

**National Aeronautics and Space Administration
Washington, DC**

**NASA ADVISORY COUNCIL
Human Exploration and Operations Committee
September 17, 2024**

MEETING MINUTES

Bette Siegel
Bette Siegel, Executive Secretary

Lynn Cline
Lynn Cline, Chair

**Public Meeting Minutes
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September 17, 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 interim Chair of the HEOC, Ms. Lynn Cline.

Ms. Cline welcomed members to the meeting, to be focused on the Space Operations Mission Directorate (SOMD).

Space Operations Mission Directorate (SOMD)

Mr. Kenneth Bowersox, Associate Administrator (AA) of SOMD, first expressed gratitude to HEOC members for their consideration, and noted that the Directorate pursues much cross-cutting activity which helps SOMD communicate and work with other Directorates.

SOMD has been busy on the operational front, having launched both Soyuz and Dragon missions, and having sent crew to the International Space Station (ISS) on the Boeing Starliner, which later landed successfully as an uncrewed spacecraft. Starliner crew, Butch Wilmore and Suni Williams, have shifted to space expedition teamwork in the meantime. There were some cargo mission launches on both the US and Russian sides. Europa Clipper is the next big mission launch, slated for October 2024. Major developments on the Space Communications and Navigation (SCaN) side include the installation of six Deep Space Network (DSN) arrayed antennae at the Madrid facility, and continuing progress in optical communications. NASA has selected SpaceX to provide a deorbit vehicle for the ISS end-of-life (EOL) maneuvers. The vehicle is using much heritage from the SpaceX Dragon vehicle. Other awards for launch services for new payloads are ongoing, as NASA is looking to nurture new participants in the launch market, including the selection of three new Venture-class launch service providers. SOMD participated in a number of conferences and symposia, sharing NASA work news. Organizationally, the Directorate is adding a new Division for Space Sustainability, led by Mr. Alvin Drew, which will deal with such issues as collision avoidance, space traffic management, and improving the space environment. The goal is not to achieve regulatory authority, but NASA does want to collect data on orbital debris to help set standards for protecting spacecraft from orbital debris, and to conduct experiments to improve the orbital debris environment. In the Human Research Program (HRP), Crew Health and Performance Exploration Analog (CHAPEA) participants exited the Mars habitat after 378 days in isolation. The number of people in commercial low-Earth orbit (LEO) continues to grow, with 19 so far.

Human Research Program

Mr. Dave Baumann reviewed highlights of recent work, noting that many HRP products are informing Artemis vehicle and mission development. HRP deliverables include a human-in-the-loop (HITL) virtual testing regime that functions across multiple Artemis vehicles; food and medication safety testing (after exposure to new environments); new tools for predicting medical conditions and loss-of-crew risk, and new testing of hardware in radiation environments. Other deliverables in work include high-tempo extravehicular activity (EVA) regimens; improved decompression sickness risk prediction tools; food acceptability testing, evidence-based recommendations for combating fatigue; determining characteristics of launch/landing loads; and gravitational transitions.

The principal health and human performance risks associated with deep space radiation exposure are cardiovascular disease (CVD), central nervous system (CNS) damage and associated behavioral health changes, and increased risk of carcinogenesis. It is expected that the Radiation Carcinogenesis risk will be identified as a Red risk for Mars, because exposures are greater than the new cumulative career exposure limit.

Dr. Lisa Simonsen addressed NASA's evolving posture on radiation risk. Exposures on a typical Mars mission are going to exceed 300-400 millisieverts (mSv), which exceeds current NASA astronaut ISS exposures. Mars missions will have long-term effects on the lifetime risks of developing CVD, CNS issues, and cancer. Strategies have been identified to ensure achievable mission objectives in terms of this radiation environment. The NASA exposure limit stands at 600 cumulative mSv. The Mars traverse will expose crew to roughly twice that at up to ~1220 mSv for missions planned during solar minimum conditions. However, if the Mars traverse is planned during solar maximum, total exposure can be reduced to ~685 mSv, due to protection rendered by the active Sun's magnetic field. Risk mitigation versus informed acceptance, policies and practices are in place for ethical acceptance parameters. Mr. Kwatsi Alibaruho asked what the cumulative exposure on Earth is equivalent to. Dr. Simonsen noted that Earth natural (background radiation) exposure is ~3 mSv per year. For comparison, the radiation exposure limit for nuclear workers is 50 mSv per year. However, the total lifetime occupational exposure averages about 10 mSv. Mr. Alibaruho commented that these deep space missions would be the highest exposure events. Dr. Simonsen acknowledged this and noted that NASA has devised a good radiation protection plan, and is identifying mitigation strategies under the aegis of Advanced Habitation Systems, including space weather (SWx) forecasting, radiation monitoring, effective shielding, and biological mitigations.

Development gaps have been identified for dealing with Solar Particle Events (SPEs); thus far NASA has determined that the technology exists for storm shelters & dosimetry, which can be optimized through design, and SWx forecasting with Earth-centric observations and real time ops communication are evolving. For Mars, there will need to be more Earth-independent monitoring and forecasting, along the lines of miniaturized onboard instrument suites for space weather observation. There is the possibility of new space weather architecture platforms along the Sun-Mars Line, with the potential for developing autonomous forecasting and warning software.

In dealing with galactic cosmic ray (GCR) exposure, NASA aims to reduce exposure by 15%. Many mitigations are too mass-prohibitive, however, and active shielding concepts do not offer dramatic improvement over passive shielding and would introduce new risks. It is evident that missions planned during solar max, along with evolved models to support prediction of solar events, and with alignment of parameters with programmatics can reduce exposures by almost 50%.

From the biological perspective, HRP continues to study individual sensitivities to radiation exposure and quantify synergistic modifiers of risk, including translating animal data to humans; GCR protection in terms of biological mitigation strategies, as low as reasonably achievable (ALARA) risk strategies and risk acceptance; personalized protection; in-flight monitoring and preventative medical countermeasures; and long-term health crew-monitoring. Asked if any progress had been made on understanding individual susceptibility, Dr. Simonsen said that there is a huge international initiative underway on this subject, as well as the development of new studies using rodent models. It is a long-term area of study. Mr. Voss asked if any biological countermeasures had been identified. Dr. Simonsen said that many countermeasures have undergone testing, including "nutraceutical" countermeasures, and pharmaceutical measures such as aspirin as an anti-inflammatory mitigation. HRP will continue to leverage advances in terrestrial research and medicine. In addition, the Department of Energy (DOE) is working on low-dose studies that NASA will be able to leverage.

Progress in the area of Moon to Mars (M2M) radiation protection includes updated health standards: all crew now have the same career limit exposure, and long-duration habitat designs must factor in GCR exposure. HRP is also developing zero-impact solutions for SPE radiation protection, and leveraging new data on individual sensitivities, the effect of combined CNS stressors, and translation of animal research to humans. NASA has a number of ongoing collaborations, including with DOE, the Million Person Study; NCI, a meta-analysis of CVD; NIH, advances in treatments; ICRP, state of the science on

individual sensitivity, and risk, dose assessment for protecting astronauts; and a DOE low dose program; in addition to collaborations with international partners. NASA also has a new GCR simulator.

Mr. Michael Lopez-Alegria got confirmation that the cumulative 600 mSv limit is now applicable to ISS astronauts in LEO. Dr. Pat Condon asked, given what is now known and the expected research outcomes, how much time it will take to identify the physical and biological solutions that will allow humans to get to Mars. Dr. Simonsen answered, in considering the path to risk reduction, that the estimate is about 2037 (based on budgets, timing of animal studies, etc.) Dr. Paul McConnaughey asked about polyethylene design requirements on future vehicles. Dr. Simonsen said that using materials such as polyethylene could decrease exposures by 15-30% and application of high hydrogen content materials would work best with inflatables. Mr. Voss said it looks like the crew will still have to accept excess risk. Dr. Simonsen thought that targeting solar max is probably the best approach, because it brings the cumulative dose to ~685 mSv, and it also includes experience of a Solar Particle Event (SPE) exposure and is predicated on experienced crew (who will have had prior exposure). Ms. Cline said she appreciated the detailed explanation.

ISS Status

Ms. Robyn Gatens updated HEOC on ISS activities. ISS mission goals are continuing to be fulfilled in six focus areas: deep space exploration, research to benefit humanity, international collaboration, commercial space industry, inspiring humankind, and a continuous LEO infrastructure and destination. Key accomplishments aligned with the goals include 29 technology demonstrations since 2018; more than 4,000 investigations and counting, 2,200 of which were internationally led; more than 700 payloads flown, 80% from the commercial sector; \$2.2B raised by start-ups after flight; 18 million people following social media accounts; and more than 23 years continuous presence in space.

An ISS Increment overview was presented. For Increment 71, with the exception of one extravehicular activity (EVA) deferment, all planned tasks have been executed. Increment 72 is about to begin, with SpaceX Crew-9 (with two empty seats) about to arrive, and Dream Chaser launching soon. The Crew-8 Dragon arrived at ISS in March 2024 and relocated to zenith port in May 2024. There are two Progresses docked at ISS now.

Next, operational status and the current configuration of ISS was reviewed. A Roscosmos EVA was completed in April 2024, US EVA 90 had to be terminated twice, and other EVAs had to be pushed out due to the Starliner event. Several EVAs will occur late 2024/early 2025, once new crew is onboard. The Starliner will return uncrewed, with its two scheduled astronauts remaining onboard through February 2025. End-of-life (EOL) deorbit planning has begun for ISS, and SpaceX has been selected to deliver the vehicle. The investigation into the atmosphere leak in an ISS module continues.

Mr. Voss asked whether the extra crew is consuming more and, if so, are there any mitigations. Ms. Gatens said, yes, and that additional consumables are being launched on cargo missions. They are well above any red lines on consumables, but there are slight impacts to science. Mr. Lopez-Alegria asked whether the crew is still productively engaged in science. Ms. Gatens responded with a hard yes and added that they are also engaged in additional duties, such as providing downlinks and education activities.

There are two new cargo vehicle developments: Sierra Space Dream Chaser, with a targeted launch no earlier than (NET) December 2024, and JAXA's HTV-X preparing for its first flight, targeted for NET September 2025.

Utilization highlights were presented next. There was a successful bioprint of live human heart tissue, using the BioFabrication Facility (BFF) on ISS. Microgravity enables printing of higher quality tissue,

with a promise of producing cardiac patches for damaged heart tissue and, perhaps, a whole organ someday. In another demonstration, a commercial length (7 miles) of higher quality optical fiber, pulled by Flawless Photonics, showed superior production in microgravity.

Dr. Ellen Stofan asked whether it is time to get new experiments, and to get more downmass from ISS. Ms. Gatens said more frequency is good, but it generally takes one to two years to get a new science experiment to ISS. BPS is looking at ways to get more iterative science onboard.

Other highlights include the Genes-in-Space program, a student-run activity, which aims to detect the placement of retrotransposons into DNA. NASA flew the first optical link on ISS in December 2023 (ILLUMA-T); and “Igniting Innovation,” which was designed to advance cancer research, now has five projects that have been selected through the ISS National Lab Solicitation, in partnership with NASA. Some high-profile PIs and universities are participating in the studies of microgravity and T-cell therapy, chemotherapy effects on heart tissue (cardiac spheroids), and “smart material” therapeutics.

Regarding the ISS National Lab (CASIS) status, the ISS R&D Conference was held in July 2024 in Boston, MA; the next one will be in summer 2025 in Seattle, WA. Future National Laboratory planning was reviewed, including the NASA-internal workshops held in spring and summer 2024. Post-ISS, there will be multiple research platforms in LEO, and the workshops will explore roles and responsibilities for those platforms that are being considered. The plan is to engage with external stakeholders soon.

For public engagement, NASA has several social media accounts that enable the public to “follow the mission,” and NASA has launched a new app, Spot the Station, to help stargazers locate the Space Station.

The development of a microgravity strategy for LEO post-ISS has begun. The three pillars of the strategy are science, inspiration, and national posture, which comprise the “why go” for NASA exploration and for NASA science mission goals. Conversations with international partners indicate that they want to stay in orbit. There is also a desire to ensure that everyday access to LEO for student engagement will continue. Learning from Moon to Mars (M2M) is applicable to the LEO Microgravity Strategy (LMS), using a holistic approach, consulting with stakeholders, using an architecture process to drive requirements for future elements, and recognizing the need for a staged approach to objectives.

The LMS team is writing a draft that contains goals and objectives in the areas of Science, Commercial LEO Infrastructure, Operations, Exploration-Enabling Research and Technology, Workforce and Engagement, and International Cooperation. There are a total of 12 goals and 42 objectives. The areas with the most goals are Science and Exploration-Enabling Research and Technology Development, with three each.

Moving forward with socializing the strategy, the public comment period is currently taking place (August – September 2024), and one international workshop and one industry and academia workshop will be held in September 2024. It was noted that Associate Administrator Pam Melroy was very involved in and enthused about the LMS Timeline, which, pending comments on the draft, is slated for publication by December 2024. After publication, the next level of activity will occur in early 2025.

Ms. Cline asked what type of feedback from international partners is expected and what their roles in commercial LEO are expected to be. Ms. Gatens said the international partners expressed gratitude to be included and that traditional partners very much want to continue to partner with NASA, and fly to LEO. There are also new partners coming onboard who are excited about how future LEO work and want to participate, as well. Dr. Budden asked whether partners will bring any funding, science equipment, or crew. Ms. Gatens replied yes to all of the above, adding that there is much interest in contributing

capabilities that are best handled by commercial LEO providers. The final written strategy will be very helpful to identify how international partners can contribute. Dr. Budden asked whether there is a board in place to approve what partners will go forward. Ms. Gatens said not yet, although they are looking at ConOps to see how it will work. Dr. Condon asked what the planning timeline is for exiting ISS; and further, what is NASA leaving there, what is coming home, and how will partners deal with the distribution. Ms. Gatens said ISS will be operating through 2030, and that the deorbit vehicle has been awarded. The deorbit vehicle needs to go up in 2029. There is a desire to have at least one commercial LEO vehicle in orbit before ISS deorbits. The last crew will depart 6 months before deorbit. Salvaging is starting to be discussed and there is already a list. It has been determined that large objects cannot be brought back. Cargo vehicles can be used to bring desired items back, and it might be possible to move some equipment to the Axiom module. All partners have committed through 2030, excepting Roscosmos, which has committed through 2028 – there is an expectation to hear their follow-on plans through 2030. NASA depends on Russia for propulsion on ISS, so it will present a risk if Russia does not commit through 2030. Mr. Bowersox said he does not think it's likely they will fly away, because of the need for the deorbit vehicle to be onboard for a year, to ensure it is functioning before altitude is lowered. Mr. Bowersox added there is also schedule margin. Mr. Lopez-Alegria asked how long it would take to deorbit, and Mr. Bowersox replied that it needs about a year and a half, which will let ISS decay for some period of time and then more active de-orbiting will take place. Mr. Voss asked whether there are any plans for a LEO microgravity science partnership with international partners. Ms. Gatens said, yes, there are active discussions with partners, including what needs to be put in place for these international science missions to continue. Mr. Bowersox said the number one thing is to commit to agreements to conduct joint science missions with international partners; the “how” can be determined later, but first NASA must determine needs and desires. Ms. Gatens said new agreements will be needed, no matter what. Mr. Bowersox said there is also planning in place both to continue current partnerships and to bring new ones aboard. Ms. Gatens said new partners may include the South Korean Space Agency (100 days old) and the United Arab Emirates. Dr. Stofan said it is important to maintain the pressure of LEO needs and it is critical to have the upmass and downmass, not just for the Smithsonian, but for the continuation of LEO presence. Dr. McConnaughey asked whether there is any mechanism to motivate new commercial suppliers. Ms. Gatens said recent policy statements on joint research state that any large piece of infrastructure must be done by working directly with industry providers. Those discussions are already underway. Mr. Bowersox said once the downselects occur, NASA should see more outreach from international partners.

Commercial Crew Program (CCP)

Ms. Dana Hutcherson said the Commercial Crew Program (CCP) is continuing safe operations in 2024, and underscored that CCP has been performing nominally since 2020. She briefly addressed the Starliner situation and gave an overview of the Crew Flight Test (CFT) from prelaunch to station rendezvous. The current expectation is that all flight test objectives associated with prelaunch will be confirmed and key objectives during launch and rendezvous phases of flight will be listed as completed. There were inflight observations of performance issues in the service module propulsion system: small helium leaks and fall-offs of five reaction control system thrusters, although hot-fire tests re-enabled four of the five thrusters.

Ms. Hutcherson reviewed the on-orbit testing and decision-making process that resulted in the decision to return Starliner without crew, which was a tough decision, despite some successes observed during the flight. The undock, deorbit, and landing sequences performed well; landing was another bullseye. Considerable lessons were learned that will enable NASA and Boeing to support Starliner rotation missions. Moving forward toward certification, NASA will determine remaining certification requirements and perform a series of validations and investigations to enable solutions and determine lessons for future flights. Mr. Voss asked whether there are any parachute issues and whether another test flight is required. Ms. Hutcherson said there are not any issues now and a determination has not been made on another test flight. She said many flight test objectives were met and the path forward to

certification is still being considered.

Crew-8 successfully launched and had a clean flight. The Dragon Endeavour is docked to station and, to date, all systems are confirmed nominal; its return is expected in early October. Crew-8 is the emergency return vehicle for Wilmore and Williams until the arrival of Crew-9. Mr. Lopez-Alegria asked about the temporary seats and compression garments. Will they not be wearing their Launch Entry Suits (LES) It was confirmed that they would not be wearing their intravehicular activity (IVA) suits. It has been determined that the Dragon environment is safe for IVA suits, but Ms. Hutcherson stressed that this is a temporary fix. In response to a follow-up question about the temporary seats, Ms. Hutcherson said there is not a lot of information; basically, the seats will be constructed out of cargo pallets using extra hardware available on station. She added that the option has been evaluated and approved by everyone, including crew and Health.

Crew-9 status: Things are going well. The Crew-9 mission will be launching with two crew members instead of four. The crew is in quarantine until the 25 September launch date, which currently has the potential for slipping. Astronauts Wilmore and Williams will return with Crew-9 in February 2025; both will have their appropriate suiting for Earth return at that time.

Crew-10 status: The Crew-10 mission is planned for launch NET February 2025. NASA is working with SpaceX to transition future Dragon recovery operations for crew and cargo to the West Coast, with recovery operations to occur in the Pacific Ocean. Pacific landings could be as early as for Crew-10 and will allow for additional operational flexibility with respect to landing weather criteria.

CCP is delivering on its goals and objectives and values the safety of crew.

Commercial LEO Development

Ms. Gatens, new Acting Director for Commercial LEO Development (CLD), presented highlights of the Phase 1 development of NASA's industry partners. The Private Astronaut Mission (PAM) Axiom Mission 3 (Ax-3) was successfully completed, and provided lessons learned on the state of the commercial environment. NASA is now preparing for Phase 2 procurement for both funded and unfunded agreements for commercial destinations.

The latest Axiom developments include critical design review (CDR) preparation for HAB-1. Primary structure manufacturing continues, and thruster hot fire testing at vacuum is completed. Ms. Gatens reviewed the upcoming milestones for Q4 2024 and Q1 2025, beginning with the Mission Concept Review (MCR) for the AxStation Payload, Power, Thermal Module (PPTM) and going through HAB CDR completion.

Blue Origin completed its Orbital Reef mockup and a payload Interim Design Review (IDR). Sierra Space conducted a life module full-scale burst test, and completed a destination service requirements and standards assessment. Upcoming milestones through the end of 2024 include hardware testing on Materials International Space Station Experiment (MISSE), primary structure and layout assessment, and medium fidelity HITL test.

Starlab announced the addition of MDA Space Canada and Mitsubishi (Japan) to its joint venture. It completed several review milestones in June through September of 2024, and has approaching milestones for the System Integration Review and the Integrated Operations Review.

Sierra Space (through an unfunded Space Act Agreement) completed a second full-scale burst test of its inflatable structure that is associated with Dreamchaser. The second full-scale structural test at Marshall Space Flight Center signals a giant leap towards the world's first end-to-end business and technology

platform in LEO. Upcoming milestones in 2024 include the Pathfinder LEO IDR and the Project Management Review for CCSC-2.

VAST completed its PDR and is working on a number of structural components for its Haven-1 habitat. There has been a significant increase in staffing, facilities, and manufacturing capabilities at the Long Beach headquarters. Upcoming milestones include Haven-1 qualification of primary structure pressure and load testing; ongoing development, manufacturing, and qualification of Haven-1 subsystems; and Haven Demo satellite integration and test campaign for launch in Q1 2025.

The latest SpaceX developments include progress towards full reusability of Starship, which has completed its 4th flight test. It has also unveiled Raptor 3, the newest generation of the engine that powers Starship and Super Heavy. Upcoming milestones include flight test #5 of Starship and Super Heavy, currently pending approval; a Polaris Dawn private mission; a crewed Dragon mission to demonstrate the first commercial EVA with a new SpaceX suit design; and Fram2, a private, crewed Dragon mission to demonstrate the first polar human space flight.

Northrop Grumman, which is also part of Starship, is evolving Cygnus to be the platform to support the next generation of LEO ventures. It is also continuing progress on implementation of docking capability through the Starlab partnership. Special Aerospace Services (SAS) announced a partnership with Godspeed Capital. They are currently in discussions with parties interested in the Autonomous Maneuvering Unit (AMU) and testing telepresence on its air bearing table. Dr. Condon asked what “telepresence” is, and Ms. Gatens said she would get back to HEOC on this.

ThinkOrbital is progressing an autonomous in-space welding/cutting/x-ray inspection system called the ThinkToolkit. It completed the first test flight on a Falcon 9 First Stage of the first-ever autonomous in-space electron-beam weld and sample return for analysis by NASA and the European Space Agency (ESA). It won three US Space Force Small Business Innovation Research (SBIR) grants and is developing relevant relationships. ThinkOrbital is also working with Defense Advanced Research Projects Agency (DARPA) for a potential in-space assembly demonstration in 2026.

For Axiom-4, the next PAM is scheduled for NET April 2025; crew members have been identified. NASA is looking at plans for future PAM solicitations, gathering Lessons Learned, and considering future PAM opportunities on ISS.

Phase 2 Status

NASA continues to make progress toward a Phase 2 procurement. Key forward work items are LEO goals and objectives gap assessment and preparing for an Agency Acquisition Strategy Meeting late in 2024.

There is a plan to release a Request for Proposal (RFP) for Phase 2 in 2025 and make an award in 2026. Dr. McConnaughey asked whether that was an aggressive schedule. Ms. Gatens said they are not waiting until goals and objectives are finalized, rather they are moving to identify big gaps as the strategy document is refined and finalized. They have completed a MCR. Dr. McConnaughey followed up, asking whether there will be a sanity check review and how feedback will be solicited. Ms. Gatens said they are engaging stakeholders and getting feedback during the decomposition process.

Ms. Gatens reviewed recent and upcoming industry Technical Interchange Meetings (TIMs), in light of the CLDP pivot from the use of RFIs to the use of public TIMs and Workshops to collect industry feedback. There will be a Commercial Space Food TIM in late September 2024 at Johnson Space Center (JSC). Dr. McConnaughey asked whether there is a firm requirement to have a platform before NASA deorbits ISS. Ms. Gatens said this sequence of events is supported from the Administrator down, and it is

a restraining requirement. Dr. Stofan said that “platform” can mean continuous presence or just a destination to visit. Ms. Gatens agreed and said they are working on a more detailed timeline. It will be a phased approach to build up the new destination, using goals and objectives to determine what NASA needs on Day One for minimum on-orbit capability. Mr. Bowersox said they are also using a phased approach to ensure that the plan is flexible to deal with unknowns, and that there are no fundamental gaps. There is also policy guidance to avoid any potential gaps.

SCaN

Mr. Greg Heckler, Deputy Program Manager for Capability Development, presented for Kevin Coggins, the new Deputy Associate Administrator for Space Communications and Navigation (SCaN). Mr. Coggins, who is new to NASA from the DOD, is engaged in providing a new philosophy for the program and wants to integrate SCaN as a single entity and a team. The focal points for change in the current strategic evolution are Engage, Execute, Evolve, and Empower. These focal points reflect the need for SCaN to move hand-in-hand with the user community and transition to meet the needs of the next decade, not only for NASA but for the entire space industry.

NASA’s Communications Networks are being upgraded, including the development of back-up capacity, in consideration of what the Agency will need for the deep space portfolio starting in 2030s. Currently, the optical ground stations are in demonstration mode, only. The Laser Communications Relay Demonstration (LCRD) in geosynchronous earth orbit just finished its two-year demonstration. There is one last major optical demonstration, which will be manifested on the Artemis 2 mission. Dr. Condon asked what the magnitude of current unfunded requirement is (to be addressed later in the presentation). SCaN is making investments to support Artemis, while using DSN to bootstrap to the Moon; e.g. there will be Lunar Exploration Ground Sites (LEGS) and Lunar relays to offload demand from the DSN.

Mr. Heckler presented an Executive Summary, describing how SCaN is resetting to become future- and stakeholder-oriented; stakeholder input is key to making budget-driven prioritization decisions and identifying gaps. The approach to commercial partnerships will be the key to SCaN’s future.

SCaN is using the Becoming One Team approach as a trinary system to put the team into alignment. The goals are to provide reliable, robust, and resilient space communications and navigation capabilities; deliver the SCaN capabilities of the future; and demonstrate world class leadership. Having recognized that the team cannot do it all and needs to prioritize, SCaN adopted a new approach in April 2024 with all its stakeholders, to determine priorities for SCaN, and then started to build a team across the Agency. Dr. Condon commented that old things find new ways of breaking and that there is never enough money: does SCaN know the magnitude of the most highly prioritized needs? Mr. Heckler replied that, in the near-space domain, SCaN is not worried about small apertures, but rather about Tracking and Data Relay Satellites (TDRS). There will be some tough choices to make about these legacy assets. The buying power lost to inflation is just one of many issues.

Commercial partnerships will be key to meeting SCaN’s goals, enabling NASA to take advantage of the growth in the commercial space sector, particularly with regard to low-latency data downloads and open-source Earth observations. It was noted that this has been done with smaller ground segment investments.

In terms of space relay continuity, in 2020, SCaN defined a strategy to transition NASA’s LEO missions to commercial services. NASA’s NSN will maintain critical space relay capabilities, including global coverage for TT&C. In 2022, SCaN’s Communications Services Project (CSP) awarded Funded Space Act Agreements (FSAAs) totaling \$278.5M to demonstrate how commercial satellites can support NASA missions. Momentum is building, as evidenced by the performance of CSP providers. The effort at present is at the equivalent of CDR-level, in terms of phasing in optical communication capability. While

NASA supported Polaris with existing TDRS assets, SpaceX also demonstrated optical connectivity between Starlink and a crewed Dragon spacecraft. Interoperability is also key, thus the SCA-N-funded Polylingual Experimental Terminal (PEXT) will launch in early 2025, demonstrating compatibility with multiple commercial services. Amazon Kuiper has also launched two prototype satellites and conducted end-to-end testing of its optical communications payload and network architecture.

The TDRS system is in decline and being phased out. Effective August 2024, NASA suspended acceptance of new mission commitments for TDRS support, with the intent of removing TDRS services from the NSN catalog of service offerings in November 2024. A final determination will be made at that time. If there is undue risk or gap, it will be necessary to work more proactively with commercial communications to fill that gap. The goal is to have CSP deliver services by 2031 in a phased approach, to include continuing demonstrations; requirements development; acquisitions and preparation for transition; verification and validation; and, finally, the availability of a portfolio of services.

Ultimately, NASA and SCA-N aim to build a partnership with commercial providers, where NASA is a partner and just one of many consumers. For the NSN, NASA is taking two separate approaches built on lessons from commercial services for LEO. The first is a commercial LEO DTE market that has been grown by NASA through direct investments. The second is the development of interoperable user terminals and support for standards.

For Mars, SCA-N needs to consider the “Next Giant Leap” to support a crewed Mars mission in the 2040s. SCA-N is tracking capability needs for already overallocated resources, so that it can begin to identify, acknowledge, and address gaps beyond LEO and cis-lunar. SCA-N is ready to work with all partners and stakeholders to build a proactive enterprise plan for NASA’s DSN.

Ms. Cline said she was very encouraged by the new approach, which she thinks is looking at all the right issues in a methodical way, adding that working with stakeholders is a very positive step. Mr. Heckler said SCA-N meets regularly with the Exploration Systems Development Mission Directorate (ESDMD) and the Space Technology Mission Directorate (STMD), which helps SCA-N look at problems in new ways. He added that the whole Agency is rallying around the program.

Public Comment Period

Christopher Steller, Comment: *Solar Max Conjunction class was not shown in the chart presented by Dr. Lisa Simonsen; and it appears to be below the radiation limit. Is there serious consideration by the Agency to look at reorienting plans to be around conjunction class, unlike the typical opposition class M2M has focused on? Bring astronauts to surface as soon as possible to limit radiation dose and allow shielding.*

Will Robinson-Smith, to Mr. Bowersox, Comment: *What is the latest status on the Orion heat shield? How soon will a decision be made on whether Artemis II will fly as is, or does it need modification?*

Ms. Cline, Answer Question 1: *I will pass on to ESDMD.*

Ms. Cline, Answer Question 2: *That is a question for ESDMD.*

Gene Mikulka, Comment: (copy from Chat)

Discussion/Findings & Recommendations

Ms. Cline suggested a finding: As we move to the commercial realm in space communications, we want to retain international partnerships. She wondered whether partners should be referred to work directly with commercial entities. One question is about how to incentivize commercial space to work with international partners. Dr. Condon asked whether there is anything that prevents US industry from including international participants. Ms. Cline replied that, no, there is not, but it has not been part of the

history of traditional international partnerships. She wondered how best to signal to industry that it is okay to work with international partners. Dr. Condon asked whether communication isn't enough. Mr. Lopez-Alegria said that incentivization implies money; internationals are already working with commercial entities. Dr. McConnaughey agreed and said that the approach should be encouragement, not incentivization. There was general agreement with this sentiment.

Dr. Stofan suggested a finding about cargo capability or the importance of commercial cargo. She noted that there already is a lot of pressure in commercial cargo, commercial crew, commercial operation of the ISS or similar platforms, and pressure to have CLD ready in time for 2030. She felt that NASA should continue to invest in ISS operations, and was concerned lest NASA start making trades that will hurt the ISS program, which is critical to the science. Mr. Lopez-Alegria asked whether the budget should be included to provide context. Dr. Budden said it should be considered for both crew and cargo. Mr. Lopez-Alegria said he felt it was okay either way: both crew and cargo are critical to ISS. Dr. Budden said budget is key to the whole thing, and suggested adding the word "crew" to the title of the finding. There needs to be continued upmass and downmass.

Mr. Lopez-Alegria suggested a finding expressing kudos for SCan. Dr. Stofan asked about verbally commending them on Starliner. She questioned Ms. Gatens in detail on the gap issue and wondered whether enough had been done in that area: outyears on the budget are already 2027-2029. Dr. Budden said NASA needs to set a deadline and make that decision in time to affect these gap issues. Dr. McConnaughey said it seems like they made a decision that they will not have a gap. Dr. Stofan noted that there is a budget risk in this assumption. Dr. McConnaughey commented that HEOC did press Ms. Gatens on this, and he thought she had defended the discussion well. He wondered whether a finding would suffice to recognize the issue.

Regarding the New Approach to space communications planning, Ms. Cline suggested that HEOC commend SCan on its new approach to retire legacy systems, transition to commercial systems, and develop new capabilities. This approach includes engaging in dialogue with stakeholders to enhance or strengthen decision-making and transition to commercial systems and develop new capabilities where appropriate. Dr. McConnaughey said budget remains a risk and wondered if this should be a finding or recommendation. Dr. Stofan said the fixed end date means a huge schedule risk. Ms. Cline said the committee is concerned about schedule risk, given the fixed end of ISS. Mr. Alibaruho said he believes there is a significant risk in developing viable LEO destinations between retirement of ISS and other options. The following recommendation was suggested: NASA should make plans that ensure alternative CLDs are online before the retirement of ISS. Mr. Lopez-Alegria said the point is: can they execute to that plan? Mr. Alibaruho wondered whether a finding could be that HEOC supports the plan.

Mr. Alibaruho said he would like to personally foot-stomp to the separation of the two meetings of SOMD/ESDMD: he felt it was a great improvement. Dr. Budden also appreciated the deeper dives regarding presentations.

Ms. Cline reminded members that there will be a full NAC meeting on 1-2 October, at which time she would give a full report from HEOC. She mentioned that HEOC must find more members, as Drs. Budden, Condon, and Siegel are leaving. At this time, transition team activities prevent specific future scheduling. Dr. Siegel thanked all the meeting participants and adjourned the meeting at 4:12 pm.

NASA ADVISORY COUNCIL

**Recommendations and Findings:
September 17, 2024
SOMD Session**

Four NAC Findings (not actionable):

Short Title of Finding: International Partnerships

Finding: The committee commends NASA for starting the process of developing a Low Earth Orbit Microgravity Strategy. With regard to international partnerships, the Committee suggests NASA consider how to encourage commercial entities to work directly with international partners in addition to NASA's traditional international partnerships.

Short Title of Finding: Importance of Commercial Crew and Cargo Programs

Finding: Despite budget pressures, NASA needs to continue robust Commercial Crew and Cargo programs to provide significant up and down mass critical for continued operations of the International Space Station (ISS), prepare for exploration, and ensure development of robust commercial LEO destinations.

Short Title of Finding: No Gap in Continuous Human Presence in LEO

Finding: We strongly support NASA's plan to avoid a gap in continuous human presence in LEO, but the committee is concerned about schedule risk, due to current funding constraints and ISS retirement date of 2030.

Short Title of Finding: New Approach to Space Communications Planning

Finding: The committee commends Space Communications and Navigation (SCaN) program on its new approach to retire legacy systems, transition to commercial systems and develop new capabilities where appropriate. This approach includes engaging stakeholders to enhance decision-making.

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

Lynn Cline, NASA HEOMD, ret. *Interim Chair, HEOC*
Kwatsi Alibaruho, Industrial Sector Eaton
Nancy Ann Budden, Special Operations Technology, DoD
Pat Condon, Aerospace Consultant
Michael Lopez-Alegria, Commercial Spaceflight Federation
James Voss, University of Colorado, Boulder
Paul McConaughy, NASA Marshall Space Flight Center, ret.
Ellen Stofan, Smithsonian Institution
Bette Siegel, Executive Secretary, NASA

Webex Attendees

Abigail Clermont	Cullen Balinski	Jacob Keaton
Ajitkumar Mulavara	Dae'Vion Harris	James Drew
Alan Feinberg	Dana Hutcherson	James Zimmerman
Alexandra Whitmire	Dani Strong	Janine Harris
Alicia McPhail	Darwina Marks	Jason Mitchell
Allen Cutler	Dave Huntsman	Jeanie Hall
Andrew Maynard	David Baumann	Jeanine Esperne
Arthur Beckman	David Kerley	Jeff Dobereiner
Ashlee Wilkins	DeAnn Reilly	Jeff Foust
Astia Plachta	Desiree Seaward	Jennifer Rawls
Benjamin Neumann	Diana Oglesby	Jeremy Fehrenbacher
Barbara Glisan	Donald Wood	Joan Zimmermann
Barbara Stacey	E Weir	John Karcz
Ben Ashman	Elaine Slauch	Jose Ramos
Brian Gore	Emily Braswell	Joshua Finch
Carol Mullenax	Erin Stuart	Julian Coltre
Charles Harris	G. Heckler	Kaitlyn Mannarino
Charlie Scales	Gale Allen	Karen Pickering
Charu Esper	Garrett Shea	Karin Sturm
Cherie Oubre	Gene Mikulka	Kathy Nado
Chris Gilbert	Heather Smith	Keiichi Wada
Chris Scarpelli	Heather Monaghan	Kelsey McBarron
Christina Zaid	Irene Klotz	Kenta Tsuchiya
Christopher Aguilar	Irma Rodriguez	Kenyatta Haygood
Christopher Stelter	Isidro Reyna	Kevin Metrocavage
Claire O'Shea	J Andy Spry	Kimberly Cashin
Corneilius Robinson	Jack Kuhr	Kwatsi Alibaruho

Laura Forczyk
Laurie Abadie
Marika Gray
Madi Sengupta
Mai Bruneau
Maneesh Arya
Marcia Smith
Mark Carreau
Melissa Gard
Michael Stenger
Michelle Bascoe
Milenka Bascope
Miles Doran
Miyoshi Collins
N Wayne Hale
Nancy Ann Budden
Nancy Fleming
Neil Mallik
Noreen Dahl
Panita Van Besien
Paul Frazier

Philip Baldwin
R James Drew
Ramzi Masri
Rebecca Durden
Richard Boling
Rick Mastarochio
Rick Irving
Robert Frazier
Robert Zimmerman
Sabrena Yedo
Sasha Ricks
Sheikh Ahsan
Shivam Patel
Sierra O'Toole
Stan Schaefer
Stephen Clark
Steve Davison
Steven Platts
Susan Helms
Susan Wertz
Suzanne Gillen

Suzanne McCollum
Taicheia Ingram
Tariq Malik
Thomisha Nixon
Tim Fielding
Tonya McNair
Trinity Bharath
Veronika Fuhrmann
Veronica Seyl
Wendy Evans
Will Robinson-Smith
Winifred Martin
Zudayyah Taylor-Dunn
Danny Lentz
Jason Weeks
Jean Kranz
Jessica Landa
Laura Bollweg
Richard Rogers
Sylvie Espinasse
Tim Travis

Appendix C Agenda

Tuesday, Sept. 17, 2024

Non-FACA meeting – Teams meeting only

8:00- 8:05.	Opening remarks	Dr. Bette Siegel/ Ms. Lynn Cline
8:05-9:00 am	Space Operations Mission Directorate Status	Mr. Ken Bowersox
9:00 am	Adjourn	

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. Ken Bowersox
10:00 – 10:30	Human Research Program	Mr. Dave Bauman/Dr. Lisa Simonsen
10:30 – 11:30	International Space Station Updates	Ms. Robyn Gatens
11:30 – 11:45	Break	
11:45 – 12:15	Commercial Crew Program	Ms. Dana Hutcherson
12:15 – 1:45	Lunch	
1:45 – 2:15	Comm LEO Dev/Comm Space	Ms. Robyn Gatens
2:15 – 2:45	Space Communications and Navigation	Mr. Greg Heckler
2:45 – 2:50	Public Comments	
2:50 – 3:00	Break	
3:00 – 4:30	Discussion and Recommendations	
4:30pm	Adjourn	

Appendix D **Presentations**

1. Status of Space Operations Mission Directorate; *Kenneth Bowersox*
2. Human Research Program (HRP); *David Bauman*
3. International Space Station Updates; *Robyn Gatens*
4. Commercial Crew; *Dana Hutcherson*
5. Commercial LEO Development/Commercial Space Stations; *Robyn Gatens*
6. Space Communications and Navigation (SCaN); *Greg Heckler*