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HUMAN EXPLORATION AND OPERATIONS COMMITTEE

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January 13-14, 2021

MEETING REPORT

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N. Wayne Hale, Chair

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Bette Siegel, Executive Secretary

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Call to order and welcome

Dr. Bette Siegel, Executive Secretary of the Human Exploration and Operations Committee (HEOC), called the meeting to order, and provided details of the Federal Advisory Committee Act (FACA), which provides governance rules for the meeting. She introduced Mr. N. Wayne Hale, Chair of the HEOC. Mr. Hale noted to the public that this particular HEO meeting counts as the last meeting of 2020, and the next scheduled meeting in March/April will be the first meeting of 2021. Mr. Hale welcomed three new members, Ms. Lynn Cline, Mr. David Thompson, and Mr. Kwatsi Alibaruho. The present meeting is focused on an update on the HEO areas, and a joint meeting with the NASA Advisory Council (NAC) Science Committee. Mr. Hale asked if NAC Chair, General Lester Lyles, who was attending the meeting virtually, had any remarks to proffer. General Lyles briefly extended his thanks to HEOC for supporting NASA.

International Space Station (ISS; Station)

Ms. Robyn Gatens, Acting Director of the International Space Station (ISS; *Station*), gave a briefing on the latest crew activity, Increment #64, which began in November and which has been very busy. With the completion of the 63S Dock and the arrival of Crew-1, NASA is proud to have a total of 7 crew on Station, 5 of them USOS. Significantly, more crew time is now available for research and utilization. To adapt to the increased number of crew aboard, the docked Dragon vehicle is being used temporarily as sleeping quarters for the duration of the Crew-1 stay, while ISS looks to improve the situation. This also marks the first time two Dragon vehicles have been docked at ISS simultaneously. Station is hitting its stride in the "new normal," with lots of vehicles coming and going. Two cargo vehicles recently departed, while two Progress vehicles remain docked. Cygnus 13 departed the previous week, while completing the latest Saffire fire safety experiment, and a Ka-band, software-defined, telemetry experiment. One Dragon will be splashing down in the Gulf of Mexico later today, after having delivered the Bishop Airlock. The Crew-1 Dragon will soon be relocated to the Station zenith to allow other crew to dock. Two pairs of spacewalks coming up in this Increment; these extravehicular activities (EVAs) will include upgrades to the Columbus module, additional antenna setups, and the completion of battery upgrades, as well as the replacement of one final battery, which had failed. In anticipation of power upgrades, preparations are being made to deliver six new solar arrays to ISS. These are "rollout" solar arrays, first demonstrated in 2017. The new arrays will be installed to provide additional power, and to supplement currently degrading solar arrays; an EVA will take place first in order to prepare the work site. A total of four EVAs will be carried out in Increment #64 to accomplish various other tasks.

Ms. Gatens provided a status on an atmosphere leak, which has been tracked for about a year. The leak has proved no danger to crew, but it is still necessary to find the major source. ISS did find one source in the Russian Service Module, which has been patched. For the near term, that part of the module is being isolated. It is thought that there is another leak, but for now, atmosphere pressure is being sustained, and additional gas will be delivered. Meanwhile, ISS awaits the next Progress vehicle. Total consumables are sufficient at present; the most limited is food, but there is enough to last through to Spring.

Utilization highlights include upgrades to the Environmental Control and Life Support System (ECLSS) as systems evolve to support Exploration. The Thermal Amine Scrubber has been installed, as well as a new distillation assembly for the Urine Processor Assembly (UPA). A new toilet was delivered in November; crew is still working to get it installed. This new toilet, the Universal Waste Management System (UWMS), will be flying on the Orion as well.

The new toilet represents an overall mass and volume reduction, and a significant improvement for the crew. ISS recently took delivery of an RFID-based logistics management (REALM) system, and a MiniION DNA Sequencer that will allow detection of gene sequences associated with microbial activity.

Coming soon will be a four-bed CO_2 scrubber and brine processor assembly, the latter of which will nearly complete the water system upgrades that will be in place for Exploration.

ISS operates under an agency priority goal metric (APG) to initiate at least five technology demonstrations per year to advance deep space exploration, and thus far, has exceeded these goals. For 2020, a summary of research activities include the MARROW (Bone Marrow Adipose Reaction: Red or White?) study, undertaken to improve the understanding of space-induced anemia, and the Nanoparticles-based Countermeasures for Treatment of Microgravity-induced Osteoporosis (NATO) study, which has implications for osteoporosis drug delivery on Earth. The Cold Atom Lab produced a paper on the observations of a Bose-Einstein condensate in microgravity, which was published in *Nature*, and research using Organs-On-Chips, microfluidic chips that mimic the physiology of organs, yielded insights on the effects of microgravity on human organs and tissues. The Arcsecond Space Telescope Enabling Research in Astrophysics (ASTERIA), a small satellite deployed in 2017, designed to detect exoplanets, just completed its mission, having detected 55 Cancri, an exoplanet that is a known transiting super-Earth orbiting a Sun-like star. In efforts designed to stimulate the commercial economy in low-Earth orbit (LEO), a ZBLAN fiber optic experiment demonstrated an order-of-magnitude improvement in fiber attenuation, attributed to suppression of sedimentation processes in zero-gravity fabrication conditions. Science, Technology, Engineering and Mathematics (STEM) educational activities such as EarthKAM, which students can control to take photos of Earth, have also been of great interest to the community at large. New memoranda of understanding (MOUs) between NASA and the National Science Foundation (NSF), and NASA and the United States Department of Agriculture (USDA) have recently been signed, encouraging other agencies to use microgravity environment for research.

Increment #64 highlights include activities such as growing radishes, demonstrating food production in space, which is one big gap area for enabling future human Mars missions. ISS is also celebrating 20 years of continuous presence in space, an anniversary that has been marked by much activity in public outreach, including a spread in *The New York Times*. In this time period, global involvement has also expanded, with up to 108 countries involved with ISS over the years, in numerous areas. There has also been a huge increase in collaboration in ISS research, especially during the last six years. Increment #64 includes 228 investigations, which in summary includes a total of nearly 3000 investigations on ISS to date. During Increment #63, from April to October 2020, planned crew hours were 268, but actual hours totaled 325. While there are a number of enablers and challenges to ISS success, Ms. Gatens said she looked to the future, as she felt the best was yet to come.

Within the directives of a new 2020 National Space Policy, key ISS mission goals will be sustained as the move to commercial LEO continues: ISS will continue to enable Exploration activities, conduct research to benefit humanity, lead the international partnership while expanding opportunities for other space agencies, and enable a commercial LEO economy. Mr. Hale asked if Russian upgrades were pending. Ms. Gatens said that Russia would be launching a new module launching later this year. Mr. Hale reiterated HEOC's continued support for ISS, to ensure that NASA has a platform to further Exploration. Mr. Pat Condon commented that he was completely blown away by the activities on ISS, and voiced the concern is that there is too much ignorance in the general public about the value of ISS, and what it means to them in their daily lives. He encouraged Ms. Gatens and the ISS program to think about getting the message out to better engage the average citizen. Ms. Gatens said she completely agreed and pointed to ongoing team discussions on how to better showcase Station's progress and accomplishments. Mr. Mark McDaniel thought that Ms. Gatens and her team have been doing outstanding work, especially in STEM, inspiring students. Noting that no one can inspire students like NASA, Mr. McDaniel felt NASA had actually been doing a much better job in getting the word out. Mr. Kwatsi Alibaruho asked what precisely was the mass flow leak on ISS. Ms. Gatens said that it averaged 2-3 pounds per day (the specification is about 2.3 pounds per day but the historical average had been 0.6 lb/day until last year). Ms. Nancy Ann Budden added her praise, citing the importance of increased research and engineering, and international

partnerships; she urged Ms. Gatens to make use of HEOC to improve the outreach. Mr. Michael Lopez-Allegria asked if there were any thoughts on the root cause of the atmosphere leak, and whether it might be indicative of something more serious. Ms. Gatens said that a root cause had not yet been ascertained, but it is not thought to be related to micrometeoroid impact or orbital debris. Mr. Jim Voss suggested using radiation protection bricks to protect the *ad-hoc* Dragon sleep station. Ms. Gatens said she was noting this suggestion, and that there is a sleep station NASA can send up and install if significant radiation exposure is a concern.

Space Communication and Navigation (SCaN)

Mr. Greg Heckler presented an update on NASA's Space Communication and Navigation (SCaN) program, in the context of NASA's road to commercialization. A commercialization of NASA's communications network is a natural extension of commercialization activities that started with commercial off-the-shelf (COTS), followed by the Commercial Crew Program (CCP), and LEO Commercialization. In 2020, NASA began the effort to define its acquisition strategy for transitioning to commercial systems.

NASA already uses some commercial ground stations to communicate with its science missions and small satellites. In the near-Earth environment NASA has provided communication services missions with a combination of both government and commercial ground stations along with the Tracking and Data Relay Satellite System (TDRSS) constellation. Today, NASA's goal is to utilize the large and expanding commercial communications services industry (worth $60B at present) to carry out this same support. NASA has delegated responsibility to the Glenn and Goddard Centers for this activity, with SCaN leading the effort.

TDRSS was last replenished in 2018, and NASA has no plans to build more satellites for this system, as the current network can support users into the 2030s. Instead, NASA plans to gradually transition to commercial SATCOM providers, targeting 2030 for 100% commercial service; this transition applies only to new missions. The Communications Services Project (CSP) at GRC will focus on demonstrating commercial satellite communications for providing data services to space users, using a rolling wave approach of demonstrating new or expanded services over the 2020s. Existing operators will continue to launch their satellites, and there are new entrants coming into the market. NASA wants to tap into the evolving market, and recognizes that there will not be a one-size-fits-all solution.

In order to pursue commercialization of direct-to-Earth (DTE) communications, NASA is looking to Goddard to execute this portion of the plan. NASA will transition to commercial ground station providers, targeting 2023 for 100% commercial service; this transition applies to both existing and new missions. GSFC will pursue and develop a portfolio of vendors, and to consolidate interfaces such as scheduling. In the long-term, the goal is to divest SCaN ground assets over time. In preparation, NASA has re-organized the previous Near-Earth and Space Networks along future commercialization alignments.

Current regulations do not support space-to-space use, thus NASA will also need to pursue spectrum regulatory changes that will be required for the use of commercial services, with the aim of creating a seamless, interoperational communication and navigation capacity.

Challenges to this transition include the fact that commercial space-based providers have different spectrum allocations and standards. NASA will be using the same approach as has been used by the Department of Defense, which has used hardware to smooth over these challenges. There is also a challenge with radiofrequency spectrum regulations not currently supporting some commercial frequency allocations for space-to-space use. NASA will be looking to consult with the World Radiocommunication Conferences (WRC 27) to address these challenges.

Mr. Hale noted that HEOC would be getting an update on Deep Space part of this transition in the near future, adding that spectrum and frequency allocations are of equal concern, and terribly important. Mr. Hale applauded Heckler's actions and concerns, and encouraged the public to use the Webex chat function to ask any related questions.

Commercial Spaceflight Division

Mr. Phil McAlister gave an update of the Commercial Crew Program (CCP), highlighting Boeing and SpaceX as current partners. The goal of the Program is to provide safe reliable and cost-effective space transportation, the same goal associated with the Program when it was originated ten years ago. NASA initially required the systems to carry up to four astronauts and 220 pounds of cargo to ISS. The CCP is now entering a new era, beginning with the very successful SpaceX Demonstration-2 Mission, which was very gratifying for all involved. Mr. McAlister noted the exceptionally smooth nature of the mission, and pointed out that these commercial entities build their vehicles to NASA specifications; he commended SpaceX for an excellent mission. Demo-2 was a 63-day mission, carrying astronauts Robert Behnken and Douglas Hurley. Their addition allowed the rest of the ISS crew to perform a lot of science, including critical EVAs to replace batteries. All test objectives were successfully completed. In terms of public interest and engagement, the May 30th launch of Demo-2 was the most watched event NASA has ever tracked on both traditional and social media. The splashdown at the conclusion of the mission was equally popular, and garnered worldwide coverage in all major cities. This speaks to NASA's leadership in space.

The first operational mission, Crew-1, was launched in November and will probably depart in April, and may have some overlap with Crew-2. Meanwhile, Boeing has been hard at work preparing for Orbital Flight Test- 2 (OFT-2), as OFT-1 had had some difficulties. 29 March is the operative launch date for OFT-2. Crew-2 is also scheduled for that timeframe; the dates will be deconflicted as time arrives. Boeing also plans to fly a crewed Flight Test to Station later in 2021; this will probably be a short Increment. Following this crewed Flight Test, NASA will certify the Boeing Starliner, giving the US a redundant human access to space for the first time in history.

Suborbital Crew Project

Suborbital vehicles that can provide several minutes of microgravity are now being offered by commercial vendors. NASA is looking at taking advantage of this program, which can fill the gaps between the capabilities between drop towers and ISS, for providing microgravity experience. Access to microgravity is increasing in cost, complexity, and lifecycle duration. Most of the opportunities here are in LEO; NASA is seeing more interest in industry in terms of cost-sharing, and other areas. These new commercial sources are good for NASA, in that they can yield cost savings that the Agency can pass along to Exploration. NASA sees potential in areas such as human-tended microgravity research, testing and qualification of spaceflight hardware, and government astronaut training. The challenge here is subsystem qualifications, which represent a little more risk. In order to ensure the safety of NASA personnel while flying on commercial suborbital systems, NASA will have to perform assurance functions to ensure safety, as there is a requirement to do some sort of safety assessment. For the Suborbital Crew Project, NASA is calling this a System Qualification. This presents an opportunity to form a new method of qualification, that will be likely somewhere between informed consent and traditional NASA Verification and Validation (V&V). Mr. McAlister credited Mr. Hale with co-authoring a proposed architecture for approaching this problem. NASA will be standing up a sub-office to Commercial Crew, which has been working with the team. More information on system qualification should be available at the time of the next HEOC meeting.

Commercial LEO Development Program

There is now a new US Space Policy document that states the US is to achieve a continuous US presence in LEO and to maintain a permanent American foothold there. It is not possible for ISS to operate indefinitely, and it could have a major unrecoverable major contingency at any time. The next LEO

destinations after ISS will not be government-owned and operated. To address a potential future gap in LEO presence, the CSP has established a dedicated management structure for a Commercial LEO Development Program, to be managed at Johnson Space Center. The Program prioritizes free-flyer development but is also continuing to pursue other commercial LEO activities (Demand Stimulation Awards, etc.). For ISS to operate beyond 2025, NASA will need to award CRD-3 contracts and CCtCap-2 contracts to provide NASA an opportunity to address the barrier of high transportation costs. NASA should make cost reduction an explicit requirement for future XRS-3 and CCtCap-2. Developing new human spaceflight systems takes time, so NASA must start now to avoid a potential extended gap in US human LEO presence. Replanning program activities are based on FY21 budget levels ($17M, after having requested $150M). This mismatch in funding shows that NASA needs to better demonstrate to stakeholders that Commercial LEO is important. To accomplish this, NASA has developed a Commercial LEO Roadmap to phase in an end-goal of sustainable commercial operations. To get there, there must be a good supply and demand relationship. In terms of supply, NASA is funding a commercial port module with Axiom that is designed to later operate as a free-flyer. NASA also wants to incentivize direct free-flyer development, as it would be desirable to have more than one provider, to stimulate competition. NASA is going to have to certify these providers in order to buy services from them, ultimately. On the demand side, NASA has made eight awards for demand stimulation (artificial retinas, FO development, semiconductor chips). In this way, the Agency has expanded the commercial and marketing activity opportunities on ISS, while continuing to fund CASIS (science, R&D, etc.), and planning for future private astronaut missions.

CASIS

At the end of 2019, Administrator Bridenstine convened an Independent Review Board (IRB), chaired by Dr. Betsy Cantwell, for the purpose of assessing the Center for the Advancement of Science in Space (CASIS). The IRB and made a number of recommendations to improve its operations. The IRB identified six actions to improve CASIS management:

- Work with CASIS on the best roles and composition of the CASIS Board of Directors and leadership
- Support CASIS' establishment of a User Advisory Committee to provide input to the organization about how best to manage resources
- Create transparent project and program evaluation and prioritization processes
- Identify an ISS National Lab program executive at NASA Headquarters as the primary liaison to CASIS
- Update strategic priorities for the ISS National Lab on an annual basis
- Work with CASIS to optimize the allocation of ISS National Lab resources to meet strategic priorities

NASA has established a new CASIS Board of Directors (BOD), of which Dr. Cantwell is Chair. The BOD has also selected an interim Executive Director James Crocker, while it searches for a permanent one. NASA has established an ISS National Lab User Advisory Committee charter, in response to the IRB's recommended action.

Mr. Hale commented that he expected activity in LEO to stimulate more transportation opportunities, eventually driving costs down, iteratively. Mr. Voss offered his congratulations on the successes of the CCP, and asked Mr. McAlister for his view of the industry's interest in parabolic vs. suborbital microgravity opportunities. Mr. McAlister said it had been a mixed bag; NASA's interests at present are primarily on the Science and Education sides. He was not yet apprised of the actual risk posture, but felt that once NASA gains insight into commercial safety and maturity profiles, it can make better judgements. Mr. Condon noted that when NASA started its Commercial Crew and Commercial Cargo Programs, it was in uncharted territory. He asked Mr. McAlister to cite any Lessons Learned that might

inform Lunar Exploration. Mr. McAlister said that the current lunar architecture is considered "commercial-ish," in that it relies on fixed-price contracts, allows contractors more say in the design, and allows for competition. Requirements really need to be nailed down at the beginning of such contracts; they have to be in order to avoid costly change requests. As a result, the CCP has seen very little churn. The commercial approach also supports a strong schedule mandate. Mr. McDaniel commended Mr. McAlister's outstanding presentation.

Dr. Siegel passed on some questions from the public chat: What was the budget request for Commercial LEO? $150M. Asked by Mr. Dan Carpenter if Mr. McAlister saw NASA as helping support the US economy's recovery from COVID (through its commercial programs), Mr. McAlister said he hoped and believed NASA can be part of it; it's a tall order, but NASA has helped grow the commercial space program with very little investment, and now NASA is now leveraging the efforts of private space entities. He said he had been excited to have been part of the process and fully expected it will go forward.

Public Comments

More public questions were conveyed by Mr. Hale:
Is the Office of General Counsel (OGC) involved in NASA's commercial space proceedings. Mr. McAlister said this was the case, but importantly, NASA's Safety and Mission Assurance programs are also critical in partnering with Commercial.
Mr. Gene Mikulka asked: is there any better way to promote and publicize ISS activities, such as working with public volunteers? Mr. McAlister noted that there is a link to NRA activities that would be relevant here (https://www.nasa.gov/ames/partnerships/spaceportal/nra).
Mr. Wye Grodin: do we know if President-elect Biden supports the Human Landing System (HLS) award that is coming in February? Mr. Hale said it was not possible to speak to this issue, as it would be mere speculation. Dr. Meenakshi Wadhwa, Chair of the NAC Science Committee, said she had been listening in, and was very much looking forward to engaging with the HEOC on the following day, especially with regard to discussing Artemis and plans for Mars.

Discussion and Recommendations

HEOC turned to discussing the tenor of the meeting thus far. Mr. McDaniel commented that the dedication of HEOMD during the pandemic had been extraordinary, wanted to thank everyone at the Directorate for their efforts. Mr. Hale echoed these comments. Ms. Budden also agreed, adding that it's a good time for good news, and for amplifying the accomplishments of ISS. She encouraged NASA to carry out a full court press on good news. Mr. Hale noted in that he sometimes had difficulty navigating the NASA website, and felt NASA would benefit from approaching its Internet presence in a more organized way. Mr. Voss said he appreciated the ample time for discussion. Mr. Hale agreed, noting that HEOC's principal task is to discuss and ask questions, and thanked Dr. Siegel for creating the agenda.

Mr. Condon proposed a finding applauding NASA's approach to commercializing LEO, and its tremendous potential. The more successful this is, the more it will free up NASA to pursue the furthering of Exploration to the Moon and beyond. It might be worth formulating a HEOC observation supporting NASA's intention there. Mr. Hale felt that it would be sufficient to verbalize this to both the Science Mission Directorate (SMD) and HEOMD, instead of writing up an observation. Ms. Lynn Cline noted she had been struck by this idea of the gradual transition to the future state of LEO. There have been problems in the past with starts and stops, thus she felt it was encouraging to see specific plans for commercializing LEO and near-Earth space communications. Mr. Hale said it had been a little disappointing that the appropriation for the commercial effort was so low ($17M); this is an important effort that is being overlooked by the budgeteers. Mr. Alibuharo commented favorably on how far ISS utilization has come since he left the Agency in 2011; it has been gratifying to see the science and upgrades. ISS has done an

outstanding job in providing a platform. In addition, Mr. Alibuharo said he had been quite impressed with the Agency's ability to move forward in pandemic conditions.

Mr. Hale, commented, in thinking about CASIS, that he was glad to see the changes being put in place, and that as NASA goes forward and fills out the science portfolio and utilization, the Agency must remember that ISS is meant to be collaborative. Dr. Ruth Gardner noted that as Mr. Alibuharo mentioned, the last year has been amazingly productive, especially given COVID, and there is still more to come (Boeing is getting to its first Commercial Crew flight, and Artemis processing and testing). Mr. Hale said that HEOC should also wish luck to Stennis in its upcoming hot fire test for the Space Launch System (SLS) Core Stage. Ms. Budden said that, with transition on everyone's minds, she was hoping that NASA would be able to keep up its current momentum. She hadn't gotten a handle yet on how to help HEOMD Associate Administrator Kathy Lueders, and hoped that she would feel free to reach out. Mr. Hale pointed out that Ms. Lueders has expressed her appreciation for the HEOC discussion, aside from official findings and recommendations.

January 14, 2021 - Joint meeting with the NAC HEO and Science Committee

Opening Remarks

Dr. Siegel introduced Mr. Jason Callahan, the Executive Secretary of the Science Committee (SC), who opened the meeting,reiterated administrative announcements per FACA rules, and introduced Dr. Wadhwa, SC Chair, to preside over the day's joint meeting. Mr. Wayne Hale, Human Exploration and Operations Committee (HEOC) Chair, offered remarks on the joint nature of the Artemis program in terms of science and exploration, and expressed enthusiasm for the joint meeting of the two Committees.

Artemis Overview

Ms. Kathy Lueders, Associate Administrator of the Human Exploration and Operations Mission Directorate (HEOMD), began the briefing by emphasizing the Directorate's collaborative mantra with the Science Mission Directorate (SMD), which is "we explore as one," noting that HEOMD is working hard with both SMD, and also with the Space Technology Mission Directorate (STMD), with multiple examples of cross-linking. This is a big year as HEOMD works toward getting Artemis I launched by the end of Calendar Year 2021. The SLS Core Stage is in the test stand for a Green Run on 16 January at 5pm Central Time. Ms. Lueders briefly alluded to the fact that five hurricanes and COVID had done little to slow down the team's efforts on preparing the Core Stage for eventual shipment to the Cape. HEOMD also continues to work on getting the Mobile Launcher-2 ready as well, and on finalizing crew transportation for future Artemis missions. It is a very exciting time.

The first Commercial Lunar Payload Services (CLPS) missions are coming up in the next few years; these first missions landing on the Moon will be SMD-supported, but they will also provide critical data for future Exploration purposes, feeding forward to Artemis II and Gateway. The HLS procurement process is also under way as HEOMD will be making a decision on which systems it will be investing in for the 2024 timeframe. HEOMD is also working surface mobility, putting together key platforms and capabilities. The first CLPS missions are the Volatiles Investigating Polar Exploration Rover (VIPER), which will be the first rover to investigate the lunar surface to characterize volatiles; and the Cis-lunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) cubesat mission, which will enter a near-rectilinear halo orbit (NRHO; future orbit of the Gateway) to collect initial orbital data. Following these are the Artemis I flight, the launches of the Power Propulsion Element (PPE) and the European Space Agency (ESA) Habitation and Logistics Outpost (HALO) components of the Gateway, Artemis II (a 10-day crewed test flight), and finally Artemis III, delivering astronauts to the Moon.

The Orion vehicle will be delivered to Exploration Ground Systems (EGS) later this month, followed by Core Stage delivery scheduled for February 2021. A great number of major milestones for Artemis I have been achieved, representing a tremendous amount of work. Artemis I will carry 12 secondary payloads (e.g. a lunar hydrogen mapper, a near-Earth asteroid imager), as NASA has made a conscious decision to get as much science data as possible from this un-crewed demonstration mission. HEOMD has been working through all the different parts of the communications networks to assure operations will go smoothly (SCaN: Near Earth Network, Space Network, and Deep Space Network).

The next milestones for Gateway will be in March 2021; these will be the HALO Preliminary Design Review (PDR) closeout and Gateway Sync Review, the latter of which is designed to make the system as flexible as possible for collecting initial science data. Gateway has established its first two science payloads. NASA will have Science and Technology payloads on the lunar surface in 2021: Intuitive Machines will launch the NOVA-C lander on a SpaceX Falcon 9 (carrying five payloads), and Astrobotic's Peregrine Lander (carrying 11 payload), launching on a United Launch Alliance (ULA) Vulcan Centaur rocket.

Ms. Lueders briefly reviewed 2021 HEOMD milestones by quarter, noting that HEOMD is fully utilizing ISS both in terms of crew and cargo, and is furthering the development of commercial LEO capabilities by using the ISS platform to allow companies to prove their concepts. A new astronaut class is also to be introduced in the fourth quarter.

Dr. Vinton Cerf asked why Soyuz vehicles were shown on the milestone listings in the presentation. Ms. Lueders said that NASA still lists Soyuz launch vehicles for crew transportation to provide a redundant resource. Mr. Hale requested details on power, specifications, etc. for the lunar landers. Ms. Lueders said she could provide information on the different classes of payloads, but that there are some Intellectual Property (IP) limitations on some of this information, depending on each company participating. Mr. Steve Creech, Assistant Deputy Associate Administrator Advanced Exploration Systems in HEOMD, offered to send HEOC key, high-level data aspects of the payloads, later provided in an email:

"**HLS-R-0056 Scientific Payload Return to Lunar Orbit**
The HLS shall be capable of returning scientific payload of at least 35 kg and 0.07 m^3 volume (threshold) and 100 kg and 0.16 m^3 volume (goal), inclusive of tare, in accordance with the mass, volume, dimension and environments parameters specified in Table 10, from the South Pole to Lunar Orbit.
Rationale: Empty sample return containers are assumed to have a mass of 20 kg (goal), each with dimensions of at least 48 cm x 30 cm x 20 cm with an expected return of at least two containers (goal).

HLS-R-0356 Scientific Payload Delivery from Lunar Orbit
The HLS shall be capable of delivering scientific payload of 100 kg and 1.42 m^3 volume, inclusive of tare, in accordance with the mass, volume, dimension and environments allocations specified in Table 11, from Lunar Orbit to the South Pole.
Rationale: HLS-R-0056 requires science payload and Sample Return. Empty sample return containers are assumed to have a mass of 20 kg, each with dimensions of at least 48 cm x 30 cm x 20 cm with an expected return of at least two containers."

Dr. Stephen "Pat" Condon asked about the VIPER rover timeframe; Mr. Creech offered to provide an answer when possible. Dr. Charles "Chick" Woodward asked when a fully populated manifest for Artemis could be expected. Referring to slide 13 (2021 milestones across quarters), Ms. Lueders said HEOMD is still in the process of working through mission scheduling and orchestrating mission tempos, dependent on the needs of the Human Landing System (HLS), Gateway, and science missions. Dr.

Wadhwa expressed appreciation for Ms. Lueders' presentation and asked her to comment on what she perceived as the greatest risks to meeting the Artemis milestones. Ms. Lueders noted that coordinating work through the pandemic in 2020 has necessitated a heroic effort and HEOMD is still operating in this mode. She stated that teams and suppliers have managed schedules well for the first six months of 2021. Mr. Scott Spencer asked if NASA had any plans for lunar-based assets after Artemis III. Ms. Lueders said there is interest from international partners on this subject. Mr. Greg Chavers commented that NASA is looking at possibilities later in the decade, especially in collaboration with international partners, for the establishment of a lunar base or exploration sortie missions, dependent on the available budget. Mr. Steve Creech noted ongoing discussions and studies regarding lunar habitats, mobility platforms, surface power, and sustainability through Gateway. Mr. Keith Cowing asked who would be using the Axiom space on ISS. Ms. Lueders noted that ISS does not have a demand backlog, but is trying to transition to a future commercial platform. She stated that the Axiom module will be useful in determining if there is a demand for non-government subsidized capabilities. She suggested Mr. Cowing consult Axiom directly.

SMD Artemis CLPS Activities

Dr. Thomas Zurbuchen, SMD Associate Administrator, presented a high-level overview of SMD topics. Key themes for SMD include: discovering secrets of the universe, searching for life elsewhere, and protecting and improving life on Earth and in space. Dr. Zurbuchen said SMD is working with HEOMD to support human activity that transcends institutional boundaries, and to carry out science in ways SMD has been unable to do before. SMD is guided by the National Academies of Sciences, Engineering, and Medicine (NASEM) decadal survey assessments, as well as by strategies that have been developed by Legislative and Executive stakeholders. Congressional directives driving planetary defense, for instance, while not driven by science, will be inserted into the next Decadal Survey for Planetary Science. NASA's strategic approach encompasses vision, mission, values, and priorities (slide).

The Biological and Physical Sciences Division (BPSD) was recently moved from HEOMD to SMD based on a recommendation from the Office of the Chief Scientist (OCS). A new Exploration Science Strategy and Integration Office (ESSIO) was created in 2018, and was expanded in 2020 with the addition of permanent Program Executives and Program Scientists. A Science Definition Team (SDT) for the Artemis III mission began meeting in September 2020, and the first call went out for the Payloads and Research Investigations for the Surface of the Moon (PRISM) step 2 proposals, which are due February 3, 2021. Dr. Zurbuchen noted that, beginning in February 2021, Dr. Joel Kearns will serve as Deputy Associate Administrator for Exploration (DAAX), replacing Dr. David Burns, who he said did an excellent job in keeping ESSIO moving forward.

Dr. Zurbuchen highlighted the fact that there is valuable lunar science to be done in the Artemis program, including the study of planetary processes and the record of the ancient Sun, understanding volatile cycles, fundamental lunar science, impact history of the Earth-Moon system, and use of the Moon as a platform for studying the universe. Two commercial lunar activities, Peregrine Mission One and NOVA-C, will be launched this year, ideally. VIPER, which is supported at Ames Research Center and Johnson Space Center, is a rover that will characterize water sources at the lunar South Pole and has been baselined for launch in 2023. The VIPER schedule has suffered somewhat from the COVID situation, but the rover itself has not encountered any issues thus far. Other missions include Lunar Trailblazer; and the Heliophysics Science Division (HPD) Heliophysics Environmental and Radiation Measurement Experiment Suite (HERMES) and European Space Agency (ESA) European Radiation Sensors Array (ERSA) space weather suites for the Gateway, both of which will monitor the radiation environment and will feed forward to deep space exploration. In addition, SMD plans to launch Biological Experiment-1 (BioExpt-1) as a smallsat pathfinder experiment for biological research beyond Low-Earth Orbit.

The Mars 2020 Perseverance rover has been nominal as it approaches its targeted landing on February 18, 2021. The Perseverance team managed an on-time launch despite the adversity of COVID. The rover

marks the beginning of Mars Sample Return (MSR) that will characterize the upcoming decade of Mars Exploration. SMD is excited for all these missions.

Dr. Wadhwa said she appreciated the fact that SMD and HEOMD are working so well together, illustrating the importance of communication and developing best practices and protocols for sharing the lunar environment. She asked if SMD and HEOMD had plans to formalize these types of communications. Dr. Zurbuchen pointed out that his schedule demonstrated his priorities, in that he already spends a great deal of time meeting with all the parties involved, conducting intradivisional discussions on a regular basis. He said he speaks with industry representatives regularly as well, to listen to the ideas of emerging companies that can create jobs and new opportunities. Ms. Lueders added that HEOMD is committed to having NASA missions function as multipliers by creating new connections, and by creating value streams for the economy. NASA does not own these value streams, but creates the opportunity for them, such as in the case of the Axiom module on ISS. She said that NASA may stumble along the way, but it learns from each stumble. The aim is to maximize NASA investments by reaching many communities and companies, working with others to create opportunity. Dr. Cerf thanked Dr. Zurbuchen for his presentation and asked how NASA might better take advantage of Artemis and Gateway as preparation for deep space and Mars exploration. Dr. Zurbuchen cited, as examples, the space weather instrument suite on Gateway and life support systems in HEO. Ms. Lueders noted that putting humans in different environments (i.e. terrestrial, ISS, lunar surface) will teach us much about how to operate in the future. NASA still has much to learn about the physical and psychological aspects of longer-term excursions into deep space.

SMD Lunar Science

ESSIO Update

Dr. David Burns, Deputy Associate Administrator for Exploration, gave an overview of the Exploration Science Strategy and Integration Office (ESSIO). ESSIO's budget is under the Lunar Discovery and Exploration Program (LDEP), which develops lunar science instruments through Commercial Lunar Payload Services (CLPS). NASA uses CLPS as a delivery service: NASA does not buy the landers, but instead puts together requirements documents to the 14 companies in the contract pool, where competition and strong interest have produced many innovative ways to deliver landers. There are currently four Task Orders (TOs) in work for the first lunar instruments: • First 4 lunar surface delivery task orders awarded with deliveries commencing in 2021

- 2021: Non-polar delivery (Astrobotic and Intuitive Machines) – TO 2A & 2B
- 2022: Polar delivery (Masten) – TO 19C
- 2022: PRIME-1 (Intuitive Machines)
- 2023: VIPER to Moon's south polar region (Astrobotic) – TO 20A

The first science payload deliveries in 2021 will come from the NASA Provided Lunar Payloads (NPLP) program (NASA internal) and the Lunar Surface Instrument and Technology Payloads (LSITP) program (external); after which NASA will move toward a Payloads and Research Investigations for the Surface of the Moon (PRISM) call that will yield two deliveries per year. Deliveries to the far side will require a lunar communications solution. The PRISM call is ongoing, with the final round of proposals due on 3 February 2021. The Astrobotic and Intuitive Machine lunar payloads are scheduled for July and October 2021 launches, respectively.

Dr. Lori Glaze, Director of the Planetary Science Division, briefly introduced the science aspects of lunar exploration, and thanked Dr. Burns for his efforts in strengthening the relationship between ESSIO and the rest of SMD. Lunar science has a prominent place in planetary science, much of which is in concert with ESSIO, as well as HEOMD.

Dr. Sarah Noble, a Program Scientist in the Planetary Science Division, (PSD) described the role of PSD, which continues to support a strong lunar research program across the board, lead the development of lunar missions, and work closely with ESSIO and engage with the wider lunar community. Lunar research is conducted primarily through the Solar System Exploration Research Virtual Institute (SSERVI), which has been around for about 10 years and is jointly funded by SMD and HEOMD, supporting 12 domestic teams. SSERVI is working with universities to develop lunar dust-mitigating technologies with electron beams and at Goddard Space Flight Center (GSFC), where studies in simulating artificial lunar atmospheres are being held. SMD is also hosting Participating Scientist programs for the Korean Polar Lunar Orbiter (KPLO, launching in 2022) and VIPER. There have been healthy lunar selections across the Research Opportunities in Space and Earth Sciences (ROSES) calls in various elements such as the Lunar Data Analysis Program (LDAP), the Apollo Next Generation Sample Return (ANGSA), and the Development and Advancement of Lunar Instruments (DALI). ANGSA looks at some specially curated Apollo samples with state-of-the-art equipment, including samples that have never been opened. ANGSA is treating these sealed lunar samples essentially as it would a new sample return mission, providing a good opportunity to link the Apollo and Artemis eras. ANGSA had just started on a 43 g sample, #73002, when COVID hit. It takes about six months of full-time work to assay these samples; COVID caused a brief delay, but testing is now up and running again. NASA held a special session on lunar sampling at the latest American Geophysical Union (AGU) conference and will also hold a special session at the March 2021 Lunar and Planetary Science Conference (LPSC), with particular emphasis on a sample that had been taken at the bottom of a lunar landslide. Thus far, a new organic compound and a new rock type have been found in this sample.

VIPER is expected to address important science as well as Exploration questions, reaching a "sweet spot" between SMD and HEOMD. VIPER managed to complete its PDR in late August of this year despite COVID. The lunar Small Innovative Missions for Planetary Exploration (SIMPLEx) missions, LunaH-Map and Lunar Trailblazer, are also both moving forward well. NASA's Lunar Surface Science Workshop, originally planned as a three-day workshop, has become a series of monthly workshops that are designed to collect input on high-priority science questions (lunarscience.arc.nasa.gov/lssw). The Artemis III SDT report was released in December 2020, and can also be found at www.nasa.gov/reports.

HERMES Update

Dr. James Spann, Program Scientist in HPD, gave an overview of the Heliophysics Environmental and Radiation Measurement Experiment Suite (HERMES) instrument and its function on the Gateway component of the Artemis program. Four of the seven Artemis science objectives relate to Heliophysics and Space Weather (SW), while one of Gateway's strategic goals is to conduct science and research unique to Gateway's deep space location. HERMES will provide data that will help to protect humans and robotic assets in deep space while addressing objectives under Artemis Strategic Goal 3 (3.1, 3.2, 3.3), focusing on the environment at the Gateway. HERMES will also provide data for Heliophysics investigations such as dust/plasma interactions, the global response of the terrestrial magnetosphere to the solar wind, solar wind interaction with the lunar exosphere, regolith & magnetic anomalies, and fundamental physics. HERMES data can also be applied to provide better predictions for SW as they affect humans and instruments in future deep space exploration.

Dr. Jamie Favors, a Program Executive in HPD, addressed the HERMES instrument suite that is comprised of four instruments: a magnetometer, which measures the magnetic fields around Gateway, the Miniaturized Electron pRoton Telescope, or MERiT, that measures ions and electrons; the Electron Electrostatic Analyzer, or EEA, that measures the lower energy electrons composing most of the solar wind, and the Solar Probe Analyzer for Ions, or SPAN-I, that measures protons and ions including oxygen. ESA's European Radiation Sensors Array (ERSA), also to be installed on Gateway, overlaps with HERMES somewhat, though it can register higher energies than HERMES. HERMES will be

installed on Gateway's HALO module; originally it was to be placed on the PPE but its location was changed to achieve better science data. This new placement is a tribute to cooperation amongst the integrated team. Goals for the HERMES payload include KDP-C in March 2021 and delivery in mid July 2023 HERMES data will be coordinated with measurements from the Time History of Events and Macroscale Interactions during Substorms (THEMIS)/ARTEMIS to more fully characterize the lunar environment.

Dr. Spann described the ROSES call for the HERMES Interdisciplinary Science Teams (HIDS), which strongly encourage participation with international space agencies. ROSES is also open to other science objectives beyond those previously described. NASA is looking to use these teams to stand up two Science Working Groups for HERMES and ERSA. A Request for Information (RFI) is also under way for SW instruments and missions; it has received a total of 54 submissions. HPD is poised to capitalize on Gateway's unique ability to study the Sun and its effects throughout the Heliosphere and fulfill NASA's responsibility to the nation to enable advances in space weather. HPD will play a critical role in exploration, supporting the Artemis mission in partnership with HEOMD, to develop Earth-independent observational and model assessment capabilities needed for on-board space environment forecasting for long-duration deep space exploration missions.

Artemis III Science Definition Team Update

Dr. Renee Weber, Chief Scientist at NASA's Marshall Space Flight Center, discussed some unique science opportunities presented at the Moon and the Artemis III SDT report. The SDT was chartered by the SMD AA, Dr. Thomas Zurbuchen and the Team's report was based on a number of guiding community documents, including the 2016 Lunar Exploration Roadmap, the Planetary Decadal Survey, and 126 community-submitted white papers. The Team was charged with expanding upon the seven science objectives of the Artemis program to provide traceability to science priorities. The SDT also considered logistics such as possible downmass and launch opportunities. The Candidate program included field geology and sample return, as well as *in-situ* and long-duration experiments. The final report yielded 15 findings and accompanying recommendations. Highlights from the report emphasized the value of geology training; the importance of samples (especially sealed samples from the lunar South Pole); the importance of deployed experiments, and the need for essential technology development. Dr. Weber closed by thanking SDT members for their contributions.

Biological and Physical Sciences at the Moon Update

Dr. Kevin Sato, the Biological and Physical Science Division Program Scientist for Exploration, gave an overview of BPSD goals and objectives in the lunar environment. BPSD takes a holistic approach to science, sitting at the intersection of fundamental science, space technologies, Earth benefits, and human exploration. BPSD regards lunar exploration as a continuation of research that begins on the ground and moved to LEO. There are multiple ways to conduct science at the Moon but only one way to bring it back to Earth. BPSD sciences are being integrated into all efforts for NASA science beyond LEO. BPSD will be holding a workshop in late January to get feedback from the community. At Gateway, investigations can be performed in a unique environment characterized by deep space radiation, lack of atomic oxygen, the absence of a magnetic field, and unknown environmental factors, and their effects on biological samples. Sample concepts of BPS Gateway science include determining radiation effects on organisms and plants, and finding ways to develop food production systems for long-duration, deep space missions. Artemis lunar surface science will provide another natural laboratory in which to study deep space radiation, lunar albedo radiation, the effects of lunar gravity (one-sixth that of Earth's); the lack of a magnetic field, and other unknown factors. BPS lunar science on the lunar surface encompasses experiments in physical science, fundamental physics, and space biology. To that end, a new BPS program is being established: the Lunar Explorer Instrument for Space Biology Applications (LEIA), that will be based on a small-satellite platform and support launch opportunities in FY23 and FY25. Dr. Woodward asked about the fate of lunar assets placed on the lunar surface: will they be removed,

repurposed? Dr. Burns commented that the Office of General Counsel (OGC) might be a better office to ask. The lunar landers under discussion are company assets. NASA has encouraged these companies to find commercial uses for unused capacity, in part to help increase demand for commercial lunar economy tasks. These assets might be protected as future heritage sites (which is where OGC can be involved). Dr. Condon asked: how do we avoid interference or conflicts with international spacefarers, and how do we prevent contamination? Mr. Michael Gold, Associate Administrator for Space Policy and Partnerships, answered this question, noting that these answers are governed in part by the newly developed Artemis Accords, through which NASA is trying to be proactive regarding these issues. NASA can lead by example by following the Outer Space Treaty, coordinating with Lenn Fisk and the Committee for Outer Space Research (COSPAR), and by updating Agency Interim Directives (NIDs) on Policy and Planetary Protection. Mr. Marc Weiser asked if NASA was thinking about secondary science for long-standing assets at the Moon. Dr. Burns noted that the first Artemis instruments placed on the surface will not survive the lunar night; VIPER, however, will survive longer. Dr. Jeffrey Hoffman asked if there were longer-term plans being developed for looking at the impact of space on humans. Dr. Sato said that the Human Research Program is involved in studies to reduce human risk factors that have been identified, and is putting together objectives based on current risk assessments and roadmaps. Dr. Amy Mainzer asked if there were an available timeline of lunar samples to be returned and how NASA could ensure sample access for future missions. Dr. Weber noted that the working idea is that every Artemis mission will bring back samples, beginning in 2024. Regarding samples from the Chinese mission, Chang-e 4, and the legal obstacles to sharing samples from China, distribution from this mission remains to be determined. For future New Frontiers missions, there is some language in the latest community announcements that describe programmatics surrounding sample return. Dr. Weber felt that most scientists are supportive of attaining more samples. Dr. Noble noted that NASA's CLPS providers are expected, eventually, to be capable of sample return.

SMD Mars Science

Dr. Michael Meyer, Program Scientist for the Mars Exploration Program (MEP), provided a status of Mars science. The "Follow the Water" philosophy has served MEP well in terms of leading to exploring habitability; the Program is now adopting the theme of Seeking the Signs of Life. The MEP Analysis Group (MEPAG) has established science goals through consultation with the community, and regards the resultant Science Goals document as a living document. One of the four goals of MEP is preparing for human exploration. The things that can be learned through the robotic exploration of Mars will feed forward to studies that consider the effects of Mars exploration on human beings. Some factors are now known with relative certainty: dust storms are seasonal and cyclical. Observations have shown that dust contributes to heating in the atmosphere, and thereby provides information on when and where to send solar-powered spacecraft. Curiosity's RAD instrument has enabled researchers to understand how much shielding the Mars regolith can provide. RAD measurements at one of the Murray Buttes recently provided an *in-situ* proof of concept for using the environment as a natural shelter. MEP is now looking forward to retrieving the first sample return from another planet; these samples contain evidence from the first billion years of the Solar System's existence, and it is possible that the origin of life in the Solar System is recorded on Mars. Scientifically, this possibility is a huge driver for the mission's prioritization. The Perseverance rover will collect samples, study the environment, explore Mars geology, and cache samples. It's science objectives are to assess the habitability of the planet and search for biosignatures, explore surface geology, prepare a returnable sample cache, and prepare for human exploration. There are currently three primary gaps to be filled before human exploration can take place: assess human health risk, terrestrial biosphere risk, and the safety of engineered systems. The Mars Ice Mapper (MIM) satellite mission is being studied extensively at present. MIM is essentially a radar asset that will be used to look for and characterize water ice on Mars, and to look at the terrain. Lastly, Dr. Meyer recommended that Committee members consult the Mars Architecture Strategy Working Group's (MASWG's) thoughts on mission architectures

[https://mepag.jpl.nasa.gov/reports/MASWG%20NASA%20Final%20Report%202020.pdf], and the numerous reasons that Mars is a compelling target for exploration.

Artemis Accords

Mr. Mike Gold enumerated details of the Artemis Accords, which seek to establish principles for a safe, peaceful, and prosperous future, based on the tenets of the more than 50-year-old Outer Space Treaty. International space agencies that join NASA in the Artemis program will do so by executing Artemis Accords agreements. First, the Accords state that any international participation must be based on peaceful purposes. Second, transparency, the very spine of the Accords, naturally helps to prevent conflict; therefore the Accords ask that international partners practice transparency in their participation with the Artemis missions. Signatories also will strive to achieve interoperability of systems, which is critical to ensure safe and robust operations. Any nation that joins the Artemis program is also asked to commit to rendering emergency assistance to astronauts in distress, and to reaffirm their commitment to the Registration Convention or to join the Registration Convention if they're not already a member in order to properly catalog and register space objects. Signatories also agree to release scientific data in a timely, full, and open-sharing fashion, embracing a traditional NASA practice. The Accords also commit to protecting heritage, and to the protection of sites and artifacts with historic value. The Accords reinforce that space resource extraction and utilization are to be conducted under the auspices of the relevant provisions of The Outer Space Treaty (OST). Deconfliction of activities, per the OST, is intended to prohibit harmful interference among parties, and will be carried out by creating safety zones. The agreement also codifies responsibilities for orbital debris and spacecraft disposal/passivation. Signatories to the Accords to date are: Canada, Italy, Australia, Japan, the US, Luxembourg, the UAE, the UK, and Ukraine. Mr. Gold summarized by describing the destination of the Artemis Accords as a peaceful and prosperous future. Mr. Hale asked if NASA had science commitments with the Accords signatories. Mr. Gold said that the substantive contributions for each country will be executed under memoranda of understanding (MOUs) or other legal vehicles on a case-by-case basis, to be carried out under the auspices of the Accords.

Planetary Protection Activities

Dr. Lisa Pratt, NASA Planetary Protection Officer (PPO), presented an overview of current policy documents within the Office of Planetary Protection (OPP). Over the last few years, the OPP has been transformed and reorganized, having been moved from SMD to the Office of Safety and Mission Assurance (OSMA). Documents have been revised and updated with respect to Planetary Protection at the Moon and Mars given that life sciences have also transformed over the last thirty years, yielding new techniques in genomics and molecular biology. Reflecting these changes, new NASA Interim Directives (NIDs) have been published for both Moon and Mars. The two NIDs were expedited through the NASA review process. Lunar NID 8715.128 governs Gateway, orbiting missions, and lunar landing activities, and also identifies new NASA Planetary Protection categories for lunar exploration: I-L and II-L. II-L areas are the permanently shadowed regions (PSRs) on the lunar surface, identified through Lunar Reconnaissance Orbiter (LRO) mapping, in addition to the Apollo and other historic landing sites. Anyone going to the II-L areas would need to have an inventory of biological burden associated with landed assets. The National Academies of Science (NAS) also released an updated report on Planetary Protection at the end of December 2019; OPP will be working to reconcile the latest NID drafts with this report.

The Mars NID 8715.129 discusses ways in which Planetary Protection knowledge gaps will be closed, using the Gateway and CLPS science and exploration activities. There has also been an interagency activity with the Office of Science and Technology Policy (OSTP) and the National Space Council to develop a national strategy for Planetary Protection. In December, a National Strategy for Planetary Protection was released. NASA participants in this effort included Mr. Mike Gold, and Drs. Pratt and

Ursula Rick. In addition, a Committee for Planetary Protection (CoPP) was created at the National Academies in 2020 to address aspects of planetary environments, life sciences, spacecraft engineering, technology, and science policy relevant to the control of biological cross-contamination arising from robotic missions and human exploration, and utilization of solar system bodies. SMD and OPP currently determine specific topics and deadlines for CoPP assessment, and going forward, OPP recommends inclusion of HEO in task setting and incorporation of experts in biodefense and disease prevention on CoPP. CoPP made a specific finding that OPP is working to reconcile with NASA's stance on biological waste and fuel; CoPP addressed biological materials for spacecraft and other lunar equipment but appears not to have considered "amount and disposition of biological waste that will remain in the lunar environment from future human missions," as identified in NID 8715.128. The CoPP is also concerned about combustion by-products on the lunar surface, as it is pertains to its use as a proving ground for Mars.

Discussion/Findings and Recommendations

Mr. Hale initiated a discussion on findings and recommendations, noting that the Webex chat would be included in the meeting minutes. He noted that HEOC would be looking at the Artemis system and how it accommodates science, and thought that both HEOMD and SMD would benefit from a joint Working Group in order to identify vehicle specifications that would allow science to coexist; this might be a recommendation for a future meeting. Dr. Wadhwa said she was grateful for the depth of information, and felt that there should be more formalized communication on how best to use the lunar environment given the involvement of different commercial entities, and to consider such things as potential interference in the electromagnetic spectrum that could have major impacts. Dr. Cerf commented that it was unclear how the commercial sector is covered by the various agreements and accords, and that these details should be sorted out quickly. Mr. Lopez-Allegria said that aspects of the commercial sector involvement were covered in Article VI of the OST, which states that any private actor is the responsibility of the nation involved. However, the area is completely wide open to interpretation by the individual signatory nations. Ms. Cline commented, citing her prior experience with the United Nations, that there does need to be a way of passing on these OST obligations; the means of doing so is very fractured in the US government. It's a complex issue that will require a framework. Ms. Julie Robinson noted that NASA has a joint STMD/SMD/HEOMD effort under way in building a strategic plan that will address some of these issues. Currently, the Agency is working to incorporate Lessons Learned; it is an active area. Within HEO, the effort is headed by Marshall Smith, and the Working Group will be tri-chaired. Dr. Woodward wondered if NASA was going to be ready for "boots on the ground" in 2030. Ms. Robinson likened the current climate to when NASA had been preparing for ISS 30 years before, and that the Agency was approaching it in a similar way. Dr. Wadhwa commented that, given the timeline of the new Planetary Decadal Survey coming out next year, there needs to be a way to dovetail it with Artemis and with the Moon-to-Mars effort. Dr. Meyer said that MEP hasn't really focused on Moon-to-Mars *per se*; for Mars Exploration, the MASWG was a way to provide a linkage with lunar exploration. Mr. Hale asked Ms. Budden to give her view, as she had been the science integration manager at JSC in the late 1980s/90s. Ms. Budden said she had generally asked the scientists to provide their best guess for the physical characteristics of their payloads; e.g., reagents, power, human or non-human, how many EVAs required, etc. The Jet Propulsion Laboratory was also involved through many workshops, and ultimately put together a Science Payloads document for the mission architectures to draw from. The document is outdated, but it could be a good template to begin with. It was helpful to the engineers. Ms. Robinson said that a similar effort is being done in a segmented way but that most of the architectures for Artemis are still in formulation; everyone is working together as the program comes together, and managing the planning through Headquarters. There is also support through the Langley, Goddard, Johnson, and Marshall Centers. Ms. Cline commented that having been associated with these programs, she was very pleased to see the extent of the collaboration between the program offices and was impressed with and encouraged by the breadth of flight opportunities for science.

Dr. Woodward asked if a crisp narrative arc for what NASA is doing in human exploration exists to support this endeavor? Dr. Cerf said that this question might be best deferred to the incoming Administration. Ms. Budden commented that it's an important point to make: why do we care? She recommended that Headquarters develop a compelling narrative to underscore the relevance of the Artemis Program. Mr. Bowersox, Ms. Lueders' deputy, commented that HEOMD has taken the issue very seriously, and agreed that the narrative needs to be clearer.

Outbrief to AAs

Ms. Sandra Connelly, standing in for Dr. Zurbuchen, received Dr. Wadhwa's comments to SMD. Dr. Wadhwa offered a tentative finding on the excellent collaboration and communication between SMD and HEOMD, and relayed the Committee's commentary on recommending developing a more formalized way of communication between NASA and the commercial sector in terms of best practices and protocols. Dr. Mike Liemohn echoed Dr. Wadhwa's comments, saying he had especially appreciated the briefings on Planetary Protection and the Artemis Accords. Dr. Wadhwa also offered broad support for NASA's efforts under the constraints of COVID, and cited a finding from the previous meeting of the Science Committee that centered on the robustness of communication technologies. Dr. Cerf reiterated the importance of resilient communications for supporting missions and the Delay and Disruption Tolerant Networking (DTN) effort, thinking that now might be the time to scale up abilities for DTN in preparation for deployment for Artemis and beyond. Mr. Hale addressed Mr. Bowersox, noting that while HEOC feels that the cooperation between directorates is excellent, he did relay HEOC's concerns about the plan forward. He alluded to some proposed wording on a recommendation to HEOMD to have a plan B in case things go badly. Mr. McDaniel praised Ms. Lueders and Mr. Bowersox for their exemplary work in HEOMD and Dr. Siegel for her performance as Executive Secretary.

Mr. Hale said that HEOC would plan to issue formal findings and recommendations for the next meeting. Ms. Connelly thanked both Committees, as did Mr. Bowersox. Dr. Siegel thanked all the support teams. Mr. Callahan echoed Dr. Siegel's thanks to all involved, and adjourned the meeting.

Appendix A

Attendees

Human Exploration and Operations Committee

N. Wayne Hale, **Chair**, Retired NASA
Kwatsi Alibaruho, Industrial Sector Eaton
Nancy Ann Budden, Office of the Secretary of Defense
Lynn Cline, Former NASA Deputy Associate Administrator, HEO
Stephen "Pat" Condon, Aerospace Consultant
Ruth Gardner, NASA Kennedy Space Center
Michael Lopez-Alegria, Former NASA astronaut
David W. Thompson, Hunsaker Visiting Professor of Aeronautics and Astronautics
James Voss, Former NASA astronaut
Mark McDaniel, Partner at McDaniel and McDaniel Attorneys, LLC.
Bette Siegel, NASA, Executive Secretary

Science Committee

Meenakshi Wadhwa, **Chair,** Arizona State University
Vinton G. Cerf, Google

Jeffrey A. Hoffman, Massachusetts Institute of Technology
Michael W. Liemohn, University of Michigan
Pat Patterson, Space Dynamics Laboratory
Amy Mainzer, University of Arizona
Marc Weiser, RPM Ventures
Charles E. Woodward, University of Minnesota
Jason Callahan, NASA, Executive Secretary

Virtual Attendees

Kenneth Bowersox
Altonell Mumford
Renee Pullen
Julie Robinson
Gregory Heckler
Robyn Gatens
Patricia Sanders
Wade May
Ryan Whitley
Sam Grey
Michael Beavin
Griffin Reinecke
William Hitt
Frederick Hubbard
Camille Alleyne
Deborah Circelli
Kenneth Chang
Brianne Palomeque
Liz Warren
K Foley
David Eisenman
Cody Knipfer
Scott Spencer
Richard Harrison
Sean Fuller
Lewis Groswald
Jaime Hurtado
Marc Timm
Stephen Clark
Michelle Rodrigues
Kevin Metrocavage
Robert Zimmerman
David Millman
John Bergstresser
Lynne Loewy
Charles Coolidge
Jim Way
Cheryl Gramling
Stephanie Schierholz
Alexander Gerst
Patrick Finley
Jacob Keaton
DeAnn Reilly
Meredith Richard
Ariel Jeffrey
Michael Jason
Mike Francesco
Michael Alexander
Erin Lynn
James Stephen
Lora Stephen

Dimitra Tsamis
Joey Roulette
Mary Lynne Dittmar
Dan Carpenter
Devashish Bhalla
Ashton Armstrong
Vinita Marwaha Madill
Laurie Chappell
James Norman
Samantha Fonder
Jeannie Kranz
Jim Pawelczyk
Lester Lyles
Gale Allen
Alicia Anderson
Eric Istasse
Linda Karanian
Emre Kelly
Brian Dewhurst
Azita Valinia
Thomas Sutliff
Meredith McKay
Danny Lentz
Lorella Angelini
Tara Ruttley
Matt Jones
Jared Stout
Bill Peterson
Philip McAlister
Neil Wolf
Alicia Baturoni Cortez
Rhoan Boucher
Marchel Holle
Hanneke Weitering
Robert Shields
Pam Whitney
Sam Black
Janet Karika
Rob Kampen
Barbara Adde
Christie Cox
Sheryl Kelley
Kota Umeda
Anne Verbiscer
Brent Blevins
Ashton Lum
Sheryl Kelley
Dennis McSweeney
Suzan Voss
Zachary Pirtle
DeAnn Reilly

Andrey Ochepovskiy
Stephan Gerard
Jack James
Paul Wooster
James Zimmerman
Jörg Mayer
Gregory Mann
Rene Balanga
Gene Mikulka
Chris Davenport
Joan Zimmermann
Marcia Smith
Mark Kinnersley
Keith Cowing
Y Grondin
Rishin A
Nick Cummings
Denise Varga
Dhruva Anantha Datta
Irene Klotz
Patricia Rausch
William Harwood
Bob Menrad
Dillon MacInnis
Aaron Weaver
Darrell Branscome
Chris Gilbert
Aline McNaull
Naem Alt
Jason Callahan
Stephen Creech
Kathryn Lueders
Dave Murrow
Thomas Whitmeyer
Lori Glaze
James John
Michael New
Gerald Smith
Mohammad Kassemi
Lewis Groswald
Danny Lentz
Richard Arnold

Donald Chavers
Amanda Nahm
Tamara Dickinson
Saki Hirama
Stephen Clark
Daniel Evans
Jennifer Heldmann
Bill Peterson

Brian Day
Badri Younes
Jack James
Tariq Malik
Alan Feinberg
Gilbert Kirkham
Brianne Palomeque
Richard Rogers
Gui Trotti
Charlie Stegemoeller
Elaine Seasly
Keith Johnstone
Kirsten Petree
Olaf Corning
Jim Watzin
Robert Shields
Robin Mdoka
Emre Kelly
Oliver Botta
Ryan Whitley
Dava Newman
Rachel Pierre
Lauren Wright
Alexandra Witze
Dan Hirsch
Pete Woll
George Ho
Marcia Smith
Joey Roulette
Lisa Scott Carnell
Scott Spencer
Hanneke Weitering
Marchel Holle
David Millman
Michael Deklotz
Andrew Rowe
Rudy Frahm
Bo Trieu
Alexa Halford
A.C. Charania
Chris Gilbert
Robert Zimmerman
Douglas Gruendel

Louis Barbier
Masami Onoda
Dave Lederer
Kota Umeda
Ashlee Wilkins
Mark Kinnersley
Laurie Abadie
Darrell Branscome
Neil Wolf
Jose Hurtado
Douglas Isbell
Lynne Loewy
Barbara Adde
Sun Chan
Monica Witt
Kevin Ford
Alan DeLuna
Hale Stolberg
Christopher Culbert
Michele Gates
Stephan Gerard
Edward Stanton Jr
Erin Mahoney
Thomas Sutliff
Dillon MacInnis
Mathew Dunn
Doug Hemingway
Aaron Lewis
Jeff Foust
Kenneth Chang
Sean Shapira
Chris Culbert
Sam Schmidt
Andrew Parks
Abby Dickes
Jim Raines
Denise Varga
Kristina Gibbs
Michael Paschke
Gregory Schmidt
Jennifer Kearns
Becca Browder
Katelyn Kuhl

Collin Rokke
Michelle Rodrigues
Paul Wooster
Jörg Mayer
Dana Hurley
Sylvie Espinasse
Adam Geron
Irene Klotz
Brian Dewhurst
Barbara Cohen
Christyl Johnson
Jackie Keshian
Laura Forczyk
James Zimmerman
Kelsey Young
Linda Karanian
Miles Doran
Aleksandra Stankovivc
Amy Mainzer
Michael Meyer
Mike Gold
Sandra Connelly
James Favors
Dave Thompson
Farood Boortalary
Bruce Jakosky
Kevin Sato
David Burns
Amanda Moore
Renee Weber
Dan Hirsch
Sara Tucker
Thomas Feeley
Ursula Rick
Eracenia Kennedy
Mark Kirasich
James Spann
Andrew Schurr
Sarah Noble
Thomas Zurbuchen

Appendix B
HEOC Membership

N. Wayne Hale, Chair
Former Space Shuttle Program Director

Nancy Ann Budden
Director for Special Operations Technology
Office of the Secretary of Defense

Stephen "Pat" Condon
Aerospace Consultant
Former Commander of the Ogden Air Logistics Center,
the Arnold Engineering Development Center, and the Air Force Armament Laboratory

Ruth G. Caserta Gardner
Technical Deputy Director for the Engineering and
Technology Directorate at NASA's Kennedy Space Center

Michael Lopez-Alegria
Former NASA astronaut and retired U.S. Navy Captain
President of the Commercial Spaceflight Federation

James Voss
Former NASA astronaut
Retired U.S. Army Colonel Scholar in Residence
Department of Aerospace Engineering Sciences
University of Colorado, Boulder

Mark McDaniel
Partner at McDaniel and McDaniel Attorneys, LLC.

Lynn Cline
Former NASA Deputy Associate Administrator
for Human Exploration and Operations

Kwatsi Alibaruho
Vice President, Program Management
Industrial Sector Eaton

David W. Thompson
Hunsaker Visiting Professor of Aeronautics and Astronautics
Former President and Chief Executive Officer of Orbital ATK

Appendix C

Presentations

1. ISS Status and Transition; *Robyn Gatens*
2. SCaN Commercialization of Near-Earth Communications Status; *Greg Heckler*
3. Commercial Crew Program Status; *Phil McAlister*
4. Artemis Overview; *Kathy Lueders*
5. SMD Artemis and CLPS Activities Overview; *Thomas Zurbuchen*
6. Moon to Mars Update; *David Burns*
7. Solar System and Beyond Update; *Lori Glaze, Sarah Noble*
8. HERMES Instrument Update; *James Spann, Jamie Favors*
9. Artemis III SDT Update; *Renee Weber*
10. Advancing Physical and Biological Sciences Through Lunar Exploration; *Kevin Sato*
11. SMD Mars Science Update; *Michael Meyer*
12. Planetary Protection Activities at the Intersection of Human and Science Missions to Mars; *Lisa Pratt*
13. Artemis Accords; *Mike Gold*

APPENDIX D
AGENDA

Agenda

Agenda

January 13, 2021

NAC HEO Committee Public Meeting

11:30- 11:35	Call to order	Dr. Bette Siegel/ Mr. Wayne Hale
11:35-12:00	ISS	Ms. Robyn Gatens
12:00- 12:30	SCAN	Mr. Greg Heckler
12:30-1:30	Commercial Spaceflight Division	Mr. Phil McAlister
1:30-1:40	Public comments	
1:40-2:30	Discussion and Recommendations	

Dial-In and WebEx Information for January 13

Event address for attendees:

https://nasaenterprise.webex.com/nasaenterprise/onstage/g.php?MTID=ef268da6a9daa9bd59ba35b80dd54bd65

Event number: 199 568 2184 Event password: 7mP6pAJvW@7

If needed, Audio conference information
US Toll: +1-415-527-5035
Global call-in numbers:
https://nasaenterprise.webex.com/nasaenterprise/globalcallin.php?MTID=e2674fb32caeca0bff43bda0b1cae7208

Access code: 199 568 2184

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

January 14, 2021

NAC HEO/Science Committees Joint Public Meeting

1:00 – 1:15	Opening Remarks / Introduction of Members	Dr. Bette Siegel Mr. Wayne Hale Mr. Jason Callahan Dr. Meenakshi Wadhwa
1:15 – 1:45	Artemis Overview	Ms. Kathryn Lueders
1:45 – 2:00	SMD Artemis and CLPS Activities Overview	Dr. Thomas Zurbuchen
2:00 – 3:20	SMD Lunar Science	Dr. David Burns Dr. Lori Glaze Dr. Sarah Noble Dr. James Spann Mr. James Favors Dr. Renee Weber Dr. Kevin Sato
3:20 – 3:35	SMD Mars Science	Dr. Michael Meyer
3:35 – 3:50	Planetary Protection	Dr. Lisa Pratt Dr. Ursula Rick
3:50 – 4:00	Artemis Accords	Mr. Mike Gold
4:00 – 5:00	Discussion, Findings and Recommendations	All
5:00 – 5:15	Outbrief to HEOMD Deputy AA and SMD Deputy AA	Mr. Wayne Hale Dr. Meenakshi Wadhwa
5:15 p.m.	Adjourn	

Dial-In and WebEx Information for January 14

Event address for attendees:

https://nasaenterprise.webex.com/nasaenterprise/onstage/g.php?MTID=e6a0f7dd70d769cb581af3a729d8e4e85

Event number: 199 200 6220 Event password: YmpNdfH*926

If needed, Audio conference information
US Toll: +1-415-527-5035
Global call-in numbers:
https://nasaenterprise.webex.com/nasaenterprise/globalcallin.php?MTID=ef59221cc82e122a9c22f81cede9fc9b9
Access code: 199 200 6220

Appendix E

Webex Chat Transcript

January 13

from Bette Siegel (Int) to everyone: 1:22 PM
please enter your comments in the chat area.
from Dan Carpenter (Ext) to host (privately): 1:22 PM
Phil, It looks as if space and high tech are growth areas (if you look at Elon but maybe more importantly, all the companies that have sprung up around ISS. Do you see a NASA role in supporting the country's economic recovery from Covid?
.from Jim Voss (Ext) to everyone: 1:27 PM
Is it OK to ask questions when Phil finishes?
from Bette Siegel (Int) to host (privately): 1:27 PM
yes. you can ask questions
phil, It looks as if space and high tech are growth areas (if you look at Elon but maybe more importantly, all the companies that have sprung up around ISS. Do you see a NASA role in supporting the country's economic recovery from Covid?
from Gene Mikulka (Ext) to host (privately): 1:33 PM
With trying to get information to the public on what ISS is doing is there anything that those who are following space can help? I know JPL has the Solar System Ambassador program but would it be possible for NASA to put out a reques to the general public for ideas to promote ISS activities and perahps participate on a volntary basis (PS - Would love to volunteer to help!)
from Gene Mikulka (Ext) to host (privately): 1:33 PM
With trying to get information to the public on what ISS is doing is there anything that those who are following space can help? I know JPL has the Solar System Ambassador program but would it be possible for NASA to put out a reques to the general public for ideas to promote ISS activities and perahps participate on a volntary basis (PS - Would love to volunteer to help!)

from Y Grondin (Ext) to host & presenter: 1:40 PM
Do we know if the Biden Administration is supportive of awarding the HLS Option A awards in February (as is currently planned)?
links to talk about ISS to the public
https://cms.nasa.gov/leo-economy/welcome-to-low-earth-orbit-economy
https://www.nasa.gov/mission_pages/station/research/benefits/index.htm

January 14

from Scott Spencer (Ext) to all panelists: 1:48 PM
For Artemis lunar sustainability any planning for lunar base assets for missions after Artemis III?
from Mini Wadhwa (Ext) to everyone: 2:42 PM
Dear Science & HEO committee members: Please include any questions here so that we can keep track of these to ask at end.
from Charles Woodward (Ext) to everyone: 2:42 PM
When a CLIPs package completes its delivery service and cconcludes the science activity, does the provider still have responsibilty for the assest on the surface and potentially the eventual responsibilty for removal and/or retrieval after human activity is established on the surface?
from David Burns (Int) to everyone: 2:43 PM
Here is a link to the PRISM call for lunar science:
https://nspires.nasaprs.com/external/solicitations/summary.do?solId=%7B03464E24-4AFA-781E-200C-956EE283CD8A%7D&path=&method=init
from Mini Wadhwa (Ext) to everyone: 2:44 PM
Thanks, David!
from Pat Condon (Ext) to everyone: 2:50 PM

Given that other nations (perhaps not partners) are interested in lunar exploration, who is the "gatekeeper" or "traffic cop" to ensure that conflicts and possible contamination are avoided?
from David Burns (Int) to everyone: 2:52 PM
Re: CLPS lander after mission is complete. I believe the CLPS lander remains the property of the company that built it, though this question should be referred to Office of the General Council for a more complete response. This hardware may be protected as a heritage asset in the future, and we do not currently have a plan to remove them.
from vinton cerf (Ext) to everyone: 2:53 PM
for Sarah - are the workshops recorded for later vieweing?
from marc weiser (Ext) to all panelists: 2:54 PM
following from Chick's question, assuming the platforms operate far past their intial spec'd mission timeline, are NASA driven secondary/follow-on science opportunites part of the consideration? Or will the commercial partners be able to offer services to other partiers?
from Jeffrey Hoffman (Ext) to everyone: 2:57 PM
What plans are being made to investigate the long-term impact of lunar gravity? This will require some instruentatin on the Moon.
from Sarah Noble (Int) to everyone: 2:58 PM
All of the talks for the Lunar Surface Workshops are available here:
https://lunarscience.arc.nasa.gov/lssw/recordings.html
from Charles Woodward (Ext) to everyone: 3:08 PM
Are all the science products returned from Gateway platforms (e.g., HERMES) integrated into NASA managed archival with access portals that enables the wide dissemination of high level sceince products to various stakeholders and scientist within the community in a VO (or Cloud) envirnomemt that maximizes the utlity of these data prodcuts?
from vinton cerf (Ext) to everyone: 3:14 PM
following Marc Weiser, the ability to upload new communiction protocol implementation in post-experment repurposing of the spacecraft would be very attractive for the space comms development effort.
from Mike Liemohn (Ext) to everyone: 3:15 PM
The change of location for the HERMES package -- could you please remind us of the orientation of the Gateway relative to the moon, Earth, and/or Sun, and why this was an advantageous change?
from James Spann (Int) to everyone: 3:15 PM
@ Charles Woodward - Yes. We are preparing a Science Ops center that will collecct, distribute the data and archive the scinece data in the Space Physics Data Facility at GSFC.
from James Spann (Int) to everyone: 3:17 PM
@ Mike Liemohn - the location of HERMES on HALO is advantageous because it provides better access to the solar wind along the Parker Spiral.
from James Spann (Int) to everyone: 3:20 PM
@ Mike Leihmon - The initial Gateway configuration in composed of the HALO and PPE. The HALO is in sunward direction and the PPE in the anit-sunward direction.
from Charles Woodward (Ext) to everyone: 3:20 PM
Are there discussion regarding commercial utlization of lunar returned samples (lunar), especially if down-mass is significant....
from David Burns (Int) to everyone: 3:22 PM
Re: platforms operating past their intial spec'd mission timeline. Yes, we can support secondary/follow-on activies for these instruments when applicable. We are encouraging the CLPS companies to carry non-NASA payloads whenever it is beneficial for them to do so. This may lower delivery costs in the future, increase the demand for their services, and build the lunar economy.
from Amy Mainzer (Ext) to all panelists: 3:25 PM
What is the approximate timeline for return of lunar samples, and under which program(s) would the samples be collected?
from Renee Weber (Int) to everyone: 3:26 PM
The goal would be to have samples returned by each crewed mission beginning with Artemis III in 2024
from Charles Woodward (Ext) to all panelists: 3:27 PM

A very key point Amy .. the US apparently is already way behind China in this activity including sample up mass, redevous, and capture and Earth return ... Quite immpotant for Mars sample return also.
from Amy Mainzer (Ext) to all panelists: 3:28 PM
Thanks. Also, is there any possibility of a cooperative multi-national agreement for US scientists to gain access to the samples returned by the Chang'E mission?
from Bruce Jakosky (Ext) to everyone: 3:29 PM
The Artemis science definition team defined a remarkably robust suite of science that should be done. But they also commented that the physical resources anticipated to be available on Artemis III were inadequate to address the objectives satisfactorily. Are plans being developed to enhance the capabilities on subsequent missions so that significant science can be carried out?
from Renee Weber (Int) to everyone: 3:31 PM
re: coodination on Chang'E samples: I am not aware of any effort at this time
from vinton cerf (Ext) to everyone: 3:34 PM
Could Gateway release smallsats into useful lunar orbit?
from Renee Weber (Int) to everyone: 3:36 PM
Bruce: that is part of why the SDT set priorities, because we recognize that capabilities will grow with time, and we can learn from Artemis III to help plan subsequent missions
from Michael New (Int) to everyone: 3:36 PM
@Renee: Note that the Wolf Amendment prohibiting NASA from entering into any bilateral collaboration with China is still in effect and would bar coordination with Chang'e.
from Charles Woodward (Ext) to all panelists: 3:36 PM
one wonders about the "space raffic" control envirnment and hazard avoidance issues as cubesats, smallstats, etc being to populate lunar space
from Charles Woodward (Ext) to all panelists: 3:36 PM
space traffic control (typo)
from Bruce Jakosky (Ext) to everyone: 3:37 PM
Renee, thanks.
from Neil Wolf (Ext) to all panelists: 3:39 PM
But under Art 6, the US government remains legally responsible for the Treaty compliance of even the commercial landers....the possession criterion is not germane, primarily. And the recent preservation act is just advisory, pertaining as it does only to licensing.
from Amy Mainzer (Ext) to all panelists: 3:40 PM
@Michael: But the Wolf Amendment does not prohibit multi-national collaborations, right? In other words, if NASA were to partner with e.g. ESA, this would be allowable, would it not?
from Michael New (Int) to everyone: 3:42 PM
@Amy: NASA could participate in a multilateral activity with China. In the past, though, there have been hair-splitting discussions about when an activity was truly multilateral as opposed to being a set of bilateral collaborations.
from Amy Mainzer (Ext) to all panelists: 3:49 PM
Thanks Renee, Sarah, and Michael for your answers.
from Michael New (Int) to everyone: 3:52 PM
@Amy: You're very welcome.
from James Spann (Int) to everyone: 3:52 PM
@ vinton cerf - someone from the Gateway Program should address this. However, it is my understanding that the initial configuration of HALO/PPE will not have this capabiltiy. However some of the Gateway science objectives call for SmallSat or CubeSat deployment capability.
from Charles Woodward (Ext) to all panelists: 3:59 PM
What is the dwell time wherein the RAD environment from the local rock and surface becomes hazardous to astronaunts (aka the terrestrial radon-like problem)?
from Charles Woodward (Ext) to all panelists: 4:13 PM
Are domestic commercial entities (especially those engaged by NASA) bound "legally" to the terms of the Artemis accord principles as a prereuisite to general access to space (and the cislunar environment)?
from vinton cerf (Ext) to everyone: 4:15 PM

Are commercial operators asked to sign the accords?
from vinton cerf (Ext) to everyone: 4:17 PM
Japan is on twice. why?
from Mike Liemohn (Ext) to everyone: 4:17 PM
One of those should be Ukraine, I think.
from Charles Woodward (Ext) to all panelists: 4:17 PM
Interesting that India, Brazil, and France seem missing in the last slide
from Lynn Cline (Ext) to everyone: 4:23 PM
For Mike Gold - Have the Artemis Accords been presented to or discussed at the UN Outer Space Committee? If so, what was the feedback?
from Ursula Rick (Int) to everyone: 4:27 PM
Note that should say south of 79 degrees S and north of 96 degrees N.
from Ursula Rick (Int) to everyone: 4:27 PM
Sorry for the typo. 86 degreeds N.
from vinton cerf (Ext) to everyone: 4:32 PM
It is ironic that we were unable to come to agreement on Earth to protect this planet....
from Alan DeLuna (Ext) to all panelists: 4:33 PM
Thanks to all the presenters for the information presented. I look forward to downloading the presentaons from the NAC HEO site for a more relaxed review. Those of us who spent much of their career in transportation sometimes get the bias that if things do not involve smoke and fire they are not important. This all reminds us of why we need the rocket as a tool instead of the being the goal. These mission objectives are why we are all here. All us old rocket builders need this reminder once in a while.
from vinton cerf (Ext) to everyone: 4:35 PM
does the COPP conclusion mean that a meteor strike that disperses bio contamination is irrelevant? Let alone the fuel issue
from Charles Woodward (Ext) to all panelists: 4:36 PM
there is a relaively high micrometeorite flux on the lunar surface ...
from Charles Woodward (Ext) to all panelists: 4:37 PM
there are also significant stakeholders that are concerned with "pollution" in general of the lunar environment as a general rule, biological contamination issues aside.
from Charles Woodward (Ext) to all panelists: 4:42 PM
mini - endorse your last idea as a finding !
from marc weiser (Ext) to all panelists: 4:44 PM
this also requires coordination with FCC who provides launch licenses
from Julie Robinson (Int) to everyone: 4:46 PM
Wayne: You are correct, we do have working groups, capabilities assessments, and eventual transition from strategic to tactical in work between HEOMD, STMD and SMD. These are the groups that will be using the results of the the SDT and incorporating them into appropriate mission plans and long term architectures, and building the first research plans for the human missions.
from vinton cerf (Ext) to everyone: 4:48 PM
do commercial companies have to get clearance from someone to operate in space?
from Charles Woodward (Ext) to all panelists: 4:59 PM
these oresentations were quite interesting, one last thought is that is there a string science plan that can derive HEO activities that are compelling to the Nation
from vinton cerf (Ext) to everyone: 5:13 PM
need to join another event - thanks for a most informative day. Really find this kind of joint event helpful from the point of view of gaining perspective on both programs.
from Charles Woodward (Ext) to all panelists: 5:16 PM
thank you alll and stay well and stay safe ... need to drop off now.....
from Sara Tucker (Ext) to all panelists: 5:17 PM
Thank you. Very interesting day.