National Aeronautics and Space Administration
Washington, DC

NASA ADVISORY COUNCIL
Human Exploration and Operations Committee
April 25, 2024

MEETING MINUTES

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Bette Siegel, Executive Secretary	**Lynn Cline, Chair**

Public Meeting Minutes
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April 25, 2024

Call to Order/Announcements

Dr. Bette Siegel, Executive Secretary of the Human Exploration and Operations Committee (HEOC), called the meeting to order, provided details of Federal Advisory Committee Act (FACA) rules, and made administrative announcements. She introduced the new interim Chair of the HEOC, Ms. Lynn Cline.

Ms. Cline welcomed members to the meeting, noting that the Committee should deliberate with an eye to bringing findings and recommendations to the full NAC meeting in May, and adding that former Chair Mr. Wayne Hale sent his regards.

Space Operations Mission Directorate (SOMD)

Ms. Tonya McNair, Deputy Associate Administrator (DAA) for management for Space Operations Mission Directorate (SOMD), briefed the HEOC in lieu of AA Mr. Ken Bowersox. The SOMD leadership team were assembling in Florida to prepare for the Boeing crewed flight test (CFT) Flight Readiness Review (FRR). Ms. McNair focused recent accomplishments in human spaceflight missions in low Earth orbit (LEO), space communications systems, launch services, and human research. The International Space Station (ISS; or *Station*) celebrated 25 years in space in December 2023. Successful launches of SpaceX 29 and 30 vehicles took place in December 2023 and March of this year. Northrup Grumman (NG) completed its 20th Cygnus mission to ISS in January 2024. Cargo ships delivered the AWS to Station, as well as the successful Illuma-T laser communications demonstration, which demonstrated two-way end-to-end, high-data-rate transmission between Earth and ISS. NASA released a new Spot the Station mobile app, available for both Android and iOS. ISS held its first Spanish language tour. The Launch Services Program (LSP), also celebrating its 25th anniversary, recently completed a GOES-U milestone, keeping the satellite on track for launch. SOMD has begun new RS-25 engine testing for future Artemis missions. Dr. Pat Condon asked if the engines were newly manufactured, and how many were under current contract. Ms. McNair said she believed there are about 18-20 RS-25s on the first contract, with a second lot in the process of being procured on a new contract. Asked if the new engines had improved performance, Ms. McNair said she believed there are some new approaches, and took a note for the Exploration Systems Development Mission Directorate (ESDMD) to answer the next day.

DSOC, which transmitted data to Earth from a distance of 19 million miles, will enable future deep space missions. Crew has been selected for next simulated Mars mission, which will begin on 10 May, and a third Private Astronaut Mission (PAM) was conducted safely on ISS. SOMD supported the 24th Annual Space Exploration Educators Conference, Human Research workshop in February, with the highest attendance to date. The Plankton, Aerosol, Cloud Ocean Ecosystem (PACE) satellite was launched, successfully demonstrating Delay/Disruption Tolerant Networking (DTN) for telemetry data. NASA's most recent Astronaut Candidate Graduation ceremony featured coverage in the Spanish language. Space X Crew-8 launched successfully as well; this crew will be part of the Complement of Integrated Protocols for Human Exploration Research (CIPHER) project, which tracks bone and joint health, brain, sensorimotor systems, vision, biomarkers of muscle, bone, and vascular system health over crew time in space. At least three astronauts volunteer for this project. SOMD is taking applications for the next Crew Health and Performance Exploration Analog (CHAPEA), the second of three ground-based Mars simulation missions. ISS just completed its seventh education downlink activity; to date this project has involved 13,000 students, 1000 educators, and 6000 members of the public. ISS recently released the 2023 Annual Highlights of Results for Space Station Research. Ms. McNair closed her remarks by thanking Ms. Cline for stepping in as Chair of HEOC.

SOMD Budget

Ms. Elaine Slaugh addressed the FY2025 President's Budget Request (PBR) for SOMD, and briefly outlined the overarching strategy for dealing with expected shortfalls. Setting context, the FY 2024

enacted budget (with the Initial Operating Plan for FY 2024 to be approved fairly soon), and represents a reduction of $30M to SOMD, compared to the previous enacted budget. The debt ceiling crisis and Fiscal Responsibility Act will constrain the budgets for fiscal years 2024 and 2025, however SOMD was happy to get an appropriation in a timely manner to avoid uncertainty and potential cuts due to sequestration requirements outlined in the Fiscal Responsibility Act. The budgets in 2025 and through the outyears are also based on lower numbers (about 5% less; the constrained budget will require some re-phasing and re-planning). However, NASA requested funds to mitigate the recent monsoon-related destruction of a Guam ground terminal, representing a significant loss to the Space Communications and Navigation (SCaN) network. A total of $460M for both the ISS deorbiting vehicle ($180M) and funding for Guam emergency relief ($280M) were proposed by the President to Congress, and NASA hopes to obtain this funding. Asked to summarize the impact of the proposed budget, Ms. Slaugh said all the programs are working to re-phase. SCaN is moving things out, and ISS is still studying options. This process will take several iterations, and SOMD hopes to finalize it by late Summer.

Ms. Slaugh provided an overview of the plan for Low Earth Orbit transition from ISS to Commercial LEO destinations and then discussed each components' budget. This includes ISS operations at roughly $1.27B, which supports continuing valuable science and research aboard Station. ISS operations and maintenance costs from 2024-29 are running at about the same level as FY25. The Crew and Cargo budget, $1.76B, reflects funding for transportation services and funding for the deorbit vehicle. The Commercial Crew budget is $100.6M for 2025. Asked where the received (reimbursement) payments go, Ms. Slaugh said they go back to the budget line accounts, as NASA charges only for its actual cost expended. The reimbursements reduce the NASA cost, and each reimbursement is a separate agreement. Ms. Slaugh offered to bring an example to future briefings make the transaction clearer. The budget for commercial LEO development, including milestones for technology maturation, is $169M, and increases in the outyears. The budget for SCaN and the Communication Services Program (which is working to demonstrate commercial capabilities for SCaN) are approximately $600M and $59M,per year respectively..

Human Space Flight
Human Space Flight Operations is funded at $105M for 2025. The FY25 budget for the Launch Services Program (LSP), which includes Alpha Magnetic Spectrometer (AMS) operations on ISS, is $104.3M. The budget for the Rocket Propulsion Test program is $48.6M, and will support state-of-the-art testing for hypergolic and other fueled engines for Artemis, Commercial Crew, and other customers. The Human Research Program is funded at $143.4M, and will continue to support research to reduce human health risks for long-duration ISS, addressing high-priority Artemis risks, with an eye to future Mars missions. In summary, SOMD stands at $4.4B for 2025. Details can be found at https://www.nasa.gov/fy-2025-budget-request/

Dr. Condon asked if NASA now accepts Continuing Resolutions (CRs) as a fact of life. Ms. Slaugh affirmed that NASA indeed expects CRs and has developed some mitigation strategies; however, this year was particularly hard, given new budget caps. However, NASA is always happy to get an appropriation instead of a CR. Dr. Nancy Ann Budden asked if any of the rules pertaining to the CR have changed. Ms. Slaugh said that in some cases, the Agency is able to request funds for anomalies, and the Office of Management and Budget (OMB) will assist. Some NASA mission directorates have done this. Ms. Cline confirmed that under major budget themes, there is now a little bit of flexibility, and in addition, a law was passed ensuring pay for federal workers. Asked if there's been some discussion to provide some form of exclusion for criticalities, as is done for the Department of Defense (DOD), Ms. Slaugh noted that ISS is excluded from government shutdown rules, as is SCaN, and launches that must go forward in order to avoid wasting hardware.

ISS

Mr. Jacob Keaton, standing in for Ms. Robyn Gatens, gave a status report. ISS continues to meet its mission goals in the "Decade of Results." A total of 26 NASA technology demonstrations have been initiated since 2018. Station is coming up on more than 4000 scientific results published, and continues activities designed to reach STEM students and educators. Increment 71 includes a Russian extravehicular activity (EVA), which will be carried out by two cosmonauts on 24 April. The Boeing CFT is on schedule to launch. Increment 71 will also include a number of US EVAs, cargo resupply missions, and a crew changeout in the Fall. The CRS30 vehicle return is now scheduled for no earlier than 27 April due to weather in Florida. The NG20 vehicle will be leaving in July. Upcoming US EVAs will focus on maintenance, lubrication, and preparation for the next installation of roll-out solar arrays (ROSAs). The ongoing atmosphere leak rate increased in February. The hatch was closed and crew continues to monitor. Mr. Voss asked what NASA is doing in terms of analysis. Mr. Keaton said that NASA is testing some material samples. Mr. Voss formally requested more detailed information. Mr. Keaton said that such information is not publicly available but could be handled in a closed session with HEOC. He noted that the leak was still below the Station specifications, but that the rate is above where it was after the first round of repairs.

NASA has issued a request for proposal (RFP) for de-orbit vehicle, and the contract award is targeted for Summer. The delivery date for the vehicle is 2028 or 2029; it will need a one-year checkout period, which will require crew on board. The goal is to fly it up to ISS in 2029. In other matters, a recent debris re-entry impact on a Florida home was traced to the loss of a Station stanchion that is used to mount old batteries. An analysis under way.

Research on ISS

The ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) experiment on ISS provided the first high-resolution thermal infrared measurements, which indicate that tropical forests are approaching critical temperatures (114F), impacting forests' ability to take up carbon. Material science research results are providing new understanding of how cement solidifies in conditions below 1G; these data will apply to construction on the lunar surface, and using *in-situ* resource utilization (ISRU) in such an environment. Astronauts are participating in another experiment to mitigate fluid shifts during microgravity, using a cuff that constricts a vein in the thigh. The cuff can be used also for bedridden patients on the Earth. The newest ISS science instruments have arrived at ISS: the AWS on ELC-1, and the Illuma-T demonstration.

A total of 159 research and technology investigations were carried out during 2024. Education on Station continues with "STEMonstrations," coverage of the 8 April total eclipse (Storytime from Space, etc.), and in-flight education downlinks. The ARISS outreach project ("ham radio in space") marked its 40th anniversary. Mr. Keaton plugged the newest Spot the Station app, which he described as much improved, noting that there have been 500,000 downloads in the last six months. The ISS National Lab still has more demand than resources available. Registration is now open for the ISS R&D Conference in Boston in late July/early August, and the *Upward* magazine is being relaunched (www.issnationallab.org/upward). ISS continues to work on a formal action from the National Space Council to develop the LEO Strategic Framework, and is currently working on developing goals and objectives, and rationales for LEO presence, such as support for scientific discoveries, deep space exploration, and enabling commercialization. The Strategic Framework will include participation from other government agencies, as well.

Commercial Crew Program/Commercial LEO Development

Ms. Misty Snopkowski presented in place of Mr. Phil McAlister. The Commercial Crew Program (CCP) flight continues to successfully provide safe and efficient flights to ISS; the next launches are Boeing's CFT, and SpaceX Crew-9. Boeing's CFT is on track for a 6 May launch at 10:34pm. CFT will be the first flight with crew on board and will mark the 100th flight of the Atlas V rocket. The FRR is in progress at Kennedy Space Center (KSC) and is closing out all the certification products. A few media events will take place with the crew, and a teleconference where NASA and Boeing will provide results of the FRR. Upcoming milestones include the pre-launch mission dress rehearsal, followed by a United Launch Alliance (ULA) Launch Readiness Review LRR just prior to launch. The mating to the launch vehicle is complete, and everything looks good for a Go. Mr.Voss noted that the Vulcan LV will be replacing the Atlas V, and asked about the steps necessary for certifying Vulcan for crew launches. Ms. Snopkowski said the program is considering what the delta certification process would be.

SpaceX Crew-8 Dragon Endeavor is preparing to relocate to a different port on 30 April to allow the Boeing's CFT Starliner to dock to the ISS forward node. Endeavor has been healthy and operating within flight rules. SpaceX Crew-7 returned to earth on 3 March, and experienced a very clean mission, with nominal landing and recovery. Asked if Endeavor would be retired, Ms. Snopkowski said that it is certified for up to 5 flights, but did not know for sure if it will be retired or if SpaceX will try to re-certify the vehicle for additional flights. Once Boeing completes its CFT mission, NASA will have a second provider for CCP, and will rotate with SpaceX, every other flight. CCP is also starting to ramp up its engagement with the Commercial LEO Development program, under an initiative called Collaborations for Commercial Space Capabilities.

ISS to CLD Transition

The transition from ISS to Commercial LEO Destinations (CLD) is currently in Phase 1, which encompasses early design maturation. Axiom Space, Blue Origin Orbital Reef, and Starlab Space LLC (formerly NanoRacks) are the current funded CLD partners. Blue Origin and Starlab concepts are being developed under funded Space Act Agreements and as such do not have to meet NASA requirements. At this Phase 1 stage, NASA has stated goals that it would like them to meet in their SAAs. Axiom space is under a firm fixed price contract and must meet the safety and visiting vehicle requirements for the ISS. During Phase 1, the partners develop their own requirements; the purpose of this strategy is to encourage innovation. NASA does not perform oversight during this phase since there are no NASA requirements to verify but does have insight into the design phase through funded milestones in the SAAs and FFP contact. NASA provides feedback to the milestone activities. Also during this Phase 1 period, NASA is developing its CLD requirements set. These CLD requirements will be levied during Phase 2, which will be firm fixed price contracts that cover certification and services – this approach is exactly what the Commercial Crew Program did during CCtCap. The transition won't be completed until the de-orbit vehicle is up at ISS. Mr.Voss asked if the most recent Congressional bill package had included anything for NASA. Ms. Snopkowski said it had not.

Funded SAA companies

NASA is funding three companies for CLD. Axiom is planning to launch their first element in 2026. They proposed to change their assembly sequence to allow them to become a free flyer (FF) sooner. NASA is considering their proposal at present.

Blue Origin recently completed milestones for its water multifiltration system and CO2 reactor. When Northrup Grumman withdrew to team up with Starlab, NASA gave an additional $42M to Blue Origin, thus they were able to add some milestones related to their ECLSS. They have made much progress on this front.

Starlab (Nanoracks/Voyager Space) is partnered with Airbus and Mitsubishi; they also received additional funding ($57.5M, for a total of 217.5M), and recently completed the Alternative Urine Processor Final Design Review.

A total of seven CLD unfunded partners were awarded in June 2023; NASA did this to ensure partnerships and to gain some insight into what industry is working on for LEO destinations and transportation. These partners represent a mix of transportation and destination. Partners receive access to NASA expertise and data, lessons learned, and designs for LEO. Blue Origin's transportation project will hold a program status review in June. Northrup Grumman is working on a persistent LEO platform. SpaceX is working on transportation and Starship bases. Sierra Space is focused on developing an inflatable LIFE module/habitat. Vast is working on a CLD with artificial gravity and is targeting launch for 2025 for a demonstration. Special Aerospace Services (SAS) is working on a robotic MMU- like system for external CLD operations instead of EVAs. Think Orbital is developing on-orbit manufacturing technologies, including welding. Asked if there was integrated oversight with these companies, Ms. Snopkowski said the program preforms insight of these unfunded SAAs through milestone reviews. During the SAA selection process, these were the seven companies the Agency thought would be most useful and valuable to establish partnerships with.

Private Astronaut Missions (PAMs) are flown under the Commercial LEO Development Program. These are commercial missions with commercial activities on ISS. Three have been flown to date. Dr. Peggy Whitson will serve as commander on the fourth and next mission. The missions are licensed by FAA, but they do need to meet ISS safety requirements. PAMs help the industry understand the costs of such missions and drive down the cost of transportation. Three PAMs have flown to date; Ax-4 will fly in October; the remaining crew is TBD.

Discussion

Ms. Cline and HEOC reviewed previous findings and recommendations to prepare for the next NAC meeting. As the NAC has not met in 18 months, and invited discussion on agenda items. She assumed that HEOC's prior SCaN finding, expressing concern about supporting lunar and deep space activities; was still relevant and should go forward. HEOC concurred. Dr. Paul McConnaughey said he had expected the Human Research Program (HRP) to include more attention to high-energy particles and gamma ray exposure in space. As the budget is going down, NASA seems to be ignoring the highest risk in deep space exploration, and HEOC should hear more detail about this. Ms. Cline said she would make a note to include the topic at the next meeting. Mr. Voss noted that the top three risks tracked in HRP are all radiation related, and thus warrant more attention. He felt that because there is no real solution, HEOC could weigh in with new ideas. Ms. Budden referred to a good past briefing on the subject of ocular/cerebral risks, and suggested the subject be revisited. Dr. Siegel took an action to put the briefing on the agenda. Mr. Voss suggested that future meeting topics include the leak on ISS, and PAM reimbursements. Ms. Cline noted these requests. Another past finding, on the subject of ensuring that there is no commercial LEO gap, was also moved forward.

Dr. Condon noted that much has happened since the HEOC's last meeting with regard to the division of the former HEOMD, and the addition of the Moon to Mars office. He requested an update on how the roles, responsibilities, and interfaces are being handled between the SOMD and ESDMD. Ms. Cline agreed and suggested a closed session on this subject.

As to the commercial space providers and their markets, HEOC discussed the need to understand how the requirements and feedback loop works with these companies. A participant commented that there may be hidden schedule challenges, and HEOC may need to dig these out. Mr. Alibaruho agreed with the tenor of the conversation, and agreed that the last meeting findings are still relevant. Dr. George Sowers suggested that HEOC dig deeper on risk postures. The LEO gap is a huge risk, so the HEOC should ask about how

they are tracking risk, as this concern is relevant to both mission directorates. Ms. Budden commented that it seems like NASA is putting all its eggs in the commercial basket; NASA is assuming they will come through, and with assumption comes risk. NASA is not driving the whole show anymore. Is NASA comfortable with giving away control to conserve costs? Mr. Voss felt that these companies are at a high risk of not getting there without more NASA funding and that HEOC needs to know more about what is really going on Ms. Budden agreed, and noted that there is also the layer of Congressional uncertainty.

Public comment period
No public comments were received.

Meeting was adjourned.

Recommendation:

Title of Recommendation: Shortfall in NASA Deep Space Communications Network
Recommendation: NASA needs to emphasize the requirements for expansion and sustainment of the Deep Space Network (DSN). NASA needs to immediately complete plans for and fund the expansion of the capability of the DSN.
Major Reasons for the Recommendation: The DSN capabilities may not be able to support the expected cis-lunar, Lagrange, and deep space missions of the future unless steps are taken to expand capabilities. These infrastructure items have long lead time requirements and need to be addressed immediately. Resources, especially appropriations, need to be a high priority. The committee is unsure if Launar Exploration Ground Sites (LEGS) will provide enough relief to the DSN to allow all the missions to be supported.
Consequences of No Action on the Recommendation: Without increased capabilities, lack of communications capability will stifle the plans that US and its allies have developed for deep space operations.

April 26, 2024

Welcome
Dr. Siegel re-opened the meeting. Ms. Cline introduced the agenda.

Exploration Systems Development Mission Directorate
Ms. Catherine Koerner briefed HEOC on the status of Exploration Systems Development Mission Directorate (ESDMD) and reviewed the organization chart. At top are the Strategy and Architecture Office, Moon to Mars (M2M) , and the Business Office. Within M2M, there are five(5) offices: Mars Campaign, SMA, SEI, Exploration Operations, and Program Planning and Control; below these are the Exploration Ground Systems (EGS), Space Launch System (SLS), Orion, Human Landing System (HLS), Gateway, and EVA and Human Surface Mobility (EHP). ESDMD's goals are to execute Artemis missions and to evolve a sustainable architecture to support M2M objectives, advance a national deep space capability, enhance affordability of all Exploration Systems, and expedite an annual cadence for

Artemis (to occur sometime after Artemis V). To accomplish these goals, ESDMD fosters high standards of program and project management, and balanced funding approaches.

ESDMD is working within a manifest that supports the 2025 PBR. Artemis II has been moved to late 2025, and Artemis III to late 2026, to incorporate lessons learned from Artemis I to ensure successful Artemis II (safety of the first manned launch). Between Artemis III and IV, NASA will be establishing the basic Gateway capability, with the launch of a Power Propulsion Element (PPE) and Habitat and Logistics Outpost (HALO) on a co-manifested launch vehicle. Artemis IV is scheduled for 2028, and Artemis V for 2030. Space Operations Mission Directorate (SOMD), Science Mission Directorate (SMD) and Space Technology Mission Directorate (STMD) are partnered with, and working both in parallel and integrally, with ESDMD.

Artemis II astronauts are working and training with EGS while the rocket is being prepared. EGS is finalizing a new escape system, with four 4 baskets. Integration and testing of the Orion Crew and Service Module (CSM) for the Artemis II spacecraft is in progress. Teams recently conducted a cryogenic simulation, to practice loading the liquid propellant for SLS; they also took part in an Underway Recovery Test off the coast of San Diego.

Starship HLS
SpaceX continues to make progress and completed its third integrated flight test, reaching a significant milestone, and finished system qualification testing for a docking system. The flight crew participated in simulations to test out the HLS elevator.

Artemis III
All booster motor segments for Artemis III are complete; ESDMD witnessed testing of the European Service Module (ESM), and saw the associated ESM-3, ESM-4, and ESM-5 for Artemis III-V respectively in various stages of assembly. Suit prototypes are being tested, both in the neutral buoyancy test laboratory and simulated lunar terrain. NASA has chosen the first science instruments designed for astronauts to deploy on the surface of the Moon during Artemis III.

Gateway
The PPE spacecraft is being assembled at Maxar, which is also performing thruster tests. HALO is one step closer to completion, and other hardware is in production.

Artemis IV
The Mobile Launcher-2 work is under way, and the International Habitat Module (IHAB), being designed for Gateway and supplied by the European Space Agency (ESA), is under construction in Italy.

Artemis V
In preparation for Artemis V, a Y-ring has been manufactured at the Michoud facility, and NASA has selected three companies to refine unpressured and uncovered lunar terrain vehicle (LTV) concepts. The Blue Moon lunar landing system, being designed by Blue Origin, just completed a drop test. The Glenn rocket reached a significant milestone and will be tested later in 2024. Beyond Artemis V, the US and Japan just signed an agreement to develop a pressurized rover, and NASA has contracted with SpaceX and Blue Origin to develop cargo variants of the HLS, to land 12-15 metric tons of cargo on the moon. These activities are creating a blueprint for exploration of the Solar System.

Dr. Condon noted that in the past, HEOC has expressed concern about the pace of launches, and asked how NASA keeps the launch crews equipped, procedurally and mentally, to ensure they can do what they need to do. Ms. Koerner said the teams do a lot of simulations, with artificial failures inserted into the

systems. These failures are uniquely challenging, and designed to simulate the stress levels that are inherent in even a nominal mission.

Budget
Mr. Brian Dewhurst covered details of the FY2025 PBR for ESDMD, which stands at $7.6B for 2025, compared to $7.468B in the 2024 CR. A budget "multiplier" is the number of signatories to the Artemis Accords (39 to date). Asked if the Artemis Accords required no financial contribution, Mr. Dewhurst confirmed that signatories do not contribute funds, and are just agreeing to the "rules of the road." He noted that signatories often reach out to engage and get involved, which does offset some NASA tasks. Ms. Koerner interjected that the Accords are a nonbinding agreement to a set of principles of how participants will explore. NASA does not assign tasks through the Accords. Within the Artemis program, and M2M, is where the specific agreements are made with the internationals.

The ESDMD financial plan emphasizes a clear set of priorities. The highest priority is to hold the near-term dates for Artemis II and III. Mr. Dewhurst stressed the delay was due to safety, and not budget. Currently, NASA is holding to a 2-year gap before Artemis IV, and an 18-month gap between Artemis IV and V (this last gap will be affected by the outyears budget). ESDMD is also holding the Artemis IV development schedule for launch as early as possible, and intends to maintain an annual cadence after Artemis V. He said it was important to note that since the end of the Constellation program, it has been actual law that $2.6B per year goes to SLS. NASA asked to reverse this law as it ties up funds, and this year Congress has appropriated this level of funding, recognizing its importance, while no longer bound by the law. The M2M Transportation System, Moon to Mars Lunar System Development, Human Exploration Requirements and Architecture budget is roughly $3.3B for FY25; this includes Gateway and HLS development. Mr. Voss commented that funds seem steady in outyears, and asked if this constituted a forecast. Mr. Dewhurst said that outyear numbers are being driven by expected expenditures, and added that the numbers are not adjusted for inflation. The budget increases 2% per year, and it is accurate to say that NASA will lose buying power based on current 3-4% inflation levels.

Deep Space Exploration Systems (M2M) stands at $4.2B for FY25, with a good portion going to ML-2, Artemis II, and III preparations. Moon to Mars Lunar System development, a total of $3.288B, including $140M for Advanced Exploration Systems (AES) to develop long-duration mission technologies that have common needs for both lunar and Mars missions. There is operational hardware on ISS today that is supported by this budget line. In response to a comment, Mr. Dewhurst said that future mission technology needs are being worked mostly by civil servants. . Budden commented that $140M for AES seemed unreasonably low given that NASA is doing a major pivot to Mars. Ms. Koerner noted that the STMD has the "seed corn" investments for M2M, and is not funded through AES. AES is more subsystem level work that supports crew. STMD looks at technology gaps and fills them ESDMD.
Mr. Dewhurst closed with the FY25 numbers for Human Exploration Requirements and Architecture, at $117.1M, which includes $71M to collaborate with programs across NASA to design a roadmap for future long-term human exploration.

<u>Moon to Mars</u>
Mr. Amit Kshatriya covered the particulars of Artemis M2M progress, an integrated test program that comprises a staggering amount of activity. Artemis II is making steady progress on mission operations, Orion, SLS and EGS. The risk profile from a trajectory standpoint is very similar to Apollo, and is designed to protect the crew, as Artemis steps from a un-crewed to a crewed mission, a highly significant step from Artemis I. NASA is still closing out the Artemis I heat shield investigation, and is applying Lessons Learned from Artemis I to Artemis II and beyond as production continues. Artemis II M2M team is also working closely with SOMD as they go to final flight readiness, as there are many common threads throughout the development of each directorate's respective vehicles (integrating with Starliner, e.g.).

Artemis II
Artemis II has a launch window of about two hours. Orion's main engine will power the Trans Lunar Injection (TLI), and has substantial performance margin. Mr. Alibaruho asked if high-speed lunar returns constitute the stressor cases. Mr. Kshatriya affirmed this was so, but that the cases cover not only return capability, but modes of return such as ballistic return and direct entry capability. Administrator Nelson has supported extensive testing and analyses in these areas. Artemis II production has enjoyed much support from industry in addressing any anomalies or snags. The goal is to find the problem, fix the problem, and not pass it down. A good example of this approach is how the teams have dealt with the Orion Digital Motor Controller (DMC) issue, an investigation that is now complete. Asked which parts of Orion are controlled by the DMC, Mr. Kshatriya said the DMC governs a flow control valve that integrates two cooling loops; vents for some cabin air control; ATCV (CO2 scrubbers); and an O2 valve that is required for crew on suit-loop only. Mr. Kshatriya said he was especially impressed with the Navy and their expertise in water recovery tests, as it is not trivial to recover crew from the open water, while also preserving the spacecraft. Asked about the top risk for Artemis II, Mr. Kshatriya said that it was understanding Orion's heat shield and the integrated performance of the Thermal Protection System (TPS). It is a risk in the program, but there are dozens of other smaller risks that the program is tracking.

Artemis III
Artemis III will introduce the use of two new major systems. SMD is heavily involved with Artemis III, in planning for a seismometer installation at the South Pole and other geologic instruments. NASA has resurrected the geologic crew training regimen that was used in the Apollo program. SMD is also supporting an agricultural experiment to evaluate the ability to grow crops off-world, and is also providing an instrument to measure the dielectric capability of the regolith, for future ISRU. SMD is also involved in the traverse plan. Asked if investigating permanently shadowed regions (PSRs) in the South Pole, with the intent of verifying that there is usable water on the Moon, is still part of the plan, Mr. Kshatriya affirmed this was so, and added that the Volatiles Investigating Polar Exploration Rover (VIPER) precursor mission will also yield important information about the presence of volatiles to further guide surface exploration. Lunar landing site selection for Artemis III is underway. NASA's partnership with SpaceX is also helping narrow down sites, with a view to what the HLS is capable of. The site will have to be characterized for the presence of boulders, slopes, and illumination. Artemis is working with SOMD on communications, which will also constrain landing site selection. In response to a question, Mr. Kshatriya said that there will be passive science instruments on-board, and a full suite of instrumentation (radiation monitors, etc.).

Mr. Kshatriya stressed that Artemis III is still a mission in development. NASA will need to determine, for instance, the size of the landing engine disturbance to determine how far the traverse needs to be. The astronaut is still a human in a suit, in a place where she or he has never been. Artemis III will be the first mission that will not need unique launch pad modifications, but it will need significant ground systems integration. On the HLS side, much has been learned to date about SpaceX Starship stage separations, which is a big step forward for the team. The fourth integrated flight test is scheduled for the end of May. Dr. Condon commented that it appears that NASA is satisfied it's learning the right things. Mr. Kshatriya agreed, adding that production is not the issue. Propellant transfer is the significant development challenge; the team is phenomenal, and there has been great progress across the enterprise. While it is an ambitious effort, it is coming together. Each and every team around the world has the right attitude. Mr. Voss commented that it seemed that the SLS solid rocket motor segment was way ahead of schedule, and asked if it was safe to store them over the long term. Mr. Kshatriya said that Yes, the program is on top of the issue, but agreed it is a fair question.

Mr. Kshatriya displayed a trajectory of a demonstration of propellant transfer in space. The spacecraft needs to stay in orbit for 3-4 weeks, and feature full insulation of cryogenic loads. NASA has done an

analysis of how the sequence will work. The fundamental demonstration will use a circularized orbit, and investigate the "slosh" dynamics of ship movement and their impacts on the tank. SpaceX has good confidence in ship LIDAR and radio frequency communications. SpaceX will need to demonstrate attachment to an active system target. The demonstration is using the same connector for fluid flow that is used on the launch pad. In response to a question, Mr. Kshatriya said that the transfer will not need pressure to flow, but there will be the ability to pressurize. In the meantime, pad issues at SpaceX have been resolved. Dr. McConnaughey asked if the demonstration will determine the load needed for a lunar mission. Mr. Kshatriya said Yes, and that the HLS will aggregate in Earth orbit. There are no plans for propellant transfer in lunar orbit.

Artemis IV
In addition to the lander and spacesuit, this mission will add the Block 1B for SLS. The PPE and HALO for Gateway will launch on a Falcon 9 Heavy Expendable and will drift into a lunar orbit a year later. Gateway extends Orion's endurance and science capability and will serve as aggregation point for international partners. Artemis IV is both a Gateway delivery and a lunar landing mission. Mr. Michael Lopez-Alegria asked if there was a logistics plan in place. Mr. Kshatriya affirmed this and added that ECLSS will be based on tanks as there is no regenerative water capability. Given the duration of the early missions (30 days), tanks will suffice, particularly as the dormancy of the water systems will limit regenerative water capabilities. NASA will have to figure out how to purge and evacuate these systems between uses. Hardware is moving along well. The European Service Module should be ready to ship by July 2025. On the SLS side, components are at Michoud. The Exploration Upper Stage (EUS) is a full spacecraft, and a complicated machine, but it is making tremendous progress. The ML-2 development had issues, primarily due to the weight of the structure, but ended up being a good recovery story for Bechtel. An incredible engineering team re-did the entire design. On the Gateway progress front, Maxar is doing an incredible amount of work on the PPE and have moved past CDR. The HALO primary structure friction stir welding is complete.

Artemis V
Artemis V will mark the first time a mission will use engines from the new RS-25 production re-start. NASA just finished all 12 of the retrofit tests at Stennis. Blue Origin finished PDR on their HLS in February 2024. Asked if there were upgrades on the RS-25, Mr. Kshatriya indicated that thrust was improved, but upgrades were mostly on the manufacturing side.

The Mars Campaign Office is working on burning down risk through the Artemis program and is leading technology development in 58 task areas across five domains: Crew Health and Performance, Earth Independent Operations, ECLSS, Surface Systems, and Transportation and Vehicle Systems. Recent accomplishments include the development of a Thermal Amine Swing Bed, Vibration and Isolation System, and Spacecraft Atmosphere Monitor Technology Development Unit 2 (SAM-2). Much has been learned from ISS on the behavior of these systems. The office continues to work to understand nutritional and mental health needs for super-long duration missions, as well as the propagation of combustion in intermediate gravity conditions. Asked if there were any significant findings out of CHAPEA, Mr. Kshatriya said he would defer to the program to answer those questions, but that crops have been growing on ISS for 7-8 years.

M2M Approach to Risk Management
The fundamental responsibility of the M2M organization, at all levels, is the active, integrated management of risks to the Artemis Campaign through the deep embedding of risk-informed decision-making throughout M2M. M2M broadly defines risk management as the control of known and potential deviations from the M2M technical, operational, or programmatic baseline, including but not limited to, risks held in the Programs and M2M risk management systems, hazards, concerns, watch items, liens, and

threats. Risk management efforts are supported by the M2M Implementation Plan, which then all flows down to EGS, Gateway, Orion, etc. NASA went back to the Apollo era to guide the flowdown.

Dr. Condon asked if there was a new planning window for humans on Mars. Ms. Koerner said that there is as yet no end date. Dr. Condon noted that engineers want to test forever, unless there is a target date. Dr. Sowers asked how often NASA holds risk management boards with the subcontractors. Mr. Kshatriya said it depended on the big development and production risks, and that there were quarterly reviews generally, but that risk management itself is infused into everyday thinking. There are control boards that meet weekly. Dr. Sowers commented that he was glad to see the risk management plan and noted that the formal process allows NASA to get a snapshot of where the risks should be. Asked to produce the top ten risks for Orion, SLS, etc., Mr. Kshatriya said he would discuss those with HEOC offline. Mr. Alibaruho asked if there were any Artemis III risks that are unmitigated or uncontrolled, Mr. Kshatriya said there were not, but that there were mitigation plans in place for all identified risks. Test data will be revealing. SpaceX has an excellent development plan for propellant transfer, for instance, but nonetheless Mr. Kshatriya said he was always worried about the ghost in the machine, and that he was committed to not passing down defects, no matter what.

Strategy and Architecture

Ms. Nujoud Merancy reported on efforts to develop the NASA strategy and architecture for Mars exploration. NASA has been holding workshops to; the latest one was held this year at NAS, and industry got a lot of information from all the NASA directorates and international partners. The workshop had 50 attendees from 18 countries. People seemed to just like the opportunity to get together, and the community aspect was integral to the workshop's success. It has become evident that some emerging space agencies have to learn how to work at a larger scale, or to detail small tasks/systems they can work on. NASA is continuing to clarify the definition of the Artemis Accords versus Artemis Campaign. The workshop overall hosted 140 attendees from 110 organizations, with more academic representation this time. Dr. Merancy invited HEOC to subscribe to updates from an email distribution system: https://socialforms.nasa.gov/Architecture-Updates

During this pre-formulation period for humans at Mars, NASA is using Element Initiation (for large elements in systems, not payloads) as an internal milestone that indicates a commitment to formulate an element that has been identified as a gap. This activity is Pre-Mission Concept Review (pre-MCR), and shows the process at a high level, illustrating points where industry steps in, etc. After MCR, the Acquisition Strategy Meeting (ASM) is the milestone that precedes establishment of the program or project. Mr. Voss noted that the next big element is some kind of surface habitat and asked where NASA is on that activity. Ms. Merancy said that an initial surface habitat is approaching MCR this Summer. There will be couple of months between MCR to ASM. Mr. Kshatriya added that about a year will elapse between MCR and RFP. The same process is used for international partners. After Element Initiation, the partners have pre-phase A contracts, which ensures the same rigor. There are a number of upcoming pre-formulation milestones for initial surface habitation, a small cargo lander, and a utility rover.

Human exploration at Mars is based on point designs, backed up by 50 years of studies. Every decision (at the architecture level) will get made, but not every decision needs to be made first. NASA has identified seven key decisions (out of 100) that it will pursue first. NASA is developing a decision-modeling process and tools and is refining the catalog of necessary decisions. The anchoring decision is Mars science priorities: i.e. what do we want to accomplish when we get there? Thus SMD is highly involved and has initiated a National Academies study on identifying these objectives. Other near-term critical decisions include determining the number of crew to Mars surface, the number of crew to Mars vicinity, Mars segment cadence, Mars target state, Mars power system, and Mars loss-of-crew (LOC) risk posture. White papers on all of these subjects have been published.

Dr. Condon asked what role AI plays in this process, and what it might it play in some solutions. Dr. Merancy said that AI will not be used in the decision-modeling process. The modeling is based on expert knowledge, and 50 years of study data. Acknowledging the power of data systems and AI, however, is a subarchitecture element. Dr. McConnaughey asked when the 7 questions are expected to be answered. Ms. Merancy said she thought there is sufficient data to answer the power question this year. The NAS study on science objectives will take about 2 years.

Progress to date has resulted in plans with the United Arab Emerates (UAE) to develop an airlock, and with Japanese Aerospace Exploration Agency (JAXA) for a surface rover, both of which can be fully digitally traced to M2M program requirements. More than one country has used the NASA architecture to identify their own strategic gaps, or how they can fill a NASA strategic gap, clear indicators that this approach is working. Space Technology Mission Directorate (STMD) has rolled out a shortfall-in-technology process, which will help M2M prioritize its needs.

For 2024, the goal is to integrate this architectural process with the other MDs. SOMD is doing a similar architecture process for LEO, which will be considered a sister product. The intent is to deliver one Mars priority decision package (power, as previously mentioned) this year.

Mr. Lopez-Alegria asked about the LOC risk posture? Dr. Merancy said this effort is very early, in the data-gathering stage. NASA will need to settle on an approximate range in order to choose systems. Radiation exposure will be part of the threshold deliberations. Dr. Condon asked when NASA would be in a position to define the planning window for boots on Mars. Dr. Merancy said that some of this estimation will be based on how quickly the technology can be demonstrated. Mr. Voss asked which critical technologies needed to be developed. Dr. Merancy cited cryogenic propellant management, CFM, and use of nuclear technology (the latter is under STMD). There are four classes of Mars transport: all-chemical, nuclear thermal (NTP), nuclear electric (NTE), and solar electric propulsion. There are some white papers on the subjects. Asked if there were active trade studies, Dr. Merancy said NASA was working on this with "Bingo" cards. Mr. Lopez-Alegria commented that NTP or NEP could change the equation considerably. Ms. Merancy said that NEP would require large investment and large architectural decisions. STMD is advancing technology in all four modes of propulsion to help facilitate the decision-making process. Asked how do technology readiness levels (TRLs) will be used to gate those decisions, Ms. Merancy said that there are many objectives for identifying points where certain technologies can be injected. ISRU is an example, but it needs to "buy its way on" to the architecture. Dr. Sowers commented that the problem with ISRU is "pushing on a rope." Ms. Merancy said that NASA will need some reliability on ISRU before it can be used in the architecture.

Public Comment

B Harvey- There was no discussion on Artemis Base Camp (ABC), realizing that Gateway is scheduled before ABC. Surface capabilities need to be proven out.

Emily Braswell- Are there different cubesats now on the Artemis mission (other than the DOD GOAL cubesats), or do the GOAL cubesats address architecture gaps? HEOC noted it cannot discuss this subject.

Eoghan McFadden- How does Blue Origin plan to demonstrate CFM? Are they planning a demo? HEOC will pass that question on to the program.

David Huntsman- I am hearing the constant refrain of SEI. How will NASA step up increased need for SEI post-Artemis II? HEOC passed the questions on to relevant programs.

Discussion

HEOC reviewed a from its joint meeting with Technology, Innovation and Engineering Committee (TIE) on the use of fission surface power (FSP). Mr. Voss said the finding sounds like the Committees are directing NASA to use FSP, and that this shouldn't be a function of HEOC. Ms. Budden said the finding says that the Committees are interested in the result of the trade studies and are asking to be kept in the loop. Dr. Sowers thought the finding served to suggest that the TRL should be advanced to the point that it is an option. Mr. Voss felt that HEOC did not know enough to make the finding worthwhile. HEOC further refined the finding.

HEOC reviewed a joint recommendation entitled: Technology Infusion into the Moon to Mars Program finding and recommendation. Ms. Cline said the finding remains valid, as a way to underscore the value of what M2M is already doing. Dr. Sowers said it sounded as if M2M was doing what HEOC had recommended. HEOC retained the finding.

HEOC reviewed a recommendation entitled: Endorsement of the Agency-wide Approach to the M2M Architecture, and moved to retain the recommendation.

HEOC reviewed a recommendation entitled: Lunar Lander Services Suppliers Should Provide Detailed Schedule Plans and Complete Risk Assessment to NASA. Dr. Sowers said HEOC didn't see a schedule or risk assessment from either provider of the lunar landers. Dr. McConnaughey said he knew that the Artemis Base Camp (ABC) had been adopted and scheduled for 2028, although it was not in the briefing. Was this due to IP constraints? HEOC concurred that the recommendation would not be brought forward but would be used to help formulate the next meeting agenda.

HEOC reviewed a prior finding on commercial LEO, targeted to SOMD, and made no changes. HEOC reviewed two findings and recommendations from November 2023 (Shortfall in NASA Deep Space Communications Network, and Increased Emphasis on SEI and Risk Management for Artemis, and concurred that both would go forward to the NAC.

HEOC discussed a new budget finding that would express how HEO supports ESDMD's establishing the top line budget in law, with allocation by program elements, as it enhances flexibility in allocating funds, and has value for financial and risk management in an integrated program. The Committee further found that NASA should continue to work with Congress to continue this approach in future budgets.

Other findings

Mr. Lopez-Alegria remarked on the much improved consideration of science in the Mars program. Ms. Budden agreed that is it a huge change, after years of struggle.

Dr. Condon commented that if schedule is held sacrosanct, it is possible to come up with the wrong solution. He found it hard to believe that Congress would allow NASA to pour money into an open-ended Mars mission, and didn't see how NASA will get there without a planning windowr. McConnaughey felt that NASA was making compromises with Congress in order to support a sustainable pathway to Mars. Mr. Lopez-Alegria said he was relieved to hear about the strategic approach, in that a technically driven strategy is good. Dr. Condon agreed, adding that that was the basis of his conflicted feelings. DR. McConnaughey noted the upsetting presence of the Inspector General on the factory floors. Mr. Voss commented that he thought Ms. Koerner wanted the HEOC to know about the burden of the audits.

HEOC briefly discussed the next meeting sometime in September, dependent somewhat on when the NAC will next meet. Mr. Lopez-Alegria asked if there were any advancement in the conversation about the two AAs. Dr. Siegel said she didn't have any information. Mr. Voss said he would prefer to be briefed

in-depth on topics of interest, vs. just status briefings. Mr. Lopez-Alegria wished for more information about the risk/schedule for lunar lander. Ms. Budden felt that HEOC might need more time for fact-finding meetings. Ms. Cline invited HEOC members to offer agenda items, including briefings that go down to the next level of program management. Mr. Alibaruho offered a foot stomp this point, noting that he was struggling to find briefings that allow HEOC to create actionable advice. It would be better to attack one or two topics and deep-dive into them. Ms. Cline felt that many in HEOC can relate to Mr. Alibaruho's concerns. The HLS plan should definitely one of the deep-dive conversations. Dr. Condon suggested, for future consideration, a meeting at Boca Chica, as SpaceX is a very important part of the Artemis program.

Findings and Recommendations:

Title: Endorsement of the Agency-Wide Approach to the Moon to Mars Architecture
Recommendation: The Committee acknowledges and applauds the effort taken in the development of the Moon-to-Mars Architecture. Ensuring alignment across all the Mission Directorates, engaging a broad community for input and establishing an iterative process is a sound approach. As written, the Moon-to-Mars Architecture Definition Document clearly embraces its purpose to translate the broad objectives into functions and use cases that can be allocated to executable programs and projects. The Committee embraces the effort as a best practice that will serve the program well as it allocates available funds into prioritized programs and projects. The Committee recommends the Architecture Definition Document serve as a consistent guidepost for development of "Shall Statements" for follow-on contracted activity with industry partners.
Major Reason for Recommendation: To ensure the efficient application of the value of the Architecture Definition Document when contracting with industry partners to minimize program risk and any potential of requirements shortfalls.
Consequences of No Action on the Recommendation: If the Architecture Definition Document is not applied consistently going forward across all program participants, the program risks losing important linkages throughout the program which could result in inefficient implementation, costly engineering change proposals, and schedule disconnects.

Title: Lunar Lander Services schedule and risk assessment
Recommendation: Lunar Lander Services suppliers should provide detailed schedule plans to NASA and complete risk assessment to NASA.
Major Reason for the Recommendation: Apollo history shows that development of a Lunar Lander will be the pacing item for human mission to the moon. The Artemis Campaign is designated to fit inside a budget and schedule constraint. Without accurate planning for schedules and proper risk understanding accurate planning and maintaining schedules is not possible.
Consequence Of No Action: If not implemented, the Artemis program will have significant cost overruns and missions will not be planned most effectively.

Title of Finding: Increased Emphasis on Systems Engineering and Integration (SEI) and risk management for Artemis.
Finding: The complexity of the Artemis missions dramatically increases for Artemis 2 and beyond. Each mission involves many elements and interfaces. Successfully executing these missions will require an increased emphasis in SEI as well as risk management at the enterprise level and within each program element.

Finding: Budget Allocation

- The FY 24 appropriations for NASA's Exploration Development Programs establishes only the top line budget in law, with the allocations by program elements in the accompanying report. The HEO committee strongly supports this approach. This approach allows for more flexibility and effective financial and risk management of this integrated program. The HEO committee finds that NASA should continue to work with Congress to continue this approach in future budgets.

Finding: Increase importance of science in both the lunar and Mars Missions

- Finding: the committee recognizes the partnership with the Science Mission Directorate. We see more complementary requirements in the lunar and Mars programs. We applaud that the mission directorates are working so well together.

Dr. Siegel adjourned the meeting.

Appendix A
HEOC Membership

Ms. Lynn Cline
Former NASA Deputy Associate Administrator
Human Exploration and Operations

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

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

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

Mr. James Voss
Former NASA astronaut and retired U.S. Army Colonel
Department of Aerospace Engineering Sciences,
University of Colorado, Boulder

Mr. Kwatsi Alibaruho
Vice President, Program Management
Industrial Sector Eaton

Dr. George Sowers
Colorado School of Mines

Dr. Paul McConnaughey
Former Deputy Center Director; Associate Director, Technical;
Associate Director Marshal Spaceflight Center

Mr. C. Douglas Ebersole,
Former Executive Director
Air Force Research Laboratory

Dr. Ellen Stofan,
Under Secretary for Science and Research
Smithsonian Institution

Appendix B
Attendees

Human Exploration Operations Committee
Kwatsi Alibaruho, Industrial Sector Eaton
Nancy Ann Budden, Special Operations Technology, DoD
Lynn Cline, NASA HEOMD, ret.
Pat Condon, Aerospace Consultant
Michael Lopez-Alegria, Commercial Spaceflight Federation
James Voss, University of Colorado, Boulder
George Sowers, Colorado School of Mines
Paul McConnaughey, NASA Marshall Space Flight Center, ret.
Doug Ebersole, Airforce Research lab, ret.
Bette Siegel, Executive Secretary, NASA

Webex Attendees

Corneilius Robinson
Zoe Wai
Christine Solga
David Baumann
Eracenia Kennedy
Arthur Beckman
Misty Snopkowski
Sasha Ricks
Stephen Clark
Stephan Gerard
Jeanie Hall
Heather Smith
Desiree Seaward
Tammy Flowers
Joshua Finch
Kirsten Armstrong
Eoghan McFadden
Eddie Semones
Brandy Henson
Jiří Hošek
Dana En
Rick Irving
Dillon Laviale
Jennifer Turner
Jeanie Hall
Marc Hone
Barbara Glisan
David Brady
Theodore Kronmiller
Christie Cox
Vivek Sood
DeAnn Reilly
Vinita Marwaha Madill
Joshua Finch
Stephen Davison
Elisha Sauers
Richard Rogers
Kathy Nado
Chris Gilbert
Marcia Smith
Karin Sturm
Susan Helms
Jeff Foust
Tonya McNair
John Gallagher
Gene Mikulka
Tonya McNair
Joan Zimmermann
Danny Lentz
Timothy Hartman
Wing Ki Chiu
Kelvin Manning
Christine McKelvey
James Wood
Kent Chojnacki
Tina Jicha
Nantel Suzuki
Sean Fuller
Kiersten White
Dave Huntsman
Dan Huot
David Eisenman
Beverly Casillas
Sherrica Holloman
Susan Helms
Masami Onoda
George Curley
Jacob Scoccimerra
Ramish Zafar
Laura Farrell
Sheela Logan
Will Robinson-Smith
Tyler Lori
Laura Means
Micah Maidenberg
Eric R Berger
Laura Segarra
Allen Cutler
Adam Proud
Carrie Rogers
Grant Tremblay
Tim Finkel
Stephan Gerard
Barbara Stacey
Veronika Fuhrmann
Shermane Martino
Bill Hill
Ruth Siboni
Dionne Whitby
Irma Granell
Jose Ramos
John Gallagher
Debbie Berdich
Jeremy Fehrenbacher
Erin Kennedy
Philip Sloss

Adie Lewis
Laura Farrell
Cathy Baroang
Rachel Kraft
Denise Holley
Kate Kronmiller
Loren Grush
Lena Burleson
David Lurie

Sylvie Espinasse
Simon Chung
Karin Sturm
Chris Gilbert
Lora Bleacher
Vanessa Lloyd
Richard Rogers
Bev Perry
Danny Lentz

Philip Sloss
Sherrica Holloman
Claire Redhelm
Kelly O'Rourke
Dayna Ise
Samina David
Tudy Lau
Will Drexler
Stacie Maloy

Appendix C
Agenda

Thursday, April 25, 2024

NAC HEO Committee Public Meeting – Space Operations Mission Directorate

9:30 – 9:35am	Opening Remarks	Dr. Bette Siegel/Ms. Lynn Cline
9:35 – 10:00	Space Operation Mission Directorate Status	Mr. Kenneth Bowersox
10:00 – 10:30	Budget	Ms. Elaine Slaugh
10:30 – 11:30	International Space Station Update	Ms. Robyn Gatens
11:30 – 11:45	Break	
11:45 – 12:15	Commercial Crew	Mr. Phil McAlister
12:15 – 1:15	Lunch	
1:15 – 1:45	Commercial LEO development/Commercial Space Stations	Ms. Angela Hart
1:45 – 1:50	Public Comments	
1:50 – 2:00	Break	
2:00 – 3:30	Discussion and Recommendations	
3:30pm	Adjourn	

Friday, April 26, 2024

<u>NAC HEO Committee Public Meeting</u> – Exploration Systems Development Mission Directorate

9:30 – 9:35am	Opening Remarks	Dr. Bette Siegel/Ms. Lynn Cline
9:35 – 10:05	Exploration Systems Development Mission Status	Ms. Catherine Koerner
10:05 – 10:35	Budget	Mr. Brian Dewhurst
10:35 – 12:00	Moon to Mars	Mr. Amit Kshatriya
12:00 – 1:00	Lunch	
1:00 – 2:00	Strategy and Architecture	Ms. Nujoud Merancy
2:00 – 2:05	Public Comments	
2:05 – 3:30	Discussion and Recommendations	
3:30pm	Adjourn	

Appendix D

Presentations

1. Status of Space Operations Mission Directorate; *Tonya McNair*
2. SOMD Budget Overview; *Elaine Slaugh*
3. International Space Station; *Jacob Keaton*
4. Commercial Crew; *Misty Snopkowski*
5. Commercial LEO Development/Commercial Space Station; *Misty Snopkowski*
6. ESDMD Budget Overview; *Brian Dewhurst*
7. Exploration Systems Development Mission Status; *Catherine Koerner*
8. Moon to Mars; *Amit Kshatriya*
9. Strategy and Architecture/Moon to Mars; *Nujoud Merancy*