennas at each of the three complexes, totaling six upgraded antennas, to increase capabilities. The second part is the 18m Antenna Subnet Development now known as the Lunar Exploration Ground Sites (LEGS), which is a dedicated new set of antennas, designed to support lunar missions, to help alleviate the user load on the current 34m and to allow for a focus on deep space support. This would begin with 3 sites spaced around the Earth. The third part of the plan is a Lunar Relay and Interoperable Lunar Network that removes Direct-to-Earth (DTE) line-of-sight communication constraint and reduces user burden. Continuous communication during Human Landing System (HLS) descent is easier supported through a relay link than a DTE link.

Lunar Exploration upgrades represent a low-risk option to help meet Artemis program and Lunar science needs. Modifications will be made to two antennas at each DSN complex that involve simultaneous operations of band exchange.

LEGS will provide DTE RF communications to users ranging from the GEO orbit to Lunar surface and orbit, and to Sun-Earth-Lagrange orbits. A key objective is to offload DSN 34m antenna assets for “near space” missions such as the Lunar Missions including Gateway, HLS, Orion, space launch system (SLS) and Exploration Upper Stage (EUS), CLPS, and Cubesats. Gateway, HLS, lunar terrain vehicle (LTV) contracts will be designed for LEGS compatibility. Mr. Baldwin stated that the DSN is entertaining commercial contacts for compatible Near Space missions.

SCaN provided a recommendation to the mission community to limit DSN hot back-up use by Artemis missions for critical events only, to develop a strategy to deal with the expected demand increase from lunar Cubesats, and to increase utilization of Ka-band to meet science data return requirements in the short term. Future missions that need data return rates beyond the capability of a single Ka-band antenna will be required to investigate alternate solutions which may include maximizing Ka-band throughput via higher-order modulation and coding via ground system receiver and flight system transceiver upgrades which is common in the industry but not leveraged within NASA; arraying multiple Ka-band antennas, allowing for high antenna gain which increases data rates; and utilization of optical communications which would help alleviate the data communication issues.

Mr. Baldwin stated that SCaN is committed to studying future mission requirements and demand to make informed decisions about Network improvements and that SCaN remains prepared to support all future NASA missions, from the Moon to Mars and beyond. Mr. Baldwin reiterated that SCaN's goal is to continue to be proactive and ensure that the needs of the Agency will be met with a robust, reliable, and cost-effective network.

Mr. Baldwin concluded his presentation and was available for clarification questions.

Dr. Diniega relayed technical member inquiries regarding how DSN was projecting supply and demand involving small spacecrafts in the future. She also presented Dr. Curry's inquiry regarding the discrepancy of the low-cost of Cubesats versus their higher operational footprint and inquired how the DSN is incorporating smaller missions into their projections and how smaller missions might be impacted by shortages or outages. Mr. Baldwin stated that it is a challenge to not overlook the Cubesat missions while supporting billion-dollar Flagship missions, but they are both being accounted for in the projections as best they can. He stated that the DSN has a Mission Commitment Office that is involved early in the AO process to allow for insight into future missions including Cubesats and how to best anticipate the needs. DSN wants to support all missions, but it is understood that the organization cannot. That is why understanding how DSN can best support with other apertures is so important and not creating competing missions.

Dr. Curry followed up Mr. Baldwin's statements with an expressed concern regarding the understanding of the prioritization and mitigation strategies, especially with the spacecraft emergencies between Class-D mission and those above. She stated that it might be worth revisiting the policies so that those types of heavy decisions are not falling solely on the DSN. Mr. Baldwin replied that a working group for prioritization is to commence after Artemis splashdown to review the prioritization schedule.

Dr. Ishii sought clarification regarding the DSN not planning to design to the spikes in demand. She inquired if the DSN looks towards, for assistance with mitigation, international partners or new capabilities and technologies. Mr. Baldwin replied that the DSN looks towards international partners and working it out in the scheduling process. Advanced planning and scheduling can be done 16 weeks out. He also stated that while DSN meets all mission needs and requirements, it may not meet all mission requests that are represented by the spikes in demand. He estimated

that approximately 69% of requests are met. He confirmed that a higher budget would help mitigate many of these issues.

Dr. Conor Nixon inquired if the current funding was able to keep up with DSN upgrades and future plans. Mr. Baldwin stated that one of the biggest challenges regarding the budget for the DSN and associated projects was DSN visibility. Being able to communicate with projects is an “invisible” or given understanding in a mission, but a communications budget is often overlooked in the planning stages. This is being mitigated by becoming more visible in the community by attending meetings and through initiatives like the “Road to Green.”

Dr. Nixon inquired if there were any hard limits to the lifetime of the antennas. Mr. Baldwin stated that there is no hard limit for the lifetime of the antennas. He did describe that the biggest thing the DSN must deal with is obsolescence and single points of knowledge in reference to the antenna’s operability. He further explained that a lack of skilled, trained personnel on the dated hardware exists and that supply chain discontinuation problems are cause for concern.

Dr. Nixon commended the DSN on its efforts in communication.

Dr. Diniega sought clarification regarding the focus of Lunar Resources onto new assets and whether that would open existing resources for other current or small planetary missions. Mr. Baldwin replied that the expectation of LEGS would be to alleviate and pull off Lunar traffic for a sustained presence. If traffic can be moved off the DSN and shifted to the NSN that would allow the DSN to focus on further science exploration and Mars.

Dr. Lisa Danielson inquired on how commercial networks are being evaluated and how does the DSN see them being used. Mr. Baldwin stated that the NSN is already 50% commercial. In the near term, utilization to 90% is the goal. It is a commodity, companies that support near Earth observation and utilizing those options allows the DSN to focus on the needs for further space missions.

Dr. Westlake clarified thoughts on the conflicts for key events. If things are on the same craft, then key events would be occurring in the sky at the same time. Think about how many secondary payloads are on the primary payloads and how much DSN loading will happen or will NASA be encouraging the consideration of use of outside agencies for the secondary payloads.

Decadal Survey Discussion

Dr. Lori Glaze stated that she was going to review a few slides from the August townhall meeting to spark discussion of the Decadal Survey Discussion. She reiterated that this is a landmark survey. The survey explicitly included astrobiology and planetary defense with a strong emphasis on how human exploration complements robotic exploration. To set the context, she reviewed that the initial written and public townhall response is available online. She reminded the attendees of the recommended program budget for PSD in FY23–32 as being \$41 million and that they recommended a level program budget for FY23–32 as being \$34 million. She presented where the current planning budget demonstrates a short fall in the near term and that some delays may occur. Dr. Glaze expressed excitement regarding the decadal survey’s thoughts on the Uranus Flagship. The science and mission concept are well established, well

studied, and strong. They are working on a plan for limited technical studies and early payload selection. NASA and other stakeholders on board before the plan is made public. She encouraged patience and flexibility as this is a long road forward. She discussed near-term activities such as trajectory studies for later launches and longer cruises, focusing the broad trade space of payload scale and strategy, and preparing the FY25 budget this upcoming spring. She discussed the recommendation for a new technology plan and that conversations regarding planning have occurred. Dr. Glaze reinforced the survey's statements regarding the State of Profession (SoP). The survey stated that SoP, including issues of diversity, equity, inclusivity, and accessibility (DEIA), is central to the success of the planetary science enterprise. Its inclusion in the survey, for the first time, reflects its importance and urgency.

Dr. Kiefer inquired about the New Frontiers launch date for that opportunity and if VERITAS was not an issue, what was the no earlier than launch date for the Discovery missions. Dr. Glaze stated she would research the dates as she could not immediately recall. Dr. Wagner stated the launch dates from the website for New Frontiers is no earlier than fall of 2031 and no later than fall of 2034.

Dr. Diniega inquired about connecting human and science priorities and an update regarding how the goals should be created. Dr. Glaze stated that more information would be provided with the Lunar Science presentation tomorrow.

Dr. Diniega inquired about an update in the PSD regarding the balance of large and small missions. Dr. Glaze stated that the situation now is still more or less the same. They are still looking at the overall balance, keeping it in mind as they work on the upcoming budget.

Dr. Diniega inquired about any update on the recommendation of the cost cap changing and how there are budget concerns especially with Phase E costs. Dr. Glaze said that she thinks that there will be a cost cap whether it applies to the project as a whole or for Phase E. She stated that cost caps would be holding projects accountable for their budgetary use. She does not think there is necessarily enough scrutiny on the Phase E costs early enough.

Dr. Diniega inquired about a plan update on the study regarding feasibility of outer solar system missions competing against inner solar system missions, especially as it relates to cost caps. Dr. Glaze stated she did not have an answer for the question at this time and directed it to Dr. Wagner. Dr. Wagner stated that there are a lot of new missions going on currently and that there are a lot of new ways to look at cost estimation. It is being assessed and that it is not forgotten, but there are so many things occurring currently. He stated that they wanted to ensure a level playing field.

Dr. Diniega inquired on the coordination efforts associated with science engineering, information development industries, and technology associated with the decadal survey. Dr. Glaze stated that they would like to have better effectiveness in their investments, such as tools and instruments working like they are supposed to and that they are being used as appropriate. She stated that conversation is going well with investment in technologies that are relevant to the PSD. Dr. Montbach replied that they are in the works of how they are going to respond to the decadal survey and the requests. They are working to put forward a list of technologies that will

be beneficial and provide support. She was unable to give specific numbers or costs currently. She expressed that they should be able to share more information in the future. Dr. Diniega made a statement that it should be a future talking point.

Dr. Diniega discussed the Internal Scientist Funding Model (ISFM) and the response of the decadal survey recommending paying civil servant salaries through R&A funding and how NASA did not agree. She inquired about expected implications then for funding distribution between those at NASA centers and those not. She made statements that the PAC has had previous discussion regarding the fairness of access to research funds. Dr. Glaze wanted to make one overarching comment about the funding distribution. She explained that the ISFM is an approach, or a philosophy, to fund a small fraction of science folks at NASA centers. She stated that the decadal survey recommendation, associated with the funding of the ISFM, fund the civil service salary only. NASA did not agree. The program is to fund the science and not just the scientists which can include travel, technology, etc. Dr. Rinehart stated that majority of people at NASA centers are not civil servants, most are contractors. Teams are integrated with civil servants and contractors. On the topic of funding balance, one of the requirements of ISFM is that funding should be done in a cost-neutral manner. The amount of money going into the funding centers has not changed relative to pre-ISFM. It does not affect the community member's odds of success in ROSES. Dr. Diniega was trying to clarify which parts of the ISFM the decadal recommendation applied to and whether it was cost neutral. Dr. Glaze discussed funding balance and the cap Dr. Rinehart has applied to centers, making statements that a center would need to adjust their portfolio of work if they wished to pursue something new. Dr. Rinehart stated that if the R&A budget was to increase significantly that the cap would most likely be increased. Dr. Diniega inquired if there was a plan for a formal reassessment at some point. Dr. Rinehart responded that SMD and OCS did a full review which was presented at a past PAC meeting that demonstrated markers of success of ISFM. Out of nine, seven were positive and Dr. Zurbuchen was encouraged and agreed for it to move forward. That being said, Dr. Rinehart ensured all that they are constantly reviewing ISFMs. They have an end of the year review. They have a plan for staggered midterm reviews with Ames Research Center being focused on next spring. Those reviews would include visiting committees to ensure interaction, hear comments, and review the science. The committees would then use the "red, yellow, green" metrics regarding the science to ensure that great science is being done. Dr. Glaze brought up comments regarding the fact that perhaps the ISFM aren't being reviewed. She assured that they are constantly reviewing. Dr. Rinehart agreed and stated that some have made statements of "why would I want ISFM when the scrutiny is double that of a ROSES award?" He stated he is trying to reach a balance between oversight without it being too burdensome. Dr. Glaze did state that they recognize that they are taxpayers' dollars and that they want to ensure that they are the getting the most out of that.

Dr. Diniega inquired about a budget augmentation if costs increase, that NASA responded that they would critically assess any cost increases and expressed concern that if the MSR needs more funding that cuts would occur to other missions. Dr. Glaze stated that as missions become more mature and as they get fidelity in the design, the cost never goes down, it always goes up. She stated that the expectation is that there would be a cost increase, hopefully modest. She

really appreciated the points that the decadal included terminology regarding the percentage of the planetary budget and that there should be new appropriations to cover the increase in cost versus cuts to other projects. This wording allows for the request of assistance from stakeholders to assist with cost increases. Dr. Diniega confirms that she understands the concept but is hesitant about the future. However, Dr. Glaze also stated that it is important to focus on the near term to prevent long-term budget changes and that they are aware that the community is concerned that MSR would cause cuts to their budgets.

Dr. Ishii inquired about a timeline regarding the results of the interagency working group (IWG) on equitable data, the SoP, and its impact on the community. Dr. Glaze stated that they would need to follow up on the IDEA leads. She did state that it would be a long-term effort to form and respond to the recommendations in relation to the SoP. Dr. Rinehart did reinforce that it is an “interagency” WG and that it takes time to communicate.

Dr. Diniega inquired about the study associated with what questions could be asked on work force surveys and how is PSD looking to include those in the future. Dr. Glaze and Dr. Rinehart stated they did not believe there had been results for that study at this time. The primary responsibility of that study would be handled at the SMD level. Dr. Diniega stated that information should be gathered to share information for a future PAC meeting.

Dr. Diniega inquired about the coordination between the PSD, the SMD WG, and NASA regarding the enhancement of minority communities in the programs. Dr. Glaze stated she could speak on the SMD WG. She stated that the PSD has its own IDEA group that works closely with the SMD WG. They are looking internally, within SMD, to try to identify places where they can do better in their own workforce and attracting talent from a broad and diverse base. An ongoing initiative within SMD, is the Bridge Program. A workshop was held recently to engage with faculty at universities that are serving the underrepresented populations where they tried to co-create what the Bridge Program might look like, one that would connect students and faculty with NASA institutions and centers. She stated that there would soon be a call put out for the Bridge Program to help with inclusivity. IDEA within SMD has a whole implementation plan that is tackling near term, long term, inter/external action items to ensure that their own “house” is as clean as they can make it. They do coordinate up and down through the SMD and PSD regarding consistency as it pertains to the action plan. Dr. Rinehart stated he would include how members could search for minorities in his presentation tomorrow. Dr. Diniega wanted to ensure that the PSD was actively involved.

Dr. Diniega inquired about planning with minorities or minority organizations that already have a framework for use or is NASA trying to create their own program. Dr. Glaze stated that they are already engaging with organizations that serve minorities. She stated that they are several approaches they are taking and that they are not trying to reinvent. They are looking to identify previous knowledge gaps and how to address those concerns. Dr. Rinehart stated that they are working with professional societies and that they are in the process of building relationships, but it takes time to build trust.

Dr. Diniega inquired if there was anything that would be helpful for the PAC to discuss regarding the fact that the AA is changing. Dr. Glaze asked for clarification. Given that the AA is changing, Dr. Diniega responded, is there anything the PSD would feel might be helpful for the PAC to discuss to encourage continuity as leadership changes. Dr. Glaze stated that PSD would need to wait to see who the new AA will be, that they have an incredibly strong program, that an endorsement of the program might be helpful, but that the biggest thing is to support up through the next science committee. Dr. Rinehart stated that he wasn't exactly sure how to answer that question without knowing who the next AA will be. Dr. Diniega stated that it would be best to continue the conversation or perhaps submit a finding. Dr. Rinehart reminded her that there would be no AA before the next PAC meeting so efforts might be best in discussion and waiting. Dr. Glaze stated that she hoped they would have a new AA by June.

Dr. Diniega inquired about CoC, the development of CoC, and IPs and requested if there could be continuity in these items but also in how information regarding these items are delivered. She also inquired about efforts being made at the PSD level and coordination with SMD. Dr. Rinehart stated that there is a lot of stuff to discuss regarding these topics and that he would not be able to hit on all of them at this time. He stated that CoC are required for field campaign. If you submit a field campaign to ROSES, there must be a CoC. Mission teams have "rules of the road" for decades and most of these include a CoC. There is a push at the SMD level to normalize or create a template that missions could start with, but it has not been created yet. Dr. Glaze stated that there was an enormous amount of pushback regarding a template CoC for mission teams and projects, for legal reasons, so they are now trying to pursue an alternate path of shared expectations and recommendations that can be shared with the teams. They are trying to find a work around that gets them to where they need to be without using that language and staying within the law. Dr. Rinehart stated that last year astrophysicists introduced the idea of IPs and that he was skeptical. However, ESSIO took it up and tried it with a few of their programs. They found that it worked well. SMD community of practice group that is working on and SMD-wide plan of what an IP would look like. Dr. Rinehart said that it is about getting "your" house in order – how do they make sure that their team is inclusive? Are they including proper training? How do they make their team work better? He felt that it was critical in addressing leaky career path issues. It is the first step in getting people to understand the bigger issues. He stated he really likes where it is going but it is not complete yet. He stated it most likely will be present in the 2024 ROSES. His biggest concern was that people were asking "too much" and wanted IPs to fix everything which is beyond the skills and budget of most proposers. When IPs are introduced, they will allow for part of the budget to cover costs associated with ensure that IP requirements are being met. Dr. Rinehart stated he would discuss this matter further during his presentation tomorrow. Dr. Diniega inquired if PSD was looking at or coordinating with Astrophysics regarding a social scientist on contract to help develop resources. Dr. Glaze mentioned that they had been discussing how to bring on social scientists for a variety of different topics. She stated she wasn't sure if it would be best to have each division with their own social scientist or if it would be more valuable to have an SMD-level social scientist engaged on those topics. Dr. Rinehart clarified that APD does not have a social scientist on their contract. SMD has a social scientist on their contract [corrected after the meeting: the social scientist is funded by APD, but is working for all of SMD].

Dr. Ishii inquired about having an annual funding level of 10% for R&A and how it didn't necessarily answer the recommendation. Dr. Glaze agreed that the budget needs to increase, that it is great to have the 10% target. She stated that some of the disagreement stems from how they define the competitive research and that they didn't want them to include the ISFM and some of the other research stuff that they do is part of the research program. Dr. Glaze stated that Dr. Rinehart has worked hard to define what they mean by 10% of that program. Dr. Rinehart stated that openly competed research should be 10% but they didn't account for the fact that they double the amount of the budget, then they need more people and support. They did not recognize that they can't increase in isolation without it effecting little things along the way. While he loves the recommendation, it is a question of definitions.

Dr. Diniega inquired about the New Frontiers draft call expected release date as the original was November 2022. Dr. Glaze stated that it is close. Dr. Wagner stated that members should check the acquisition website and that as soon as available, details would be released there. No further comment would be made.

End of Day Discussion

Dr. Diniega opened for discussion. She handed the floor over to Dr. Ishii.

Dr. Ishii inquired if the VERITAS delay would be enough to mitigate the issues. Dr. Glaze stated that it only partially offsets the additional cost of Psyche. They are working on a fuller solution that takes care of everything in the budget. They are not looking at one single mission to fix all problems, but it does help offset challenges, particularly in the near term. She then further explored the topic by asking if the VERITAS delay addresses the workforce balance issues out at JPL and is it sufficient. Dr. Glaze stated that did not know. That it may or may not be sufficient. It is one knob that they have turned and that they are going to be doing an assessment in Spring to see where JPL is with the workforce issues. She would not expect a delay in VERITAS to be an immediate solution for all issues. JPL is not only supporting Clipper and MSR, but they also have multiple other projects that they are not able to staff appropriately. Through all of those, it makes it difficult to staff the bigger projects. Dr. Glaze said that she does not think this will fix everything, but it is a part of a much more complex solution. Dr. Ishii asked if this could ultimately lead to delays in New Frontiers or Discovery calls in general. Dr. Glaze stated that the whole spectrum is open, but as of right now they are holding to the New Frontiers schedule. They really want to hold to that new Frontiers call. She stated that it would require effort on her part to acquire funding to support both the VERITAS and Discovery missions.

Dr. Glass inquired about to what extent CalTech, who oversees staffing and managing JPL, should be brought into the conversation. Dr. Glaze stated that CalTech does manage JPL at the top level, in the fact that all JPL employees are CalTech employees. However, CalTech does not manage staffing of individual projects. Because there is so many projects and so much work, it occupies a lot of senior management's time at JPL, to ensure that they have the staffing covered on each of the projects. She addressed it as a dynamic problem with ripple effects associated with people being transferred, retiring, or leaving. She does not think that CalTech needs to be engaged in day-to-day staffing – the expectation might be that they would be more engaged in

the leadership of JPL. Dr. Glaze stated that the findings were directed at JPL and not at CalTech or NASA. JPL has concurred and is working on those issues.

Dr. Ishii inquired if other options were considered and what they might have been. Dr. Glaze stated she alluded to the fact that there are no good answers in her presentation. She stated that they have been looking at everything for months, even before Psyche. With the inability of Psyche to launch and the IRB findings, they focused more on this issue. Dr. Glaze listed the projects at JPL: Europa Clipper, MSR, NEO Surveyor Mission, Psyche, Trailblazer, VERITAS, and EnVision. She brought up the fact that the decadal survey says to prioritize the competed missions over the big, directed missions and agrees that in the longer term she would be inclined to prioritize trying to get Discovery and New Frontiers before the next Flagship. But in thinking right now, if they contemplated a slip in the Clipper, it would affect MSR and create an enormous cost implication. Dr. Glaze recognized that the priority is competed missions but stated that the delay in larger missions will end up costing even more longer term. So, with that thought process – Clipper and MSR were taken off the table. As far as NEO Surveyor, she discussed how they have repeatedly had their budgets cut, their launches delayed, and faced other issues including not meeting goals given to them by Congress. So, the decision was made to not impact that mission, but to try to get them to confirmation. The Lunar Trailblazer is a small mission and a nearly finished mission that would not address either the workforce or cost issues. Dr. Glaze stated that they could have opted to cancel Psyche. It would have saved some funding in the near term, but it does not address much of the workforce challenges. EnVision was reviewed but it is a European mission and there is no control over that launch and that the relationship with ESA could suffer. She stated that the bottom line is that they looked at every single option. Dr. Curry spoke on the thought process during this decision and whether things were being looked at on a mission level and if R&A was included. Dr. Glaze stated that she and Dr. Rinehart have fought hard to protect R&A to not have to dig into there. She did admit that it doesn't mean that they won't have to dip into it to fix some problems, but they are trying so hard to increase that budget. Dr. Rinehart stated that when R&A goes down, it is difficult to get it back up again. If anything would be taken from R&A, it would be with a clear understanding that it would be a payback soon. A one for one dollar payback so that they can maintain an overall budget without impacting R&A in the long run.

Dr. Ishii inquired if funding, during the delay, would be provided for engineering support as it is for the science team and expressed concern regarding continuity for the engineering team so that expertise and momentum are not lost. Dr. Glaze replied that, unfortunately, this would be a complete stand down. In the current context, she is unable to keep the whole team going at a continuity level. She expressed that she understands that it is awful and that she doesn't like it. The project is in the process of coming back to HQ to let them know what is required for the orderly standdown. She knows that has implications for the team and for international partnerships.

Dr. Grant sought clarification regarding the standdown of VERITAS. He stated that there was a comment that Dr. Glaze did not know yet if the standdown of VERITAS, regarding money and personnel, would solve the problem. Then he stated that another comment, more recently made,

was that if they had canceled Psyche that it wouldn't have solved the problem. He then pointed out that there are more people and money in Psyche. He made the statement for clarification that the stand down of VERITAS will not solve the problem. Dr. Glaze responded that they are looking to address issues that they will face in the next couple of years as VERITAS would have been ramping up. While the standdown of Psyche may have addressed something right here today, it would not address issues that they are seeing as they move forward. Dr. Grant followed up by inquiring if more people and more savings needed to be found. Dr. Glaze stated that it was possible. She stated that the IRB would be re-evaluating in the Spring, and they have asked for them to return in 2024 prior to standing VERITAS up to ensure that challenges are resolved. Dr. Grant sought clarification regarding "2024" and whether that meant FY24. Dr. Glaze stated a hesitant yes. Dr. Grant followed up with a statement of possibly reviewing the stand up of VERITAS as early as the end of next year (2023). Dr. Glaze stated that it could although the thought process would be possible stand up in 2025. Dr. Grant then led discussion into whether VERITAS would get the priority above a Discovery call since it had been selected and competed. Dr. Glaze stated that she would think that they would but that they would need to have communication with the community and review all things.

Dr. Ishii inquired about the effect this will have on complementary missions such as DAVINCI and EnVision and how it was anticipated that those projects would use information provided by VERITAS. Dr. Kiefer, as a member of the DaVinci science team, spoke on the matter. He stated that he disagrees with the fact that they need data from VERITAS. DAVINCI is an entry probe and will do imaging. It cannot land on a Discovery budget but the data from a higher resolution radar data will not change where the mission is going to go. VERITAS would provide data to extend the DAVINCI data to a larger domain so that is valuable. On the other hand, DAVINCI is the ground truth for interpreting the radar data below the clouds. Both missions effect each other but from his perspective it doesn't matter which one goes first. EnVision is a little more scientifically complicated but believes that the same answer is probably true. While both missions were originally going to launch in the same year, this demonstrates that they could be done so independently. Dr. Glaze stated that all three missions (DAVINCI, EnVision, and VERITAS) were independently proposed and developed with no reliance. They were selected on the basis that they did not rely on any other missions. So, while it is very valuable to have the data from all three, none of them have a set requirement of data from the other missions. They may benefit from those measurements, but they don't require them.

Dr. Ishii inquired about the plan to monitor the progress. Dr. Glaze stated that they have a whole policy group at SMD, and they have an assigned individual who is going to take each one of those recommendations that is going to track them and follow them. She stated that this process would not just be until the Spring but for the continuing future.

Dr. Ishii turned the floor back over to Dr. Diniega.

Dr. Diniega inquired about how the only viable asset in the 2030s is to be TGO and what affect that would have on MSR and beyond. Dr. Glaze stated that she could answer on a high level. MSR was envisioned that the earth orbiter provides communication relay upon return. So, there should be no need for additional relay networks specifically for MSR as it is self-contained. That

does not mean that it would not be helpful or great to have other assets there. She stated that they do recognize that there is a sustained need for infrastructure.

Dr. Diniega inquired about the potential for a recommendation regarding the DSN. Dr. Curry stated that most of the feedback could come back after the findings from the strategic retreats that the offices are having because there would be more understanding. She expressed appreciation with how hard the DSN is working. She felt that one of the biggest actions was to have a community driven policy and an agreed upon set of protocols for the different class missions.

Dr. Diniega brought up the potential for a recommendation regarding the decadal survey. To continue working on the budget for missions and mission technology development. She stated that NASA is heading in the right direction and hopes that they continue heading that way.

Dr. Diniega turned the floor back over to Dr. Ishii.

Dr. Ishii brought up the issues associated with remote and hybrid work as it relates to JPL policy. She stated that it wasn't clear if there needed to be a recommendation.

Dr. Ishii spoke to the SRB process and how the timing is potentially an issue. She stated that the concern would be the "red/green" averaging issue. Dr. Glaze stated that would be an SMD level activity, but it could be elevated to the NAC.

Dr. Ishii addressed the concerns associated with a potential of need for more mitigation following the Psyche/VERITAS delay and the potential impact of JPL workforce issues continuing into other NASA missions. She stated that it wasn't clear if there need to be a recommendation at this time as there didn't appear to be a complete picture of understanding. Dr. Glaze stated that it might be valuable for the PAC and the community to provide a sense of priority between continuing VERITAS versus delaying Discovery call.

December 6, 2022

Research and Analysis (R&A) Program Update

Dr. Rinehart presented information that the Research Opportunities in Space and Earth Sciences (ROSES)-21 is complete. The average time to notification on programs with due dates is down to 128 days with 96% of notifications out within 180 days. The overall selection rate is 20% across all programs with due dates. NoDD programs average time to notification is 162 days, 50% of notifications within approximately 140 days, with 90% of notifications within approximately 235 days. The target is 80% in approximately 180 days and currently 80% is achieved within approximately 200 days. The overall selection rate is 29% across all programs with no due dates. Dr. Rinehart provided an overall listing of ROSES-21 program and their results.

NoDD programs will be reporting statistics, in general, for the past year. Selection rates have improved, and proposals are still meeting high standards. However, it is taking too long to get proposals reviewed and notified. Dr. Rinehart expressed that improvements have been made. Too many selections had been made in earlier years which caused an issue with being able to budget new awards was Dr. Rinehart's response to Dr. Joseph Westlake's question regarding program's having hold overs or extensions.

Proposal pressure continues to be down in Due Date Programs and NoDD. A decrease in proposals in all programs are being demonstrated. Dr. Rinehart doesn't believe it is any one thing that is causing this issue. He stated it would be a good time to write a proposal since pressure is down. The changes in selection rates are relative to ROSES-20. He reviewed NoDD proposal submissions by month and indicated that people may have treated month 15, March 2022, the closing ROSES-21 as a de facto due date. He indicated that that is not in the spirit of NoDD but expressed that he hoped that people would continue to submit proposals.

NoDD time to notification was discussed. He explained that no proposals are older than 270 days. At the beginning, some proposals languished while they waited for additional proposals. Now, time to notification is improving. A graph was displayed that illustrated the time to notification prior to implementation of the NoDD programs. ROSES-20, with due dates, showed that most of the notifications went out between 150 and 180 days. ROSES-21, with and without due dates, showed that most notifications went out before 150 days. However, Dr. Rinehart does state that he wished to see an improvement in the notification for NoDD programs.

Informal feedback after one year of NoDD included responses from the community, from officers, and overall general concerns. Community feedback has, mostly, been very positive. Although, Dr. Rinehart recently heard a comment that the long time to notification was a negative. Internally, program officer feedback stated that NoDD was more work partially due to, Dr. Rinehart explained, low proposal pressure and the inefficiencies in using micro panels for review. Dr. Rinehart reinforced that NoDD is on a three-year trial and that they knew that the first year would be the toughest as everything makes the transition.

Reminders for ROSES-22 is that NoDD programs are open. He encouraged anyone with a proposal to submit one as it appears it is a good time to do so. He reinforced that everyone

should remember the rules on duplicate proposals and that they are strictly enforcing compliance rules. Dr. Rinehart stated that they are returning proposals if they are noncompliant regardless of intrinsic merit score from the panel. He reminded those in attendance that compliance rules exist in part to ensure fairness, readability, and accessibility.

All the Step-1 due dates have passed. Two programs with no Step-1 have Step-2 due dates coming soon including Analog Activities to Support Artemis Lunar Operations due December 6, 2022, and Planetary Science Early Career Award due December 8, 2022. Dr. Rinehart stated they are actively working on ROSES-23 which will be coming out in February 2023. As none of it is finalized, he is unable to share a lot of information except for the fact that they will not be adopting inclusion plans at this time. Dr. Rinehart provided a standard graph with the PSD ROSES-22 Programs.

NASA introduced inclusion plans (IPs) last year. The Astrophysics Division did a pilot and Exploration Science Strategy and Integration Office (ESSIO) followed up with their own version. There were concerns about the early trials of the IPs which are being addressed by the SMD Community of Practice and a more comprehensive plan for IPs is coming together. PSD will likely start adopting IPs as part of ROSES-24. The goal of IPs is to address inclusions within teams. These are not intended to be outreach plans or to address larger issues. The focus is on the barriers to inclusion for team members with activities to address and/or mitigate those barriers, and metrics are used to assess success. IPs are reviewed by a separate panel of IDEA experts which are comprised of social scientists. At first, unsatisfactory IPs will not affect selection. The SMD is working on compiling and creating resources for proposers writing IPs and will post the information as it is found.

At the previous PAC meeting, the PAC requested NASA to respond to the recommendations from IDEACon. IDEACon was held the April 25 to 29, 2022 and was sponsored by NASA and the Lunar Planetary Institute (LPI). NASA stated that there is a lot of information to digest from the workshop and giving complete, thoughtful answers to everything in the report will take time, but it can provide some reflections on those recommendations.

The first recommendation is to create an outward-facing position within the NASA SMD to advance and implement IDEA principles within NASA. The PSD agrees that a position like this could have immense value, provided that the individual has both authority and resources to implement change. PSD is prepared to advocate for such a position, but as the recommendation stated, this position should be at the SMD level. This requires a much broader buy-in across the directorate. SMD is in the process of developing the NASA Bridge Program which is designed to develop access points for underrepresented groups.

The second recommendation is that NASA should consider team diversity when selecting and extending missions, projects, facilities, and other large teams with a sub-category reflection that focuses on the retention of said diversity by having project teams implementing policies for creating inclusive and safe environments, including but not limited to CoC and bystander intervention training. NASA already considers team diversity on the axes allowed by law (e.g., geography, institutional types, career stage). NASA does not, and cannot (by law), consider

protected demographic factors including but not limited to race, sex, gender, national origin, etc. Dr. Rinehart presented a question to the PAC on whether it would like to hear from the Office of the General Counsel (OGC) regarding this topic? Over the past several years, mission teams have voluntarily started incorporating CoC into their “rules of the road.” PSD considers this as a best practice and encourages all teams to adopt it. A SMD IDEA Working Group is developing a CoC template for mission teams and flight projects, as a step towards having a CoC for all missions. CoC are being implemented for all field campaigns and for conferences and workshops. Dr. Rinehart defined the terminology of “bystander intervention.” He explained the training as an attempt to help people understand the signs of discrimination and/or harassment as it occurs and how to better address the issue in real time.

Recommendation three is that NASA should fund members of the community for their IDEA service work within planetary science and astrobiology. This recommendation is rather complicated, in that the wide range of service activity does not lend itself to a single solution. PSD is considering several approaches to address some of these areas, within “the restrictions faced by NASA as a funding agency to support such work.” A couple of specific thoughts include that many of the suggested activities could be supported institutionally with funding provided through overheads. NASA cannot “fix” IDEA without the active contributions of institutions. As IPs are implemented, funding could be associated with those efforts to support some activities. They are working to build relationships with underrepresented communities. New collaborations can be sought through the Minority Serving Institutions (MSI) exchange.

Recommendation four is that the community and NASA should define professional ethics more broadly than only financial conflict of interest and should treat harassment the same way as any other type of research misconduct. PSD agrees that harassment in all types is detrimental to the advancement of science, to developing a more diverse scientific culture, and to the principles which NASA stands. Dr. Rinehart stressed that they absolutely agree that there should be real consequences for those who participate in discrimination or harassment. NASA now requires disclosure of institutional harassment findings, and those findings can have impacts on current and future funding for harassers. Harassment can be reported to NASA online, but the authority NASA has to investigate claims is very limited. There is not much NASA can do in an investigative sense unless it happened at a NASA event, at a NASA center, or involves a NASA employee. Addressing harassment starts with individual institutions.

Dr. Rinehart repeated information from the February 2022 PAC meeting as it bears repeating. Within the R&A, the approach is to improve itself. Training and education are not by themselves a solution but a HQ workforce cognizant of IDEA issues is better able to address them. Institutional self-reflection allows for places where improvement can be made while addressing thoughts such as who will benefit, who will pay, and are the impacts measurable? The group has limited bandwidth available for new activities, but the PSD R&A wants to focus on doing a few things well, get them established and ingrained, and then move on to the next item.

The FY21 Budget was provided and illustrated that the PSD R&A budget was at the highest level of all time.

Dr. Rinehart concluded his presentation and was available for clarification questions.

Dr. Diniega expressed that the PAC members were interested in having someone from the OGC attend a future PAC meeting. However, she stated that she would appreciate someone who knows what is possible not just someone who will focus on what is not possible. She stressed that the PAC needed a mindset of “how do we make this work?” but acknowledged that it may be difficult. Dr. Rinehart stated that including it a future meeting could be possible and a need to lay out possible talking points.

Dr. Danielson discussed IPs and problematic templates from outside institutions that are violating the protected classes and are compelling members to disclose personal information which means that no team can have anonymity especially if it is small. She expressed gratitude towards the specificity described with Dr. Rinehart’s presentation. She requested possible guidance regarding topics such as psychological safety, training, and how to apply it to proposals. Dr. Rinehart replied that IPs that are too broad have the potential to become meaningless drivel. He stated that he wanted the IPs to be small, tight, and actionable.

Dr. Walter Kiefer inquired about a lower sized threshold for proposals that are going to need to create IPs and, if it this is necessary step, he expressed a concern regarding training on how to create IPs. Dr. Rinehart stated that there are not any lower bounds but did clarify that a null-inclusion plan might be okay if the proposal included one person. He did state that community collaboration was necessary. He did not want to provide too many examples as it could prevent new ideas of how to be more inclusive from being presented. Dr. Rinehart stated that, in time, there would be more inclusion workshops and training, but the effort will span years.

Dr. Ishii inquired if a customer base is shrinking regarding proposal pressure, would that affect the budget of the customer base. Dr. Rinehart stated he was not worried about budget requests. He further stated that he would have no issues requesting an increase in the budget, despite the decrease in proposal pressures, as the decrease seemed to be experienced across all boards and is not necessarily indicative of the decline in programs.

Dr. Westlake expressed kudos regarding the transparency of the R&A program. He then inquired if the metrics being used to measure the R&A program are sound. He inquired about the metrics for measuring the programs. Dr. Rinehart stated that currently there are no metrics for good or bad. As of now, R&A is funding good science that advances the fundamental objectives of NASA. With proposal pressure low, it means that good things are being left on the floor, but it is not as much as before. He also stated that he does not know if lower proposal pressure means that the community is shrinking. As far as metrics used to measure the merits of an R&A program, Dr. Zurbuchen has requested that Dr. Michael New lead an effort to investigate this very topic.

Planetary Science Enabling Facilities (PSEF)

Mr. Aaron Burton, a planetary scientist within the Astromaterial Research and Exploration Science (ARES) Division, currently on detail to NASA HQ, was introduced along with Dr. Jeff Grossman and Dr. Kathleen Vander Kaaden. Mr. Burton presented the Program Update for the PAC and expressed that he was excited about sharing the information.

Mr. Burton explained that the PSEF 2022 Program overview included a total of 25 Step-2 PSEF proposals. Ten proposals were selected for full or partial funding. Two proposals from one institution were combined into a single facility and one additional selection is contingent on matching funds from the NSF. The four-year expected outlay is on the order of \$22 million while spending about \$1 million a year. The next PSEF Solicitation expected to be competed in ROSES-24. Step-1 proposals would be due around April 2024 and Step-2 proposals would be due around June 2024. Mr. Burton stated that one legacy facility will be continued until PSEF round 2. He provided a pictorial timeline of awards.

Dr. Burton discussed how the criteria for facility mid-term reviews are still being created. He said that the focus was to ensure that the facilities are serving the community, that people are interested in using them, and that users are getting what they need out of them. As an example, he explained that one facility is coming under review in FY24/25 and ideally the facility would meet criteria, receive feedback, and then plan for continuation. If said facility is performing well, the option of extension without reproposing, or minimal burden, would exist. On the other hand, if the facility is performing poorly then the recommendation would be to wind-down, receive close out funding, and could potentially repropose later.

Each facility has been asked to supply a quad chart with key details on facility capabilities, how it can be accessed, and who to contact for further information. Information for all facilities will be contained on the NASA Science webpage.

Mr. Burton briefly reviewed the facilities selected.

Planetary Aeolian Laboratory (PAL) at NASA Ames Research Center, a legacy facility. PAL is used to conduct experiments and simulations of aeolian processes under planetary atmospheric environments in the 4000 m³ chamber. Available instruments and apparatus include the Mars Surface Wind Tunnel (MARSWIT), the Titan Wind Tunnel (TWT), one differential and two absolute pressure transducers, Vaisala dewpoint and temperature transmitter, 24 type T thermocouples, Keithley 602 Solid State Electrometer, and LabView data acquisition system. Access available to the facility and instruments will be in person and there are no restrictions to access. To be able to utilize the facility projects funded through Solar Systems Workings (SSW) requires access via proposal while projects funded elsewhere request access via email to the PAL PI. Requests are evaluated and prioritized based on PSD priorities and the facility schedule first of which goes to PSD R&A, followed by work relevant to PSD R&A, with third priority going to other users. Cost to use the facility per day in low-pressure conditions is \$1500.

The Lunar and Planetary Institute Scanning Electron Microscope Facility is a scanning electron microscope laboratory. It has a Phenom XL Desktop scanning electron microscope (SEM). Currently, more than 50% of the time it is available for outside users. It requires in-person use with no remote access and requires training. Following training, unsupervised access is allowed. There are no restrictions to access other than the required training and demonstration of competence to use the instrument. To be able to utilize the facility an email is sent to the PI and the Co-Manager to request time. Requests are evaluated based on training and need. LPI and

ARES/Johnson Space Center (JSC) personnel are given priority but currently the demand is low. There is no charge for use of the LPI SEM.

Planetary Cloud Aerosol Research Facility is a new facility. This facility would allow for the investigation of formation, lifetime, and optical properties of planetary clouds and aerosols via condensation and evaporation processes in a temperature and pressure controlled atmospheric gas environment. Available instruments would include a Scanning Mobility Particle Sizer Spectrometer, an Aerodynamic Particle Sizer, a Particle Tracking Velocimeter, a Phase Doppler Particle Analyzer, and a Gas Chromatography/Mass Spectrometry. A fraction of instrument time would be available to the community with in-person access needed. No restrictions would exist for use of the facility. To be able to utilize the facility contact must be made with the point of contact (POC) or another JPL science team member and those interested will need funding from the PSD ROSES program award. Science team reviews PI proposals, provides proposing PI relevant guidance on facility capabilities on a first come, first served basis as it coordinates with the JPL schedule. Chamber operations cost anywhere from \$8 to \$20k per day depending on thermal loads plus experiment set up at \$2K per day.

The Reflectance Experiment LABORatory (RELAB) is a spectral reflectance and transmission data of Earth and planetary materials at visible-near-mid-far infrared wavelengths. A custom bi-directional spectrometer (BDR) for reflectance or transmission measurement is available and viewing geometry can be changed for photometric studies. Fourier Transform Infrared Spectrometer (FTIR) and microscope FTIR for reflectance and transmission measurements is also present. This facility is available 100% of the time for community use. Analysis is done by either facility personnel or by visitors. There are no restrictions for short-term use but long-term use requires completing university lab safety training. To be able to use the facility contact must be made with the PI. All requests for feasible measurements are accepted and are prioritized on a first come, first served basis; however, NASA-funded researchers are given priority. Large number of measurements for a single user may be interspersed with other user measurements. No charge to use the facility other than shipping costs for materials to and from the facility.

KiloElectron-Volt Ion (KEVION): A KiloElectron-Volt Ion Irradiation Facility for Space Science is now going to be available. It is a 25–300 keV Ion Implantation Instrument with dual multi-technique analytical chambers (GRAINS/ICE) and minimally instrumented TEST chamber. The GRAINS chamber with X-ray photoelectron spectroscopy (XPS), Rutherford backscattering spectrometry (RBS), ultraviolet, visible, near-infrared (UV-Vis-NIR) Hyperspectral Imaging, and Ion-neutral mass spectrometry. The ICE chamber with quartz crystal microbalance (QCM), FTIR, Kelvin Probe, UV-Vis Interferometer, and Ion-neutral mass spectrometry. Approximately six months out of the year, the NASA DPS instruments would be available for use. Access is available for “in person” measurements or irradiation and analysis can be done by facility personnel. Requirements to use the facility include completion of safety protocols and instrument training prior to “in person” access. To be able to use the facility a “Request for Service” must be submitted on a form found on the KEVION website which is currently under construction. Requests are evaluated by the PI and the TBD Instrument Scientist with input from Co-Is and Collaborators. Requests are to be prioritized by the request date, need

date, and experimental readiness. There is no cost for NASA DPS awarded projects, but a tiered cost system exists for other projects. NASA non-DPS and UVa is \$45 an hour, external academic and government users cost \$55 an hour, and industrial clients cost \$150 an hour.

Facility for Astromaterials Research at NASA consists of twenty plus laboratories and is housed by ARES. These laboratories provide a unique combination of instruments and infrastructure for conducting broad-based world-class planetary research. The list of available instruments or apparatuses can be found on the ARES website. 10 to 20% of instrument time is available for the community, depending on the laboratory. In person access is available or analyses can be done by facility personnel. All visitors must possess a personal identity verification (PIV) card to obtain IT access. To be able to utilize the facility short proposals are solicited three times a year. These proposals are reviewed by ARES scientists for feasibility and a proposal review panel reviews it for merit. NASA funded research in active PSD R&A proposals are prioritized. Additional consideration is given to access requests from early career/next-generation scientists, under-represented minorities, and those PIs from minority serving institutions. There is no cost to use the facility.

The Kuiper Materials Imaging and Characterization Facility (KMICF) at the University of Arizona was founded in 2016 and was motivated by the need for accessible world-class instrumentation in support of planetary materials analysis including returned samples from missions like Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx). Techniques include scanning electron microscopy, electron microprobe analysis, focused-ion beam scanning-electron microscopy, Raman spectroscopy, nanoscale secondary ion mass spectrometry, and transmission electron microscopy. 60% of facility time is available to PSD researchers. Analyses can be in person or can be completed by facility personnel. Users must contact the lab managers for access. To be able to utilize the facility, requests for access are completed through the KMICF website. Requests are evaluated based on a short two-page maximum proposal either via email or an attachment after a conversation with one of the laboratory managers. Requests are prioritized on a first come, first served basis. The costs to use the KMICF are located on their website.

GeoSoilEnviroCARS (GSECARS) Synchrotron Facility for Planetary Science Research Sector 13 beamlines at the Advanced Photon Source for synchrotron-based microanalysis in planetary science research. Access exists to an X-ray microprobe for X-ray fluorescence, an X-ray absorption fine structure spectroscopy, an X-ray diffraction, a full-field computer microtomography, and support for a focused ion beam section preparation at the University of New Mexico. There is support for both in-person and remote analyses. To be able to utilize the facility for beamtime, requests are made through the peer-reviewed Advanced Photon Source General User System. Approximately 80% of available time at these beamlines are allocated to Earth and Planetary Science proposals. No experiment fees exist for non-proprietary experiments. One should contact the GSECARS facility PI for assistance in preparing and submitting proposal requests.

The University of Texas High-Resolution X-Ray Computer Tomography Facility (UTCT) houses two high-resolution X-ray computer tomography (XCT) scanners to image mm- to dm-

sized samples and an image analysis laboratory. Specialized XCT capabilities include oversampling for better resolution on large samples and zoom, subvolume imaging for small ones. Diffraction Contrast Tomography (DCT) for 3D crystallographic orientations in samples exists. Visitors are welcomed to observe scanning, utilize the image analysis laboratory for data exploration, visualization and quantification, and participate in short courses in SCT data acquisition, visualization, and analysis. To be able to utilize the facility, contact must be made with UTCT to discuss the sample, image and measurement goals, and feasibility. The sample may be shipped or hand-carried with an approximate 2-week turnaround from sample reception to data delivery. A 50% discount exists for NASA PSD-funded projects, resulting in a typical cost of approximately \$200-500 per sample depending on the sample composition, the desired resolution, and the data quality requirements. An estimate can be provided prior to data acquisition. A free test scan can be provided as proof-of-concept for grant proposals.

Mr. Burton concluded his presentation and was available for clarification questions.

Dr. Ishii inquired about the sustainability of the program in relation to its cost and the long-term prospect implications for new facilities against legacy facilities. Dr. Rinehart built a plan for this program to have money for new selections for basically three rounds. Following, it becomes static. The facilities must be available and adding value to the community. They should be extra impactful in that way while reducing cost for other proposals. He agreed that there could a point where existing facilities are consuming the entirety of the budget which is why the mid-term reviews are so critical. Having legitimate reviews with dedicated reviewers would allow for a checks and balancing system.

Dr. Grant inquired about a legacy facility that was selected that would have to repropose in 2024 and whether it was included in the presentation. Mr. Burton replied that the facility was the NASA Ames Vertical Gun Range. Dr. Rinehart explained that they requested one of the legacy facilities to wait until the next round to ensure fairness for new facilities.

Analysis Group (AG) Reports

Dr. Aileen Yingst presented findings from a recent AG Caucus following the delay of the VERITAS mission and release of the Psyche IRB report.

The AG Caucus is deeply disappointed that problems on the Psyche mission have resulted in the delay of VERITAS and strongly supports the launch of VERITAS on its new schedule. Should budget be the rate-determining step, NASA should follow the OWL guidelines for budgetary decisions. The issues revealed by the Psyche IRB illuminate what may be a systemic problem with how missions are selected, funded, and monitored through every phase. Given the timing of the release of the IRB report, the AGs are presenting and discussing the results with their respective communities and will report AG-specific findings to the PAC at its next meeting. These findings will likely include discussion on the balance between funding of selected missions that are in development, and selection of new proposals.

Dr. Diniega inquired if Dr. Rinehart could speak directly to the AGs based on their findings. Dr. Rinehart mentioned the idea of precursor science investigations, if they happen early enough, that leads into a place that helps the mission. However, R&A should never pick up the cost of the

mission, so how do programs and projects pay for this process? Dr. Rinehart said that none of the NoDD programs DAPR until the completion of the third year so that there isn't a complication of the experiment. If NoDD continues past year three, the expectation is that all programs would go DAPR. Technology programs have been lagged based on the skepticism associated with the anonymity online. Dr. Ishii thanked the analysis groups for their efforts and responses.

Cross-AG Inclusion, Diversity, Equity, and Accessibility Working Group (IDEA WG)

Dr. Maggie McAdam introduced her co-chair, Julie Rathbun. She then presented the Cross-AG IDEA Working Group report. The Equity, Diversity, and Inclusivity Committee (EDI) WG endorses PAC recommendation 2, 3, and 8 from June. They do suggest that the PAC consider moving #8 up to the NAC as requesting an outward facing Equity, Diversity, Inclusion and Accessibility (EDIA) position at the SMD level instead of PSD. They request that NASA explore the legality of using diversity, including race, gender, disability, sexual identity, etc., of a team as a selection criterion for selecting and extending missions, projects, facilities, and other large teams. They believe IPs could be a way to increase EDIA in planetary science. They suggest that NASA work with the community to develop resources, including funding members of the community, to educate the community. This should include education on why IPs are important and best practices for implementation.

Dr. Diniega reiterated that to present a topic to the NAC, a finding must be had.

Dr. Julie Rathbun expressed that Dr. Rinehart's idea of speaking to the OGC was a good one. She stated that more communication and support for sharing ideas that could be included in IPs needs to occur as Dr. Rinehart stated he wanted the community to provide ideas.

Extraterrestrial Materials Analysis Group (ExMAG)

Dr. Barbara Cohen presented the ExMAG report. ExMAG continues to encourage NASA to explore a path to permit sample exchange and reciprocal sample loans between NASA and the China National Space Administration (CNSA). This will become even more urgent as China's Chang'E-6 mission will return material from the SPA. SPA sample return has been the highest priority for the lunar science community in three consecutive Decadal Surveys but there is currently no NASA plan to implement such an activity. Facilitating U.S. scientists working with SPA samples from such a mission would be a uniquely enabling opportunity. ANSMET was canceled again in 2022/2023, not because of the pandemic or logistics, but because it was not deemed "critical." They do not fully understand how "critical" is being defined by NSF. ANSMET cannot change its remit, so how can NASA advocate for ANSMET? ExMAG strongly supports IDEACon recommendations to the PAC. ExMAG members participated in the cross-AG IDEA working group and highlighted IDEA activities to their membership.

Dr. Diniega inquired about the integration of planetary data and if communication and progress is being made with the planetary data chair. Dr. Cohen stated that communications and progress is being made but occurring slower than they would like. The ExMAG Lunar subcommittee has been cross-pollenating with LEAG. Dr. Cohen stated that ExMAG has attempted communication and offered support with various organizations with MSR with no real success. Dr. Fagan

addressed the concern for being ready for sample return from the Moon such as trained personnel and aging equipment. She stated she has communicated with ExMAG. Dr. Yingst stated she wished to amplify Dr. Cohen's statements. Dr. Diniega inquired if the PAC should be coordinating communication between the groups or if there is something NASA should be doing at the PDE level to help facilitate coordination. Dr. Cohen replied that for the PDE, ExMAG, and the PAC to get a better handle on what options exist in today's environment for sample analysis and the landscape associated with funding and implementation. She further stated that in reference to coordinating Mars Sample Analysis with relevant AGs, the PAC could certainly recommend that the MSR and analysis teams use the resources of appropriate AGs, in this case ExMAG and MEPAG. She also expressed concern if the program and are plan is ready for the return of the Mars samples.

Dr. Mary Voytek expressed that there was a new intra-agency group who has been struggling with what is to be considered "critical." She further stated that COVID disrupted the Antarctic program and "critical" right now means getting fuel, repairs, etc. She stated that there is progress in voicing concerns on what is critical to the science division. She suggested having the group leadership come to speak on the topic, such as Dr. Michael New. Regarding the Decadal survey, Dr. Voytek stated that the PSD has created small groups to review items for further concerns. She continued that one of the activities brought to attention was the need for further telescopic observations. Dr. Fast stated that there was an astronomy component that could be offered to help support the community.

Exoplanet Analysis Group (ExoPAG)

Dr. Laura Schaefer presented the ExoPAG report. They have no recommendations for the PAC. She described ongoing and recent activities that included the Exoplanets in our Backyard workshop, Planetary Science Advisory Committee Meeting, Great Observatory Maturation Program, Cross-PAG SAG on barriers to participation, Cross-AG IDEA working Group, ExoExplorers Program, and Science Interest Groups (SIGs) and Study Analysis Groups (SAGs).

Lunar Exploration Analysis Group (LEAG)

Dr. Amy Fagan presented the LEAG report. LEAG strongly urges NASA to engage the lunar community actively and continually in the development of the Integrated Lunar Strategy. Active broader community involvement and cooperation will provide important benefits for NASA, the lunar community, and the advancement of lunar science and exploration goals. To achieve strong backing and buy-in that is required for both the success of the strategy along with development of cohesive and inclusive lunar science community. LEAG believes that it is important to communicate the scope of the planned lunar strategy and seek community feedback throughout its development as broader community input could be provide a useful perspective early from a variety of backgrounds. They believe that non-NASA community members should be actively included in the process along with having non-NASA community representatives in current mission concept study teams as it builds community support for the missions, mitigates potential perception of mission centers making decisions based on their own interests, and builds and supports an inclusive community.

Dr. Diniega inquired about community engagement and emphasized the importance of integration with the community. Dr. Fagan stated that they are aware that there is an analysis group and pointed out that there is not something similar for the lunar mission. She expressed that communication would be extremely helpful in being able to assist programs as they learn from others. Dr. Yingst stressed the importance of the community feeling like they do have a say and that their comments matter, especially if workshops are being recommended.

Mapping and Planetary Spatial Infrastructure Team (MAPSIT)

Dr. Brad Thomson, chair of MAPSIT, presented the MAPSIT report. There is a lack of community tools currently available for landed image processing. MAPSIT encourages NASA to support a fund such software tools. Missions with a dedicated “lead cartographer” role are more successful than missions without when the target is relevant. MAPSIT encourages NASA to include language recommending or requiring this role in future calls where appropriate. MAPSIT has made the Geologic Mapping Subcommittee (GEMS) a standing subcommittee under the leadership of Professor Jeanette Luna from Tennessee Tech) and allows for a broad community membership to include planetary surfaces across the Solar System. The group will meet monthly to discuss issues pertinent to geologic mapping. A Lunar Strategic Defense Initiative (SDI) group has been established following the Laser Communication Demonstration (LCD)-SAT recommendation. Dr. Thomson did express concern regarding the constraints of a lightning presentation for matters that might require more in-depth conversation.

Dr. Grant inquired about an example of the role of the cartographer in missions that have flown versus the provided examples that have not. Dr. Thomson provided the less formalized role of “Keeper of the Maps.”

Mars Exploration Analysis Group (MEPAG)

Dr. Yingst, chair for MEPAG, presented the MEPAG report. The Psyche IRB report and the PSD response to it are very concerning. In addition to uncovering issues at JPL and postponing the VERITAS mission, this situation reveals what may be a wider problem with multiple mission selections, mission monitoring by PSD, and effects on the rest of PSD when missions and centers encounter problems. MEPAG questions if the PSD has plans to evaluate its own processes and to consider how to better prepare for and solve problems encountered in the execution of aspirational science/engineering? Deep-space communication is a challenge across PSD and particularly at Mars. Given that the next opportunity to launch an orbital Mars mission is no sooner than 2028, and more likely 2031, there is an urgent need to establish a communications infrastructure plan for Mars, including the ground segment. Communications is a multifaceted issue, including support for current assets, a continuing MEP as described the Decadal Survey, and long-term support of humans to Mars. MEPAG suggests that an important part of addressing this issue and bringing orbital communication assets with high-quality science components online efficiently, could be lower cost and/or size missions.

Mercury Exploration Analysis Group (MExAG)

Dr. Steven Hauck presented the MExAG report. As a new AG, they are on target to finalize their first Science Goals Document in quarter 1 or 2 of 2023. MExAG encourages NASA to work with ground-based observatories where it acquires observation time to enact policies that

equitably enable Mercury observations. Opportunities are being lost due to issues with standard ground-based observatories.

Dr. Diniega inquired about a possible presentation regarding ground-based observations as the PAC does not have much knowledge on the issue and who might be the best person to present said information. Dr. Hauck discussed possible presenters from MExAG and PSD.

Outer Planets Assessment Group (OPAG)

Dr. Amanda Hendrix presented the OPAG report. OPAG strongly supports the Europa Clipper Mission and commends JPL and NASA for working together to make Clipper the highest priority planetary flagship mission as it moves to launch in October 2024. OPAG thanks Dr. Glaze and NASA HQ for prioritizing Europa Clipper to preserve schedule margins as instrument deliveries and integrations proceed. They are supportive of NASA's efforts to resolve issues regarding Center workforce as highlighted in the Psyche IRB Report to minimize impact to current and future missions. OPAG urges NASA to fund focused studies for Uranus Orbiter and Probe (UOP), to methodically prepare for and clear a path to Phase A. OPAG encourages NASA to start work in FY23 on the topics of exploration of trajectories and launch capabilities, models to retire the radiation risk environment for close orbits of Uranus, and identification of potential science instruments and performance parameters including those pertaining to astrobiology and/or ocean worlds exploration as specified in the UOP study science objectives and OWL recommendations. OPAG is strongly supportive of continuing investment in outer planets related R&A programs and requests that the DAPR process be expanded to include the technology programs and that the Precursor Science Investigations for Europa (PSI-E) program be a recurring call, possibly every 2 years, to support the Europa Clipper mission and to draw in additional science expertise.

Small Bodies Assessment Group (SBAG)

Dr. Lori Feaga, chair, presented the SBAG report. No findings were brought forth. However, SBAG presents significant issues to the PAC. Apophis SAT Report released, is posted on the SBAG website, was announced in the DPS Newsletter, and will be presented later to the PAC and in January at SBAG 28. Ocean Worlds inter-AG collaborative working group general purpose and guidance was captured during the meeting of SBAG and OPAG. The Psyche IRB implications are big concerns and will be a topic of discussion at SBAG 28 in January 2023. It is too soon for SBAG to officially respond although SBAG participated in AG Chair caucus to discuss initial thoughts and to begin to formulate a united front. CoC for the Steering Committee was approved at the last SC meeting. The upcoming SBAG 28 meeting is taking place January 24 to 25, 2023, and the agenda is being finalized. Early Career recipients have been selected and notified. The event has 2 invited talks and 5 lightning talks. High-priority findings from SBAG 27 were elevated and presented at the last PAC meeting and will undoubtedly be continued concerns for the SBAG community.

Venus Exploration Analysis Group (VEXAG)

Dr. Noam Izenberg, chair, presented the VEXAG report. VEXAG finds that VERITAS needs to be launched as soon as possible, without further delay. They suggest that VERITAS be prioritized over solicitation of new proposals, particularly for the same mission class. VEXAG

finds that a “Precursor Science Investigations – Discovery” (PSI-D) R&A program, focused on ensuring success of and maximum scientific return from upcoming Discovery missions and the EnVision partnership, is in the interests of the broad planetary community. A new “CloudTech” R&A program to focus on aerial and airborne technologies and implementations applicable to multiple planetary targets, in addition to a HOTTech 3 program, in an upcoming ROSES cycle would allow focus on maturing important technologies and integration into platforms and systems.

Dr. Diniega focused the AGs of the PAC on how to proceed in response of the VERITAS delay. She acknowledged that the process is frustrating. Dr. Noam Izenberg discussed the risk associated with other institutions and how does NASA regain their confidence in their ability to proceed with missions. Dr. Rinehart stated that the message sent to the JPL by the IRB has not been lost on other institutions which has caused everyone to perform some internal scrutiny. He stated that it will take time to rebuild trust in institutions, but he feels that everyone is being proactive from what he can tell. Dr. Barbara Cohen explained that the biggest risk is to the scientists because if missions are canceled or delayed the scientists do not receive results which help to, not only promote scientific research, but their own careers. This has caused a lot of distrust and concern among the community. Dr. Yingst addressed the step forward as genuinely concerning. She stated that it is not just a question of trust in the institutions but a question of trust in NASA. Dr. Glass echoed the PAC member sentiment and stated that perhaps it needs to be the root for the finding.

Apophis Specific Action Team (SAT)

Dr. Jessie Dotson, astrophysicist, introduced the Apophis Specific Action Team and informed those in attendance that the full report is available online for personal reading.

Asteroid (99942) Apophis’s Earth close approach on April 13, 2029, will be an extremely rare event. It is not fully understood to what extent this rare event offers comparably rare—and realizable—science opportunities. NASA HQ requested SBAG to convene the specific action team and specified four tasks. SBAG established the specific action team to fulfill the HQ request. The four tasks were to: (1) identify and quantify the detectable effects on Apophis expected to result from the Earth encounter and identify the measurements and instrumental sensitivities needed to detect them and determine their magnitudes; (2) assess and prioritize the importance to planetary science and planetary defense of detecting and measuring each of these effects, as well as the value of the upper limits of non-detections; (3) categorize these effects according to detectable using Earth-based assets, detectable using a spacecraft arriving only after Earth close approach, and detectable using a spacecraft arriving before Earth close approach; and (4) quantitatively assess the possibility that spacecraft sent to Apophis could increase the risk of a future Earth impact. The study was not meant to assess, prioritize, or recommend specific instruments, facilities, flight hardware, mission profiles, or concepts. The study also did not consider observations or measurements that are not specific to the physical effects of the Earth

encounter, unless advantages afforded by the proximity to Earth would enable unique measurements that would otherwise be impossible.

Apophis approaches from below the ecliptic plane on the night side. The closest distance will be approximately 38,000 km at 21:46 UT on April 13, 2029. The asteroid gets closer than geosynchronous satellites, though it does not pass through the belt.

Apophis is an Sq class asteroid that has an approximate 40-m diameter with an elongated and possibly bifurcated shape which was demonstrated from radar. It is a non-principal-axis rotator with a slow apparent rotation period.

Currently, available literature does not enable a definitive quantification of the likely effects of the encounter. Quantitative predictions of available models vary due to different modeling approaches, different assumptions for unknown properties, and uncertainties in available measurements. It is noted that not all plausible configurations or effects have been modeled.

Qualitative assessments of the effects of the encounter were discussed. Apophis' orbit will change from an Aten to an Apollo orbit. Apophis' spin state will most likely change significantly. Apophis may experience localized areas of resurfacing. Apophis might experience small changes in shape.

A wide variety of observational capabilities will have rare opportunities during the close encounter – either due to prospect of observing the effects of the encounter or due to the nearness and/or brightness of Apophis. The SAT investigated a variety of remote observing techniques including photometry, spectroscopy, polarimetry, and imaging at wavelengths varying from optical through submillimeter along with radar frequencies in the GHz and MHz range. The SAT investigated a variety of in-situ observing techniques including multi-band high resolution optical/near-ir imaging and seismometry.

Criteria for prioritizing investigations include capitalization on the close encounter, results of the investigation must provide valuable information for Planetary Science and/or Planetary Defense and the investigation must rely on mature, demonstrated technologies.

A top priority in this investigation is the direct observation of resurfacing due to tidal effects as Apophis may experience resurfacing during the encounter. Movement of surface material can be diagnosed by looking for shifting of material, changes in albedo, changes in spectral shape, and changes in spectral bands. Comparing high resolution, multi-band images taken before and after the encounter will allow identification of surface alterations due to this encounter. Surfaces of asteroids are the result of a variety of geophysical processes and understanding these processes and their interplay is essential to connect the observable face of asteroids to their history. Most understanding of geophysical processes on small bodies are acquired from “forensic” observations and this opportunity allows for contemporaneous observations. A rare opportunity to directly observe a geophysical process, eliminating the uncertainties inherent in forensic investigations about time scales and causes exists. Understanding the role and ubiquity of geophysical processes such as tidal resurfacing is necessary to connect the surface of asteroids to their history and a cohesive strength of regolith is an important factor in how asteroid surfaces

respond to disturbances, whether natural or caused by humans. Appropriate high-resolution, multi-band cameras have been flown on multiple missions which means that a variety of mission profiles are suitable, and there are robust models capable of evaluating the observed phenomenon.

Another top priority in this investigation is leveraging spin change to investigate mass distribution and strength. The spin change due to the encounter enables this investigation. Information about the interior structure of asteroids informs models of small body evolution as well as planetary defense atmospheric entry and mitigation models. Ground based radar and light curve photometry are robust technologies with active communities and models of spin state changes due to Earth encounters have successfully been used to reduce uncertainty in the state of knowledge about asteroids.

Other intriguing, though not prioritized, opportunities exist, such as electrostatic lofting, in-situ seismometry, and ground based, long-wavelength radar. Additional considerations include the fact that the Apophis encounter is an opportunity to demonstrate the utility of several observing methods which are not commonly used for small bodies research such as long wavelength radar, optical polarimetry, and speckle photometry. The overall science output from the encounter would benefit from practice campaigns, coordination, and timely data sharing. The design of spacecraft visiting Apophis near the close approach should include a plan for robust operations during radar observations.

The SAT assessed effects on potential Earth impacts over the next century due to a spacecraft which interacts with Apophis anytime between April 2024 through April 2033. It was stressed that Apophis should not be disturbed until after 2029.

Dr. Dotson concluded the presentation and was available for clarification questions.

Dr. Diniaga inquired about the opportunities that exist for the community to build upon this study and for the encounter. Dr. Rinehart believes that the core R&A programs will be sufficient with no need for any new programs.

Dr. Diniaga inquired about whether the opportunities were sufficient to allow for the build of science. Dr. Dotson replied that she is giving a more abbreviated version at SBAG in January and that she will bring that question up for conversation. Dr. Diniaga inquired about observation opportunities and whether the PAC could facilitate opportunities for observations if there is a need for that. She also includes data sharing and research opportunities within her comments.

Dr. Diniaga inquired if data archiving work well within the Planetary Data Ecosystem (PDE) or are there gaps. Dr. Dotson replied that the focus of the SAT did not encompass that kind of information.

Dr. Grant inquired if the discussion is to create new spacecraft or can any existing orbital assets around the Earth be used to image it because of how close it is coming. Dr. Dotson replied that any asset could be used to capture images of the asteroid but stated that the priority

investigation regarding high resolution, multi-band imaging must be done in proximity. She stated that it could be difficult to obtain meaningful images from current assets.

Planetary Defense

Dr. Kelly Fast, Near-Earth Object Observations Program Manager, was introduced.

She began her presentation with a brief overview of DART. The first test of an asteroid deflection technique by impacting a spacecraft into an asteroid. DART mission goals were to target the binary asteroid Didymos system, impact Dimorphos and change its orbital period, and measure the period change from Earth. The period change ended up being 32 minutes. Dr. Fast reviewed the observers around the world in the global reach in participation of the DART impact. She presented light curve measurements to provide evidence of the deflection and change in the orbit.

Dr. Fast discussed the warned impact on November 19, 2022 (2022 WJ1). It was first observed by the Catalina Sky Survey and was placed on the NEO Confirmation Page by the Minor Planet Center. Within minutes, the impact probability and corridor were calculated by the Center for Near-Earth Object Studies (CNEOS) Scout system. Additional observations by the Catalina Sky Survey and Farpoint Observatory, Northeast Kansas Amateur Astronomers' League allowed Scout to narrow the impact location to Southern Ontario, Canada. Observations by the community continued and ground observers were notified all within 2.5 hours. At less than 1 meter in size, 2022 WJ1 was a much smaller object than NASA is tasked to detect and warn about since objects of that size easily disintegrate after they impact Earth's atmosphere. This real-world event exercised capabilities and gave confidence that NASA/JPL/CNEOS impact prediction models are adequate to inform response to the potential impact of a larger object. The success of this real-world exercise was due to routine rapid reporting and orbit determination by NASA-funded projects. This is the sixth impact tied to observations obtained of a natural object while it was still in space, specifically the fourth for Catalina Sky Survey.

Near-Earth asteroids discovered since 1980 number over 30,000. The George E. Brown NEO Survey goal, tasked in 2005, was to find at least 90% of NEOs 140 meter and larger within 15 years. As of September 2022, progress indicates that only 42% of the total population of 140 meter and larger asteroids, estimated to 25,000, have been found. At the current assets' discovery rate, it will take more than 30 years to complete the survey. New capabilities in development will cut that time in half. The NEO Surveyor is a space-based infra-red telescope whose objective is to find 65% of Potentially Hazardous Asteroids (PHAs) larger than 140m in 5 years (>90% in 10 years) with the capabilities to estimate object sizes. NEO Surveyor would survey along the Earth's orbit that is not viewable by NEOWISE and ground-based surveys, creating a complementary system. Preliminary Design Review (PDR) took place in September 2022 and the Project entered Phase C in November 2022.

Dr. Fast concluded the presentation and was available for clarification questions.

Dr. Diniega inquired about the NSF-led study on the Next Generation Planetary Radar and if it encompasses the development of the Arecibo site. Secondly, are you able to share more information about the membership of the taskforce and if there will be a mechanism for

community input. Dr. Fast stated that it is an interagency study that is led by NSF with NASA, Space Force, and other agencies. They would review the broad national needs for such a capability and where the needs of different agencies intersect and how that might point to possible concepts. As the study proceeds, members of the community will be brought in to report out on capabilities. Dr. Diniega clarified that currently membership is limited to the interagency committee members and not open to the community at large. She questioned once more if the meetings would be open to the public. Dr. Rinehart made a statement that interagency meetings are not required to be open to the public.

Public Comment Period

Dr. Rinehart discussed the format of the public comment period and how to handle it in the future. He stated that perhaps in the future that they have the period open during a break so that they could review the questions and bring them forward for discussion during the designated public comment period.

The public comments and answers are listed below:

John Whitehead: It would be worth an effort by the PAC to review the membership of the MSR Standing Review Board (SRB). Which members have rocket expertise relevant to the MAV, a brand-new miniature launch vehicle beyond the state of the art?

The rocket engineer on the MSR IRB told the Decadal Committee that the mass of the MAV and its payload capability will not be known until the MAV is built and tested, but the Decadal report takes the MAV for granted.

NASA plans as of 2010 referred to a requirement for two successful MAV flight tests during MSR Phase B, now apparently absent from the plans.

Jeff Gramling spent time yesterday explaining the science case for MSR and made no mention of any progress for launching off Mars. What's wrong with this picture?

Jeff did say that the helicopter wheels need to go, to save mass, but why? Obviously, the MAV is the huge mass-hog.

Dr. Diniega stated that the PAC will continue to get MSR updates in the future.

John Cooper: Re falling mission dominos at JPL, encourages Lori and JPL to reach out to Goddard, e.g., for Assembly Test Launch Operations and Guidance Navigation Control engineers to support Clipper, Psyche, Veritas.

Dr. Rinehart stated that this information and/or question should be forwarded to Dr. Glaze. Dr. Diniega concurred.

Darby Dyar: OWL (p. 653) provides clear guidance on what to do in times of budget crisis. It does not include delaying/standing down of selected missions. Why did HQ not follow this guidance? Considering comments about confidence from the scientific community in the NASA centers, should HQ initiate comparable IRB reviews of missions at all centers?

Dr. Rinehart stated that the OWL guidance is great over the timeline of a decade. This a timeline of now. Saving money by not soliciting something four years from now is not going to help solve problems today. There is immediacy associated with today. Dr. Diniega stated that discussion did occur yesterday and that they are reviewing the information. The IRB review, while an important avenue for gathering information when an issue is identified, is difficult and time consuming.

Amanda Hendrix: Q for Stephen: how much longer until the end of the NoDD 3-year experiment? (Not exactly sure when it officially started - will ROSES 2023 be the last year? The feedback I have heard is not as positive as you have evidently heard, so I'm wondering what metrics will be used to determine whether NoDD will continue longer than 3 years.

Dr. Rinehart stated that there is roughly 1 year and 3 months left in the experiment. He stated that the two major metrics were decoherence and reduced proposal pressure. He stated that they would need to reconsider the metrics when it comes time for review as the current metrics are bad.

Sean Marshall: Not really a new question but related to the questions from Serina about the inter-agency radar panel: I just want to say that there are lots of members of the planetary radar community (with experience at Arecibo, Goldstone, and/or Green Bank) who would be happy to contribute to this panel, so I hope there will be some avenue for that.

Dr. Diniega appreciated the information and would forward this suggestion to the relevant organizers so that they could make contact for possible future contributions.

Astrobiology & Research Coordination Network (RCN) Updates

Dr. Mary Voytek, Senior Scientist Astrobiology, presented the RCN updates.

A Research Coordination Network (RCN) is a virtual collaboration structure that helps support groups of investigators to communicate and coordinate their research across disciplinary, organizational, divisional (intra and inter), and geographic boundaries. NASA has modified a mechanism utilized by NSF to achieve the research goals for the Astrobiology Program. Astrobiology crosses all of SMD.

The NASA Astrobiology RCNs are a mechanism for community collaboration. Each RCN will have a steering committee comprised of the PIs of all teams who have elected to join, both from large teams selected from the ICAR solicitation as well as smaller teams from relevant ROSES R&A programs. The NASA Astrobiology Program, along with representatives of relevant research elements and SMD Divisions, will identify co-leads and potential members of the RCN and provide funding to support the logistical requirements of the RCN. The Astrobiology RCNs will be regularly reviewed, approximately every five years, by a senior review-like independent panel of experts to provide input to any decision to continue, modify, or sunset the RCN. New RCNs may also be established as the science in astrobiology evolves, new missions come online or the priorities of NASA shift.

Expected outcomes for the RCNs include investigators carrying out and proposing interdisciplinary research that addresses new topics through new collaborations; producing a plan

for utilization of current mission data, if applicable; spawning ideas for new and exciting missions, and encouraging participation in and contributions to mission from planning through operations, if applicable; identifying new targeted technologies or instrumentation needed, but not yet reported elsewhere; influencing Decadal Surveys for all NASA SMD Divisions; enhancing international engagement; and supporting continued development of the astrobiology community.

Dr. Voytek reminded attendees that one of the ten objectives of the National Aeronautics and Space Act is the search for life's origin, evolution, distribution, and future in the universe. Areas of research covered by the five RCNs include Biosignatures and Life Detection (RCN-NfoLD) covering distribution, Habitability and Detection of Life on Ocean Worlds (RCN-NOW) covering distribution, Habitability and Detection of Life on Exoplanets (RCN-NExSS) covering distribution, Prebiotic Chemistry in Early Earth Environments (RCN-PCE3) covering origins, and Primitive Cells to Multicellularity (RCN-LIFE) covering evolution while NASA's ESD covers the future.

LIFE, from early cells to multicellularity, will build a research community dedicated to understanding life-planet co-evolution as recorded in the rock record, in biodiversity, in genome databases, and revealed by *in silico* models and lab proxy studies that look both backward and forward in time. LIFE will foster a "science of living worlds" that views life-planet co-evolution through a single holistic lens. Our community will address four "Big questions." What environmental pressures, biological mechanisms, and evolutionary opportunities: -give rise to cellular life? -caused life to expand to planetary scale? – led to the emergence of eukaryotes? - favored the transition from single cells to multicellularity? In parallel, LIFE researchers seek to understand how major biological innovations transitions affected our planet, shaping the evolutionary path of our integrated life-planet system. LIFE will discern rules of co-evolution that will enable us to predict how life could evolve on worlds other than our own and inform how we might search for it.

NExSS goals include the following: to understand planets in context throughout their formation and coevolution with their parent star and planetary system; to investigate the diversity of exoplanet characteristics and learn how their properties and evolution can create the conditions for life; to understand how to identify the best exoplanet targets for life searches; to learn how to recognize, and search for, signs of habitability and life on exoplanets.

NfoLD is to promote discourse relevant to life detection and act as a think-tank for life detection science and technology. It consists of a forum-style talks on SC research to discuss new life detection science and technology and build cross-discipline collaborations. It provides life-detection feedback to AG groups such as MEPAG and OPAG. They are involved in journal clubs, career development activities, communication, and research nuggets.

NOW research priorities include the physics and chemistry of Ocean Worlds (OW), the biogeochemistry and life on Ocean Worlds; the analog studies to inform Space Missions, and the technological need for future missions. Future priorities of NOW include the training of Next

Generation Planetary Ocean Scientists, continuing OW discussion meetings, and developing national capabilities for OW Missions.

PCE3 had positive feedback with their community workshops in 2021 and 2022. The PCE3 influence can be found in the Decadal white papers, OLEB workshop report, and EOS perspectives. There is a PCE3 Seminar Series that has been sustained for over 2 years. They have plans of focusing on early career scientists with a proposal incubator workshop.

The presentation was concluded and Dr. Voytek was available for clarification questions.

Exploration Science Strategy and Integration Office (ESSIO)/Lunar Science Update

Dr. Joel Kearns, Deputy Associate Administrator for Exploration, and Dr. Sarah Noble, Program Scientist for the PSD/ESSIO, were introduced.

They presented the Lunar Discovery & Exploration Program (LDEP) Elements that included the Commercial Lunar Payload Services (CLPS), with two landings per year, which enables community-driven science, and an expected Volatiles Investigating Polar Exploration Rover (VIPER) delivery in November of 2024; the Science Instrument Development for CLPS Delivery and how the instruments will be deployed by CLPS along with the maturation of instrument concepts; the VIPER Rover as a project and the VIPER Review Team (VRT); the Lunar Reconnaissance Orbiter (LRO) mission operations; the Lunar Trailblazer project and the IM-2 rideshare launch; lunar international mission collaborations; the science instrument development for Artemis human missions; and Lunar Science Research, including the completed Artemis Geology Teams, the Internal Science Team, Artemis Curation, Data Infrastructure/Tools, increases in lunar R&A to prepare for sample return, and including Apollo Next Generation Sample Analysis (ANGSA); Mission Concept Studies for Endurance-A and LRO's successor; and future mission and projects.

The President's Budget Request for 2023 was presented along with the current estimates of mission cost associated with the Endurance concept. For a 2030 landing with Mod-1 Next Generation Power System, the cost is a significant fraction of LDEP's budget through 2034. A review of CLPS Deliveries from 2023 to 2026 was provided along with a FY23 PBR Moon to Mars Planning Manifest.

From the Decadal recommendations the PSD should develop a strategic lunar program that includes human exploration as an additional option to robotic missions to achieve decadal-level science goals at the Moon and conducting decadal-level science should be a central requirement of the human exploration program.

The Integrated Lunar Science Strategy is an opportunity to think strategically about the tools available, within budget constraints, and how they map to the high-priority science that is desired to be accomplished at the Moon. It should create a path forward that is flexible enough to react to the changing landscape as the capabilities grow and priorities evolve. The Strategy is not a document, carved in stone, that will come down from the proverbial mountain top and be handed to the community. The approach being taking is to create a path for developing a strategy to meet the biggest challenges for lunar science as it is defined by the community. The length of this

process should span over the next couple of years as a plan to start mission studies and Science Definition Teams to make informed decisions about the strategic direction. The development of the Strategy is an assembled joint PSD/ESSIO working group along with community participation through science definition teams (SDTs), workshops, LEAG SATs, and townhalls.

The Three Pillars of Exploration are science, national posture, and inspiration. The agency priorities at the Moon include science, but also the safe transport and return of the astronaut crew, human landings at the lunar south pole, as directed in SPD-1, promoting a lunar economy to produce rapid, frequent, and affordable access to the lunar surface and cislunar space, and to prepare for human exploration of Mars and beyond.

Specific missions that can be achieved through multiple architecture options include the SPA Sample Return, the Lunar Geophysical Network, and the Cryogenic Volatile Sample Return. Objectives that require a build up of knowledge and global access to samples to achieve include Lunar Chronology and Lunar Formation and Evolution. These are all goals that require a strategic plan to achieve and are necessary to address Decadal Science Questions.

The implementation strategy for the SPA Sample Return includes a myriad of options. The use of New Frontiers, Endurance-A or another rover design, one or more human sorties, CLPS sample return with mobility (although CLPS is not currently capable of this), or some combination could be used. The path to a decision includes looking at different mission studies and their approaches for a long-duration sample-collection rover, initiating an SDT or National Academy study on non-polar sorties for human exploration, and exploring alternative mobility options such as a CLPS service.

The implementation strategy for the Lunar Geophysical Network includes options such as New Frontiers, Multiple CLPS deliveries of a self-contained long-duration payload, polar and non-polar human sorties, or some combination of the above. The path to a decision includes looking at the SDT or National Academy study on non-polar sorties for human exploration, conducting a payload design study, and performing a CLPS capability assessment.

Cryogenic Volatile Sample Return is a big challenge, although the implementation strategy for this is the simplest of the tall poles because there is a viable path to achieve this with Artemis, we would be remiss to underestimate the difficulty of collecting, transporting, and curating a cryogenic sample. The path forward for a SR include developing requirements for freezer sample containers in a 3-phase plan (sealed, but unconditioned return, then a -85-degree C freezer, and finally a cryogenic freezer); reviewing current JSC/ESDMD studies regarding laboratory studies, developing a roadmap for cold sample return, investigating non-Orion return options, and considering what a freezer looks like. We are also working to get a new Artemis Curation Lead, a Contamination Control Scientist, and a Contamination Control Engineer in place as soon as possible.

The implementation strategy for Lunar Chronology includes options such as CLPS sample return, in-situ dating, Artemis non-polar sorties, or some combination of the above. The path forward to achieving this includes working towards CLPS sample return, developing in-situ

dating tools, and reviewing the SDT or National Academy study on non-polar sorties for human exploration.

Progress on the implementation strategy for Lunar Formation/Evolution would be made if other goals were achieved such as the SPA sample return, Lunar Geophysical Network, and many of the same locations for sample return as Lunar Chronology. The path to achieving this includes reviewing the SDT or National Academy study on non-polar sorties for human exploration and making decisions on SPA and LGN.

Unfortunately, LRO is not going to last forever. However, an orbiting asset is critical for achieving high priority science objectives and to enhance science return from human exploration. The Goddard Space Flight Center (GSFC) has begun a pre-phase A study, based on community needs as delineated in the Continuous Lunar Orbital Capabilities Specific Action Team (CLOC SAT) report. The CLOC SAT report was clear that a large “LRO-class” orbiter is required due to pointing and duration requirements.

The capabilities of the CLPS vendors continues to evolve and they are eager for input on where to put their future development efforts. It cannot be afforded to go down all the paths simultaneously so decisions and a strategy that maximizes science while maintaining the establishment of a sustainable lunar economy must be made.

R&A strategies were discussed. To be prepared to take full advantage of Artemis, strengthening of the science community, in particular the sample science, as well as the field geology community is needed. Ensuring that the instrument pipeline is meeting the needs for both Artemis and CLPS. We are targeting specific calls to expand those communities and capabilities that are needed to grow; high priority research areas may be called out specifically in certain calls. We are working with intention to use the expansion of the community as an opportunity to also diversify the community; CLPS data, as it become available, will be incorporated into LDAP with a supplemental budget from ESSIO. We are working with curation/O-REx to develop AstroMat as a repository for sample data and ensuring it will meet the needs of Artemis and CLPS sample return; developing a Lunar SDI community with help from the USGS; and preparing for laboratory needs, particularly for cold-curated samples.

In preparation for Artemis III, draft text C.25 Artemis III Geology Team was released for community comment. The Artemis deployed instruments call is still planed for ROSES-22. Analog activities call was due this day. The Planetary Science Training Team is assembling a curriculum and there is a virtual landing site workshop April 4 and 5, 2023.

They concluded their presentation and were available for clarification questions.

Planetary Science Division (PSD) Interns 2022

David Barth, in explanation of the PSD Internship stated that the goal was to provide accessible video interpretations of NASA programs to be used by new Program Scientists (now) and the community of ROSES proposers in the future. The task presented was to produce high-quality information videos on NASA ROSES programs within the Planetary Science and Heliophysics Divisions that highlight the details and significance of each program.

He explains that since June 2022 approximately 20 research program videos have been made and have covered a myriad of topics including: Concepts for Ocean Worlds Life Detection Technology (COLDTech); Yearly Opportunities for Research in Planetary Defense; Laboratory Analysis of Returned Samples (LARS); Planetary Science Enabling Facilities; Interdisciplinary Consortia for Astrobiology Research; ESSIO; Solar System Workings (SSW); Solar System Observations (SSO); Discovery Data Analysis; H2O; Emerging Worlds; Exobiology; Interdisciplinary Science for Eclipse; Heliophysics Citizen Science Investigations; Living with a Star Science; Heliophysics Artificial Intelligence/Machine Learning-Ready Data (H-ARD); Heliophysics Supporting Research (HSR); Space Weather Centers of Excellence; Space Weather Science Application Research-to-Operations-to-Research; Habitable Worlds; Citizen Science; and Exoplanets Research (XRP).

Hasrouni presented the work process of the Video Production Process that is broken down into three phases including a pre-production, production, and post-production. She further stated that creativity plays a major role, and each project has its own flow. She thanked the mentors of the program, stating that they have been blessed with the help and support of Nicolle Zellner, LaJuan Moore, Abigail Rymer, and Meagan Thompson.

Georgiana Hasrouni is from Cleveland, Ohio and recently graduated from Baldwin Wallace University. She graduated college three years ahead of her class and graduated with her B.A. at 19 years old. The NASA internship was an amazing and fulfilling experience. Doing this with has helped her to gain a larger understanding of what to expect in future opportunities and throughout opportunities in general. To this date, she has worked on eight projects and counting including Exobiology, Habitable Worlds, NASA Cross Divisional (NASA xD), H2O, ESSIO, Parker Solar Probe, and NASA Acronym Rap. Her favorite memory during the internship was flying out to Washington D.C. and working from NASA HQ for an entire week. She expressed that she cannot wait to continue working with NASA and is excited for the future.

Caitlin Davis is from Brooklyn, New York but resides in Baltimore, Maryland. She graduated from Morgan State University and attended boarding school in high school. Projects that she has been involved in include Living with a Star; Emerging Worlds; Discovery Data Analysis; Research Coordination Network; Space Weathers Centers of Excellence; Solar Systems Workings; and NASA Acronym Song. Davis stated that the internship has helped her develop her professional standards. Working at NASA has allowed her to push herself and allowed her opportunities for education which she gets to share with others. Her favorite memory during the internship was coming to D.C. And meeting Gregory Robinson at his retirement party.

David Barth is from Houston, Texas. He graduated from Loyola University New Orleans. A fun fact about him is that he owns a rapier sword. He worked on the Exobiology, PSEF, Space Weather Science Application (SWxSA), Planetary Defense, and NASA Acronym Rap projects. Barth stated that the most valuable part of the internship has helped him expand his view of video and catering to clients. His favorite memory was making a video with Nicola Fox at NASA HQ.

Alexander Zinn is from San Antonio, Texas but is working from Manhattan, New York. He graduated from New York University. He finished at a Top 10 Individual in the NASA Fitness Challenge. Projects he has been involved in include COLDTech, LARS, SSO, XRP, SSW, NASA Acronym Rap, and NASA xD. Zinn explains that this experience has been eye opening in so many ways. He has always had a personal interest in science and appreciated the opportunity to focus on that narrative. His favorite memory was spending the entire week at HQs which included meeting Gregory Robinson, Thomas Zurbuchen, and a duck.

McKenna Doherty is from Madison, Wisconsin and is residing in Iowa City, Iowa. She graduated from Grinnell College and once scored a perfect 90 in bowling by hitting nine pins in every frame on accident. She was included in the COLTech, Citizen Science, Radio JOVE, HSR, H-ARD, SSW, and NASA Acronym Song projects. She stated that she was surprised about how much learning took place during this entire internship. Her favorite memory was stumbling around a famous duck while filming a NASA music video.

Doherty informed the PAC of guest speaker highlights that the interns experienced including Emily Furfaro, Stephen Rinehart, Greg Robinson, Mike Toillon, Lori Glaze, Eric Ianson, Thomas Zurbuchen, Jenny Mottar, Denis Hill, and Nicky Fox. She stated that they all feel they have taken a lot with them from all presentations. Doherty stated that the experience is best summarized with a quote from Rob Kelso, "We can change without growing, but we cannot grow without changing."

Dr. Diniega inquired about where the interns see taking this experience as many of them did not have a science background. Hasrouni stated that she would potentially continue science education videos. Zinn indicated how they learned how they refine learning associated with science.

Dr. Diniega inquired of Meagan Thompson if the videos created would be made public for viewing as the understanding was that they were educational tools for informing the community of the ROSES programs. Thompson confirmed that that was the long-term goal but short term the videos were to be used internally to educate members of NASA. She reinforced the idea that the videos are a point of accessibility and allows varying methods for learning and education. Thompson stated that all five of the interns would be continuing through the next semester and the goal was to complete ROSES and get the videos open to the public.

Dr. Glass thanked the interns for their presentations and expressed hopes that some of them might consider NASA as a future employer.

LaJuan Moore thanked the interns and encouraged them to stay productive. She expressed enjoyment of working with all of them.

End of Meeting Discussion

Dr. Diniega welcomed Dr. Michael New, Deputy Associate Administrator for Research, into the discussion.

Dr. Diniega inquired if the PAC should reissue a finding on the importance of the ANSMET program with possible elevation to the NAC level. Dr. New stated that he had been working at

the office of Polar Programs and NSF with possible discussion of an interagency WG to tackle interests where NASA and NSF intersect. It got put on hold by the pandemic and now it is on hold because NSF has another problem. They are in the middle of rebuilding the Amundsen-Scott South Pole Station. However, they are not expanding the SPS. It will be able to support the same number of individuals it does now. They have finally decided to come up with some way to manage the use of that facility. So, there is a new interagency WG that is trying to come up with how to manage limited resources. Dr. New stated that he is on that group. Interestingly enough, the NSF has never heard about senior reviews, baseline and threshold objectives for projects, or including sunset costs and planning in the initial proposal. He stated that he has been talking these topics up and feels like he has made some progress. Once that responsibility is completed, he will go back to trying to set up the interagency WG about Antarctic access more broadly. From the point of view from NSF, he stated that he could see how ANSMET would not be a high priority. He was unable to say if NSF is even engaged as a partner with ANSMET. Dr. Grossman confirmed that they still have the three-agency agreement in place with NSF and that they are still operating the MSG. Their role is primarily to support the field teams where NASA's role is to choose the field teams, fund them, and cooperate with the Smithsonian. Dr. New stated he believed that OPP is slowly digging out of their giant backlog of projects caused by their ability to supply fuel, the pandemic shutdown, and then the actual outbreak of the virus on the continent. He feels that it will be a couple of years before they work off their backlog. He assumes that would include ANSMET teams but stated that he would follow that up. Dr. Diniega inquired whether the PAC needed to issue a formal finding and/or recommendation or if this current discussion would suffice to encourage communication at the appropriate levels. Dr. New stated that the issues would be discussed on the new NASA/NSF WG that he creates in the future but also said that he did not think a re-recommendation would hurt.

Dr. Diniega shifted the conversation to the LDEP.

Dr. Diniega inquired about the return of a Cryogenic Volatile Sample and whether Lunar was engaging with the AGs, especially ExMAG. Dr. Noble stated that they are very much in need of input from the community on those topics and are currently planning to meet with LEAG and ExMAG to for a SAT.

Dr. Curry inquired if the architecture is defining the science or if science is directly affecting the architecture in terms of the Lunar paradigm. Dr. Kearns stated that their focus for the Moon is to ensure that strategic research for the decadal survey drives the scientific activities that we are doing on or about the Moon. They are working very hard in the planning effort to ensure that the strategic applicable to Mars is driving their planning. They spent quite a bit of time looking at how to establish the science objectives in strategic research that should be planning space flight architecture for Mars while trying to determine if they should be doing things on the Moon as demonstrations or operations which will inform maximize science return for the eventual human Mars mission. He thinks that what will happen is science definition team take a new approach from the community to look at what those likely science objectives are for the first human mission. Dr. Noble stated that science is not an afterthought, that science is at the table. They

are making decent progress, but they do not win every argument when it relates to human exploration.

Dr. Diniega then went through the draft findings page. She presented the PAC potential findings and recommendations and encouraged any needed discussion.

In reference to RCN, Dr. Diniega presented the following: **Finding** - Commending the successes of the RCNs communications and their impact in bringing together different communities and encouraging future plans to establish these types of cross directorate relationships. No dissent was voiced.

In reference to the multiple sample needs of the community, Dr. Diniega presented the following: **Finding** - Recognizing that there are many sample efforts going on in an effort in sample analysis data curation and data management. Some data may fit within the existing Planetary Data Ecosystem while some of it may not. **Recommendation** - To better understand what sample data management capabilities and needs would be for the communities, including compliance with federal regulations. To push for continued engagement with NASA, specifically with the Planetary Data Ecosystem. To engage with the relevant sample focus community groups. No dissent was voiced.

In reference to the DSN, Dr. Diniega presented the thought of the risk associated with reliance on commercial providers for ride shares. She suggested that there was not enough information obtained during this meeting and that they should revisit it in the future. No dissent was voiced.

In reference to the Decadal Survey, Dr. Diniega presented the fact that the PAC would revisit the topics. No dissent was voiced.

In reference to the DSN, Dr. Curry presented the following: **Recommendation** - Understanding metrics better and creating transparent, community driven policies regarding different mission classes associated not necessarily to the cost of the mission but the risk class. No dissent was voiced.

In reference to incivility, Dr. Diniega presented the following: **Finding** – The need to educate the community to respect what is legal and allowable and what makes a good inclusion plan. **Recommendation** – Provide resources, training, and perhaps examples with various sized teams and settings. No dissent was voiced.

In reference to community inclusion and science strategy, Dr. Diniega present the following: **Finding** – The need for science engagement in important strategy decisions, specifically related to Mars and Lunar. No dissent was voiced.

In reference to the Psyche launch postponement, Dr. Ishii presented the following: **Finding** – The postponement of Psyche and the consequently delayed VERITAS has created a crisis in confidence in NASA and a loss of trust in the institutions that support those NASA missions. Of particular concern are the critical issues that were missed that impact flight readiness. Need for an internal NASA review over the SRB process. **Recommendation** – Supporting the IRB

recommendations and that “reds/greens” should never average out to “yellow” which appears to reduce severity and could be masking something serious. No dissent was voiced.

In reference to the VERITAS delay, Dr. Ishii presented the following: **Finding** – The decision to delay VERITAS was met with disappointment and raised concerns and fears regarding potential need for mitigation and measures in the future. A negative impact of standing down a selected mission on potential PIs and on scientist participation on future missions. **Recommendation** – Both the PAC and AG strongly support the launch of VERITAS on its new schedule or sooner if the situation should allow. The PAC requests the process for recertifying VERITAS and metrics that will be used to support this decision be clearly defined and communicated to the community as soon as possible. Finally, the PAC strongly supports the importance of competitive selection in the Discovery program as a result the PAC believes that the launch should be prioritized over possible new Discovery mission selection. In the event the budget is in limitation in future years, OWL guidelines should be followed. No dissent was voiced.

Dr. Diniega announced that the next PAC meeting, hybrid in nature, would be February 28 and March 1, 2023, at NASA HQ.

Dr. Rinehart thanked everyone for their time and expressed appreciation for all their hard work. Dr. Diniega thanked Dr. Shoshana Weider for her hard work. Dr. Diniega declared the meeting closed.

Appendix A Attendees

PAC Members

Dr. Serina Diniega
Dr. Stephen Rinehart
Brent Barbee
Dr. Shannon Curry
Dr. Lisa Danielson
Dr. Jennifer Glass
Dr. John Grant
Dr. Hope Ishii
Dr. Kandis Jessup
Dr. Walter Kiefer
Dr. D'Arcy Meyer-Dombard
Dr. Conor Nixon
Dr. Tyler Robinson
Dr. Joseph Westlake

Attendees

Aaron Burton
Aaron Zucherman
Abigail Rymer
Adrian Brown
Adriana Ocampo
Alan Thurgood
Alana Johnson
Alexander Zinn
Alison Murray
Alistair Funge
Amanda Hendrix
Amanda Nahm
Amy Fagan
Andrea Riley
Andy Kwok
Anne Verbiscer
Ashlee Wilkins
Ashley Rivers
Barbara Cohen
Barbara Hilton
Barry Jenakuns
Becky McCauley Rench
Brad Bailey
Brad Thomson

Bradford Arnold
Brett Denevi
Caitlin Davis
Caleb Scharf
Carol Raymond
Chris Dateo
Chris German
Colin Dundas
Curt Niebur
Curtis Williams
Cynthia Dinwiddie
Dana Hurley
Daniel Brack
Darby Dyar
Dave Murrow
David Barth
David Eisenman
David J. Smith
David Millman
Delia Santiago-Materese
Dennis Feerick
Ed Riedel
Ed Rivera-Valentin
R. Aileen Yingst
Emily Braswell
Eric Lanson
Erica Montbach
Flaviane Venditti
Flora Paganelli
Francesco Bordi
Frank Rosenzweig
Friffin Reinecke
George Cooper
Georgiana Hasrouni
Heather D. Smith
Heather Graham
Henry Throop
James Lochner
James Tuttle Keane
Jeff Foust
Jeffrey Gramling
Jeffrey Grossman

Jeffrey Volosin
Jeremy Fehrenbacher
Jessie Dotson
Joel Kearns
John Cooper
John Rummel
John Whitehead
Juergen Nussbaumer
Julie Castillo
Julie Rathbun
Justin Filberto
K Beisser
Kathleen Vander Kaaden
Karyn Lynne Rogers
Kelly Fast
Kim Reh
Krista Soderlund
Kristin Jansen
Kurt Retherford
LaJuan Moore
Laura Schaefer
Lewis Groswald
Linda Billings
Linda Karanian
Lindley Johnson
Lindsay Hays
Lisa Gaddis
Lori Feaga
Lori Glaze
Lorraine Fesq
Luisa Fernanda Zambrano
Marin
Lynnae Quick
Maggie McAdam
Marcia Smith
Marrin Ferrais
Mary Voytek
Maxime Devogele
McKenna Doherty
Meagan Thompson
Megan Ansdell
Meghan Bartels

Melissa Kirven-Brooks
Melissa Morris
Melissa Six
Michael Lienhard
Michael New
Michael Meyer
Michael Mischna
Mike Fanelli
Mini Wadhwa
Mitchell Schulte
Monty DI Biasi
Nick Lang
Noam Izenberg
Patrick Taylor
Paul Byrne
Paul Voosen
Philip Baldwin

Prajakta Mane
R Aileen Yingst
R Ruffin
Raha Hakimdavar
Ram
Richard Rogers
Richard Zurek
Romy Hanna
Ryan Park
Ryan Watkins
Sarah Noble
Sarah Valencia
Sean Hsu
Sean Marshall
Shawn Domagal-Goldman
Shoshana Weider
Stephen Clark

Steven A. Hauck, II
Sue Smrekar
Sylvie Espinasse
Tammy Dickinson
Taylor Townsend
Teresa Jensen
Thomas Wagner
Thomas Widemann
Timothy Lyons
Tom Young
Van R. Kane
Victoria Hamilton
Victoria Meadows
Wade May
Will Thomas

Appendix B
Planetary Science Advisory Committee Members

Dr. Serina Diniega, Chair
Jet Propulsion Laboratory

Dr. Stephen Rinehart
NASA Executive Secretary

Brent Barbee
NASA Goddard Space Flight Center

Dr. Shannon Curry
University of California, Berkeley

Dr. Lisa Danielson
Los Alamos National Laboratory

Dr. Jennifer Glass
Georgia Institute of Technology

Dr. Hope Ishii
University of Hawaii

Dr. Kandis Jessup
Southwest Research Institute

Dr. Walter Kiefer
Lunar and Planetary Institute

Dr. D'Arcy Meyer-Dombard
University of Illinois at Chicago

Dr. Conor Nixon
NASA Goddard Space Flight Center

Dr. Tyler Robinson
Northern Arizona University

Dr. Joseph Westlake
Johns Hopkins University Applied Physics Laboratory

Appendix C **Presentations**

1. Planetary Science Division (PSD) Update, *L. Glaze and J. Salute*
2. Psyche Independent Review Board (IRB), *T. Young*
3. Mars Exploration Program (MEP)/Mars Sample Return (MSR) Updates, *E. Ianson, M. Meyer, and J Gramling*
4. Deep Space Network (DSN) Update, *P. Baldwin and J. Volosin*
5. Decadal Survey Discussion, *PAC Members and PSD*
6. Planetary Science Enabling Facilities, *A. Burton and J. Grossman*
7. Assessment/Analysis Group (AG) Q&A Period, *AG Representatives*
8. Apophis SAT, *J. Dotson*
9. Planetary Defense, *L. Johnson and K. Fast*
10. Astrobiology & Research Coordination Network (RCN) Updates, *M. Voytek and RCN Representatives*
11. ESSIO/Lunar Science Update, *J. Kearns and S. Noble*
12. PSD Interns 2022, *M. Thompson, L. Moore, and Intern Cohort*

Appendix D **Agenda**

Planetary Science Advisory Committee Meeting **Virtual** **December 5-6, 2022**

Monday, December 5

1000 AM	Welcome & Roll Call	Stephen Rinehart
1015 AM	Planetary Science Division Update	Lori Glaze
1100 AM	Psyche Independent Review Board	Tom Young
1130 AM	PAC Q&A/Discussion	All
1200 AM	Break 1	
0100 PM	MEP/MSR Updates	Michael Meyer & Jeff Gramling
0145 PM	Deep Space Network Update	Phillip Baldwin
0230 PM	PAC Q&A/Discussion	All
0300 PM	Break 2	
0400 PM	Decadal Survey Discussion	All
0500 PM	PAC Discussion	All
0600 PM	Adjourned	

Tuesday, December 6

1000 AM	Greeting & Roll Call	Stephen Rinehart
1015 AM	R&A Update	Stephen Rinehart
1100 AM	Planetary Science Enabling Facilities	Aaron Burton & Jeffrey Grossman
1115 AM	PAC Q&A/Discussion	All
1130 AM	Assessment/Analysis Group Q&A Period	AG Representatives
1215 AM	Break 1	
0115 AM	Apophis SAT	Jessie Dotson
0145 PM	Planetary Defense	Lindley Johnson & Kelly Fast
0215 PM	PAC Q&A/Discussion	All
0230 PM	Public Comment Period	All
0235 PM	Astrobiology & Research Coordination Network Updates	Mary Voytek & RCN Representatives
0305 PM	ESSIO/Lunar Science Update	Joel Kearns & Sarah Noble
0330 PM	PAC Q&A/Discussion	All
0345 PM	Break 2	
0445 PM	PSD Interns 2022	Meagan Thompson, LaJuan Moore, & Intern Cohort
0515 PM	PAC Q&A/Discussion	All
0600 PM	Adjourned	