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HUMAN EXPLORATION AND OPERATIONS COMMITTEE

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MEETING REPORT

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N. Wayne Hale, Chair

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Bette Siegel, Executive Secretary

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Prepared by Joan M. Zimmermann
Zantech IT, Inc.

May 28, 2019

Call to order and welcome

Dr. Bette Siegel, Executive Secretary of the Human Exploration and Operations Committee (HEOC), called the meeting to order, and made administrative announcements relevant to FACA rules and public meetings. Mr. Wayne Hale, Chair of the HEOC, noted his great pleasure at being asked to Chair the HEOC, after former Chair, Mr. Kenneth Bowersox, had been hired back to NASA as Deputy Assistant Administrator (DAA) of Human Exploration and Operations Mission Directorate (HEOMD).

NASA HEOMD Overview

Mr. Bowersox, newly appointed DAA of HEOMD, gave an overview, expressing his appreciation at having Mr. Hale taking over the Chair position, having seen how influential HEOC has been in the past. Mr. Bowersox reported having officially rejoined NASA on 15 February, as the Agency looks toward getting its Commercial Crew Program (CCP) going, launching the Space Launch System (SLS), and commercializing work in low-Earth orbit (LEO). On 26 March, NASA received direction from the National Space Council to accelerate its plans to return to the Moon in a sustainable fashion, changing its target date from 2028 to 2024. He felt this direction was a gift to the Agency, which needs to grab the opportunity and lay as much hardware and procurement into place, to anchor the program. HEOMD already had a plan in place to land on the Moon in 2028; the question now is how to move to 2024. First, the procurement process needs to be expedited, using existing procurement approaches. Secondly, HEOMD needs to get its resources and requirements balanced. For this purpose, the Agency received a budget amendment of $1.6B, and is standing up a five-year plan to implement it, which will be briefed to Congress. In the short-term, HEOMD reduced requirements for a 2024 lunar landing: there will now be two landers with two people instead of a four-person crewed lander, which make the pieces of the mission smaller to achieve. The Agency has also backed off on some requirements on reusability, which will be focused on at a later date.

Thus far, there has been no need to change much else in Space Policy Directive-1 (SPD-1) in order to meet the 2024 target. HEO still plans to go to the lunar surface while maintaining Mars exploration as a horizon goal. Exploration Mission-1 (EM-1) will be launched as soon as possible, focusing on the three EMs as a package, and not as individual missions. The Deep Space Gateway must be in place, with international and commercial partners. If international partners are able to accelerate their 2028 plans, they will be welcome to participate. The three major changes have been: timeframe to lunar surface; the notional build-up of a minimally capable of Gateway, (mini-habitat or utilization module, with extended life support systems on Orion); and the name change to the Artemis Program, for the twin sister of Apollo. EM-1 is now named the Artemis-1 mission.

Mr. Bowersox addressed a past, proposed NAC recommendation on bolstering support for Program Managers (PMs), which demonstrated how the Council presaged discussions that NASA was to have. The recommendation was on how to help PMs be more successful, to move to goals more quickly; this a big item under discussion at NASA now, especially as it gears up to meet the 2024 goal. This is a top issue at the Agency PM retreat that is now under way, and it shows how aggressive goals can be helpful to NASA. Mr. Bowersox then addressed HEOC findings regarding progress on the International Space Station (ISS) Transition, with respect to lunar landing plans. HEOC supports the development of a lunar orbiting platform, with its cargo management aspects and an integration challenge. There were also HEOC concerns that Mr. Bowersox thought were helpful and applicable. NASA continues to work with its Russian partners on ISS, and recognizes that the anticipated SLS/Orion launch rate is still too low. Regarding HEOC concerns about HEOMD organization, the directorate is still considering the findings, but is not creating a new directorate in response. He thanked HEOC for the discussion and input, and welcomed the Committee to stay connected between meetings via HEOMD's website. He displayed some of HEO's latest news releases and said he had been impressed with how quickly the message is getting

out, via tweets from Administrator Bridenstine tweets, or excerpts from speeches by the Vice President. Changes in the HEO program are being driven at a very high level, making for news worth watching. NASA is worrying less about controversy, and is concerned about being more transparent.

Discussion

Mr. Mark McDaniel said he had noticed new day-and-night access to the Administrator, as well as more NASA TV presence; outreach is noticeably better. Mr. Robert Sieck was curious about ISS work and its relevance to the Moon shot and to Mars: is there anything in the new program that will change any priorities in ISS research? Mr. Bowersox reported that there is a lot going on at ISS that is focused on long-duration space flight and microgravity transit, all while Station shifts to a more commercial program. Mr. Sam Scimemi commented that there are some discrete Human Research elements at ISS that are being directed to lunar surface research, and some extravehicular activity (EVA) demonstrations related to Gateway and the lunar surface. Dr. Pat Condon asked what the key milestones and greatest challenges would be for the accelerated schedule. Mr. Bowersox said that one category was a team challenge: how do we make the whole team (internationals, Office of Management and Budget, commercial, etc.) sync up to work toward the same goal? There are many groups to be represented. The aggressive date helps NASA to have a reason to work that team harder; he thought the challenge would make NASA stronger, especially for the horizon goal to Mars. The other is challenge is technical; he thought that the technical challenges are a lot more achievable, but it will take a huge amount of work to get a lunar lander developed and constructed in a 5.5 year-timeframe.

Mr. Hale observed that the $1.6B budget amendment for Fiscal Year 2020 (FY20) represented just a down payment for the accelerated lunar program. Mr. Bowersox said that he anticipated further budget increases from 2021-24, and that the Agency has laid out estimates internally, in anticipation. Congressional assessments will follow. Mr. Bowersox said the internal runout numbers looked reasonable so far, recognizing that HEOMD will need the proper funding during development phases. NASA is not trying to keep the budget elevated forever. Mr. Hale noted that insufficient in the early days of development has been a perennial problem for NASA, and that this is important to keep in mind. He raised another concern about EVA suits and suits for the moon, in that there clearly needs to be a major evolution of space suits. Mr. Bowersox reported that HEO is focusing on suit development, and that Johnson Space Center (JSC) has identified the work needed to be done to make lunar suits suitable. The Agency is having discussions and is in a pretty good posture, and is getting ready to conduct suit tests at ISS early next year. Mr. Scimemi said that HEOMD had had an action from the NAC on this very subject. A demonstration is due on ISS in the 2021-22 timeframe, which will test the upper torso portion of the suit, a new helmet, and a new portable life support system (PLSS). The arms and legs of the evolved suit will be of Station/Shuttle heritage. Soft parts are not a long pole issue. There is a detailed plan for suit evolution; when ready, the finished plan should be brought back to HEOC. Mr. Scimemi added that these suits are not meant to be returned, but that there is a focus on maintainable parts. Dr. Pat Sanders commented that the Aviation Safety Advisory Panel (ASAP) had also made a recommendation to get on with the suits, recognizing the extraordinary efforts on ISS to make the suits available. The suits are 40 years old in design, and need to be evolved as soon as possible, particularly as ISS has a very limited supply.

Mr. Hale asked Mr. Bowersox why he felt the Deep Space Gateway was important for lunar surface activity, as some in the community feel it would be faster and cheaper to go directly to the Moon. Mr. Bowersox noted that Gateway will be needed for Mars; the current question is how it contributes to going to lunar surface. For this consideration, one needs to step back and consider how Artemis differs from Apollo. In Apollo, NASA launched the service module and lander in one vehicle, returning as one vehicle. Looking at where NASA is now, with the size of Orion and the service module, the mission needs to be broken into two pieces. Where is it better to join these missions? It is better to launch and burn cryogenic fuel, to get to lunar orbit. If this is done in lunar orbit, which is the best orbit to use? The

near-rectilinear halo orbit (NRHO) is the best place to do this; it is very benign thermally and more stable than a lower orbit; a lander can stay there a long time before the crew comes to use it. Landers might wait there for months before the crew gets there. The Gateway provides redundancy and power, and contributes to the sustainability of the exploration effort. Orbit and use of Gateway are separate arguments, but they are related. It's the two-launch aspect of the plan that makes it more suitable to use Gateway.

ISS Update

Ms. Robyn Gatens reported on ISS activities. ISS Increment 59 has just ended, marked by battery changes, cargo missions, and a number of EVAs. A Russian EVA is scheduled for 29 May, and crew will undock on 24 June, completing the current Increment. Three crew members are departing, and three are staying. ISS is now tracking the FY18-19 Agency Priority Goal of initiating at least eight technology demonstrations for the fiscal year. A refabricator was launched in Quarter 1 (Q1), and a HERA unit was launched in Q2; HERA is a siloxane control technology. In addition, a thermal amine system technology demonstration (tech demo) for advanced carbon dioxide removal, and Astrobee, a small free-flying robot, were brought to Station in Q3. Data shows that siloxane levels have been decreasing, and air and water quality have been improving on ISS. Four more tech demos have been scheduled for Q4: REALM-2, an RFID reader; a Spacecraft Atmosphere Monitor (SAM) Major Constituents Analyzer; a T2 Augmented Reality system (for the treadmill); and a Spacesuit Evaporation Rejection Flight Experiment (SERFE), a new sublimator for the PLSS. Asked how much volume these demos took up, Ms. Gaetans indicated they were roughly the size of two Express-rack lockers. ISS also has a redesigned four-bed scrubber. Astrobee represents the next generation of the Spheres experiment; it has cameras and docks to attached science payloads as it moves about the station. Astrobee's first task will be to take inventory with the RFID reader. In the Human Research Program (HRP), tasks are under way in risk reduction. The recent program acceleration is impacting some HRP planning. Some EVA risks are being accelerated, thus HRP is taking a look at this issue and will be coming back later in the summer with a revised plan. Mr. Hale commented that it appears NASA will need ISS after 2024. Ms. Gatens noted that forecasting what will be needed after ISS constitutes part of the commercial LEO strategy. The bulk of risks are being mitigated, and NASA still expects to use LEO on a private platform for exploration.

Utilization of crew time reached a record week of 120 hours; a high of 140 hours is expected by 30 September. There have been 3000 investigations since ISS began, with a total of 218 for the most recent Increment. ISS has reached 107 countries; Armenia is the most recent addition. In FY18, a total of 50 national laboratories projects were flown to ISS. The target is 80 for FY19, with 46 manifested so far. CASIS has recently rebranded their work as "ISS National Lab." Of newly selected projects, 62% are commercial users, and 70% of FY18 payloads had significant private sector involvement. ISS had 24 new-to-space customers in FY18, and is on track to exceed this number in FY19. Seventeen journal publications of ISS origin were tallied in FY18, bringing the total to 127. ISS's private investor network now has 43 members, which have generated about $150M in external funding. Commercial lab facilities on ISS have been bringing on their own customers. Operational status was challenged during Increments 57/58 by an anomaly and by a temporarily reduced crew, and subsequently ISS has had to alter some planned hours.

Recent EVAs included some battery replacements and truss work. At some time during the summer, EVAs will be carried out to install International Docking Adaptor 3 and some more batteries. ISS is currently in good shape on consumables, with no issues noted. The Space X Demo-1 mission was carried out successfully in March; NASA is still reviewing the data. The Northrop Grumman CRS-11 mission is currently docked; after its release, it will stay on orbit for several months before returning to Earth. CRS-11 brought up the first pressurized rodent capability. On 4 May, SpaceX brought up the Orbiting Carbon Observatory (OCO-3), and returned some items. Space-X18 launches tentatively in mid-July.

In LEO commercialization, there have been twelve 4-month studies on commercial habitable platforms, carried out by a variety of firms, including some independent marketing consulting firms. The studies also looked at business cases and the role of government in LEO commercialization. Habitation concepts include spent first stages, inflatable modules, new modules traditionally built but modified, and the use of the Gateway. Boeing, Deloitte, Blue Origin, and Lockheed Martin are among companies that participated. The studies also explored accommodations such as sleep stations, toilets, tourist galleys, and in-space manufacturing (exotic fibers); general research and development (R&D); and lesser markets for entertainment, sponsorship and advertising, and large structure and satellite assembly. Some observations from these studies: there are wide variety of predictions, making forecasting difficult. Early on, it appears that NASA will be the anchor tenant to enable the emerging commercial market. ISS has published a white paper on NASA needs in LEO, and is about to update this white paper with quantification. ISS needs to determine an end steady-state, budget-wise, but Ms. Gatens did not foresee a dramatic reduction in budget; transportation will remain a large part of the ISS budget. High crew and cargo transportation costs will have a big impact on whether these commercial markets will be successful. Continuing ISS use over the next few years will help to support commercial industry growth.

To stimulate sustainable demand, ISS continues to leverage the national laboratories to accommodate many industry R&D projects. NASA has just published a new thrust area for ISS Utilization, and is looking for additional concepts that lead to sustainable demand. Questions include how to reduce launch costs and how to establish a feeder pipeline for commercial interests. A new ISS commercial-use policy has been created for resources beyond ISS National Lab and will be released shortly, concentrating on more nontraditional areas. The Commercial LEO Development Framework will initially leverage ISS for test markets, and will later add habitable platforms, and free-flyers. In the long term, the plan is to complete transition from ISS to purchasing from private facilities, and turn LEO operations over to the private sector. Dr. Condon asked what the level of commercial interest in LEO seems to be. Mr. Scimemi commented that there is commercial interest today, as long as the government is the tenant. Ms. Gatens said the intent is not to compete, but to buy services from new LEO commercial capabilities. Mr. Hale asked whether a Soyuz seat could be provided to customers after commercial interests come in. Ms. Gatens indicated that there is a potential for other seats. Mr. JimVoss asked if the new commercial use policy would add any incentives to commercial users, to test the real desire in the market. Ms. Gatens said the intent of the policy is to charge a fee for services; one way of testing the market is to see if companies will buy at the price NASA sets. Upmass, crew time, and locker space will all have price points.

Mr. McDaniel noted the role that ISS plays in inspiring students to pursue careers in math and science. To continue to pioneer in space, ISS's open-ended research provides unanticipated answers, which will be critical to going to Mars and beyond. Dr. Sanders commented that ISS makes space operations look easy, but it is obviously not easy. The extent of the work done to keep ISS operating is not widely appreciated. Mr. Sieck said it was good to see there are no significant operational issues; the last major anomaly was the Soyuz failure. Dr. Sanders said that while the ASAP has asked ISS for a de-orbit plan, the panel was hoping ISS wouldn't need it for a long time. Mr. Hale said that orbital debris is a big part of the concern. Mr. Holloway asked whether ISS has thought about the research needed for Mars if Station deorbits in 2025. Mr. Scimemi said that ISS is committed to completing research in LEO long-term, whether it is on ISS or on another LEO facility. Ms. Gatens thought the Administrator was committed to not de-orbiting until the requisite research is carried out. ISS de-orbiting affects international partners as well. Ms. Gatens felt the community had been educated on these critical issues: continuity of human space flight, as well as continuity of partnerships. Mr. Hale felt that ISS is a great national asset, and NASA should make use of it as long as possible. NASA should not give away this capability until it has something better already in place. Mr. Scimemi noted that the changing geopolitical environment also plays into decision-making. NASA has had over 107 countries participate on ISS, including potential competitors. This work has reached students around the world. ISS regularly receives requests through LinkedIn and Facebook.

Human Lunar Exploration

Mr. Marshall Smith, Director of Human Lunar Exploration Programs, gave an overview on how the program is pushing hard to get the first woman and next man to the lunar South Pole by 2024, and establish a sustained presence on the Moon by 2028. NASA is very energized to accomplish this. Why go to the Moon? Many of the technologies are transferable to Mars exploration, and moreover will inspire a new generation. Mr. Smith said he himself had been very inspired by the Apollo Program, which was responsible for an uptick in STEM PhDs by a factor of three. In terms of global and civilizational impact, he firmly believes a strong human lunar exploration program, followed by the journey to Mars, will inspire the next generation similarly.

Artemis is split into two phases – and work on both phases has already begun. Phase 1 is from today until 2024, and will be focused on getting systems in place to support the first human lunar surface landing in more than 50 years. Phase 2 comprises the capabilities required to establish a sustainable human presence on and around the Moon by 2028. NASA needs to start preparing for Phase 2 today, by developing surface habitation and mobility, and in-situ resource utilization (ISRU). Phase 1 will include the first uncrewed test flights in retrograde orbit. Artemis-2 (formerly EM-2) will be the first crewed mission around the Moon in a highly elliptical orbit. The Power Propulsion Element (PPE) will be delivered in late 2022, followed by the first pressurized module to the Gateway. The pressurized module will include a minimum habitation capability, allowing the Artemis 3 crew to board the Gateway, transfer to the human landing system, and descend to the lunar South Pole.

By 2024, the goal is to have at least one man and one woman on the Moon, and an initial capability space suit designed for the needs of 2024, which are still under evaluation. The expedition duration could be hours or days; that trade is still open. The initial requirements for 2028 had been a 7-day stay. This could be turned into weeks. As far as partnerships are concerned, NASA is focusing on US industry for prime contracting, with a potential for international partners and suppliers. The Gateway's NRHO orbit provides NASA global access to the Moon by default, although it will be biased to the Moon's south pole, initially. Reusability is currently not required for the 2024 mission; perhaps the transfer vehicle or ascent vehicle could be made reusable. Dr. Sanders asked if and how industry partners would be held accountable for schedule. Mr. Smith said that NASA planned to use a different approach in expecting bids to meet schedule, and was looking for industry to be the designer, and to own the process. The onus will be clearly be on industry, but they do have to meet the NASA human rating requirements. Eventually, NASA would like to have an evolvable vehicle capable of landing four astronauts on the surface. NASA is also looking at a large-scale cargo lunar lander for both science and technology payloads. HEO has been working on the suits for some time now. The goal is to incrementally develop a sustained capability suit that will have capabilities for longer term exploration.

In Phase 1, Human Landing System work has been focused on ascent, descent, and transfer elements. Gateway work has been focused on establishing a minimal configuration needed to land two astronauts on the surface in 2024. The minimum Gateway is envisioned as an aggregation point for the 2024 expedition to the Moon, while providing a building block for a future, expanded presence on and around the Moon. There is a broad trade for space for the drive toward sustainable human lunar access: reusability, launch vehicle options, duration, destination, staging options and delta-v splits. These parameters will be dependent on the laws of physics, available technology, and weighted figures of merit. A delta-v of 6390 m/s is required for a roundtrip through Gateway. Delta-v for the equivalent direct-to-low-lunar-orbit (LLO) is approximately 5% lower, but would require slightly more mass for the first mission. These contributing factors led NASA to the three-stage landing system concept that leverages the Gateway to reduce mass and cost for subsequent missions and drive toward sustainability. NASA is still open to other ideas and concepts, however, and will challenge U.S. industry to propose alternate landing systems.

There are some key takeaways from initial approach studies. Several lander vehicle architecture options were assessed: single-stage landers are not considered viable given the desired requirements, so the program is still trading two- and three-stage options. Currently the program is considering a three-stage option because these can be accommodated by commercial launch. Three-stage options allows increased partnering opportunities. A two-stage concept is still in play; it may be possible to accommodate two-stage options with different orbits.

Lunar science goals by 2024 are: learn about polar volatiles via direct measurement by landers; learn about the geology of Aitken Basin; and land at a lunar swirl to make the first direct magnetic measurement on the lunar surface. Non-polar landers and rovers will explore areas that can help expand the Apollo footprint, and visit volcanic features. Thirteen cubesats will accompany the Artemis-1, mission; they will provide orbital data and mineral mapping. Experiments with ISRU can determine the ability of lunar ice to yield water. Water is a high priority for sustained lunar activities, which are anticipated to take place with long duration in sunlight, but with proximity to permanently shadowed regions (PSRs) for access to volatiles. Other science goals are to determine the safest sites for landing, and establishment of direct-to-Earth (DTE) communications.

Dr. Michele Gates addressed the progress of PPE. NASA now has a partner, Maxar Technologies, for the development of the PPE. The work addresses some NASA-unique requirements work heavily is invested in NASA-unique requirements, but it also leaves room for commercial requirements. The PPE will be the first 50kW-class solar electric propulsion (SEP) module, and also the first dedicated lunar data relay satellite, also marking the first public-private partnership of the Artemis program. Maxar Technologies has good flight heritage in spacecraft busses and on-orbit reliability. In addition to NASA-unique requirements, the propulsion system will use a combination of approaches and will provide Ka-band communications. An additional payload transfer capability of 1000kg for a lunar lander or science instruments is also part of the design. HEOMD is very excited about the partnership. Mr. Hale commented that the news had been a long time coming, and that he was glad to see that an SEP unit is in work.

Mr. Smith resumed the briefing, describing the NextSTEP habitat prototype testing process, which now has five major providers: Lockheed Martin, Northrop Grumman, Bigelow, Sierra Nevada, and Boeing. The testing has been a valuable exercise, as NASA can adapt data from vendors into initial requirements. The companies are in varied stages of delivery and testing. Mr. Smith provided a brief system summary for Phase 1, followed by a summary of lunar development plans. NASA has awarded 11 companies for work on the descent element, transfer element, refueling studies, and prototypes. A NextSTEP Appendix H is in work and will solicit development, integration, and crewed demonstration of integrated human landing systems from U.S. industry. Thus far, no long-lead studies have been awarded. A synopsis has been released for Gateway Logistics Services, intended to leverage investments for pressurized modules. For surface suits, NASA is pursuing parallel paths in an initial capability and a sustained capability suit. A refueling element, not needed for Phase 1, is in study phase, as part of NextSTEP Appendix E.

The baseline concept for human landing systems (HLS) is to aggregate the transfer/ascent/descent elements at Gateway. Lunar industry suppliers, located all across the country, have been benefiting local economies with current NASA work. HEO is also working actively to keep the public informed about lunar planning activities. Mr. Hale asked Mr. Smith to elaborate on the trade studies, bearing in mind that "Moon by any means necessary" could have been a clean-sheet design. Mr. Smith noted that NASA already had a plan in place for 2028, with a descent element scheduled for 2023/24, and a full-up demonstration of the entire system in 2026, with 2028 targeted for the crewed system. Given the original timeline, Mr. Smith felt a 2026 lunar landing could have been accomplished fairly easily, such that the current acceleration is really within 2-3 years, planning in a budget-neutral context. As far as trades go, NASA has been trading Direct to Moon (DTM) and Gateway concepts, and is still quite open to DTM if

these concepts include other aspects of sustained presence. The real differences appear two or three levels down into the planning. Mr. Sieck asked if any technology readiness level (TRL) concerns have popped up during the trade studies. Mr. Smith said that to make 2024, NASA will have to take systems that are in use or close to being in use, but is still looking at low TRL concepts in the long run for sustained systems; surface power, for instance. Early systems will need to be high-TRL. Mr. Sieck commented that during Apollo, there were no long lead items; the commitment and money were there from the beginning. Mr. Smith agreed that HEO needs everything, now. Mr. Lopez-Alegria said that while the program is very ambitious, it seems like there's a plan. Phase 1 looks like "flags and footprints." He asked: are there any milestones in Phase 1 that can give future administrations an incentive to not to pull the plug. Mr. Smith reiterated that the systems HEO is building today can be used in the next steps. He felt that the program could make those milestones clearer for the consideration of future Administrators. Mr. Holloway asked if HEO had considered simplifying the transition from Phase 1 to 2, to ensure survival of the program. Mr. Smith said that NASA has been thinking about becoming more affordable, with more rapid procurement timeframes for Gateway landing services, and is thinking of LEO, lunar orbit, etc. moving in parallel. Mr. Gerstenmaier interjected that there have been many architecture studies, even those that pre-date Apollo; right now, HEO is looking at everything. There is SLS and Orion, but HEO does not have a large launch vehicle yet, which is what leads to NRHO. If NASA builds the right system so that anyone can use it, it is a lasting piece of space hardware in deep space that enables new capabilities (power source, docking configuration, atmosphere). NASA can create a presence that anyone can use; this is a key piece of sustainability that can attracts partners. If there are useful resources on the Moon, NASA can think further about surface operations. Descent systems at the beginning will use storable fuel; later systems can accommodate cryogenic stages, which allows flexibility going forward.

Mr. Hale commented that ISRU is said to be the key to many future items, such as extracting hydrogen and oxygen from ice in the lunar regolith; is there any work that can speed up harvesting these resources? Mr. Smith said HEOMD is working with STMD and SMD to investigate how ISRU might be done. For sample return, there has been a lot of discussion on how to move forward with that. Mr. Hale said it seems NASA should be thinking much harder about how to get oxygen on the Moon. Mr. Gerstenmaier pointed out that the budget amendment of $132M is aimed at STMD for precisely this problem. Mr. Voss was concerned that added capabilities jeopardize the 2024 date: these capabilities add cost and schedule. Mr. Smith reiterated that HEO wants these systems to be evolvable in the near-term, and is prioritizing such systems. Mr. Gerstenmaier said that he was very mindful of the issue, and would like the 2024 systems to be reusable; however reusability is currently desired but not required; these issues need to be traded back and forth. If there is no urgency in terms of schedule, there is no forcing function to make hard political decisions, or to get the requisite funding. Mr. McDaniel asked: what is the advantage of Gateway in cislunar space for the long-term goal of Mars exploration? Mr. Smith said that the PPE has many advantages over chemical propulsion. SEP is also good for transporting large systems over long distances, and is also good for sustained interest from industry. Mr. Hale observed that reusability can really bring costs down. It was hard to re-use the Shuttle; how hard will it be to re-use a vehicle in deep space? Mr. Bowersox noted that Shuttle re-usability was hampered by going in and out of the Earth's atmosphere. Mr. Hale thought lunar dust would pose a greater problem. Mr. Gerstenmaier pointed out that ISS is a good example of how to maintain a spacecraft without bringing it back to the barn. As with ISS, NASA can change out avionics, etc., on Gateway. Mr. Holloway commented that Shuttle was never really re-usable, as it was too expensive, and presented this as a caveat to not repeat the past. Mr. Gerstenmaier said that SpaceX has the reusability goal but pays for it through performance. It is important for the lunar exploration to keep this in mind. Mr. Hale expressed his appreciation for Mr. Smith's efforts.

Mr. Hale offered congratulations to Mr. Gerstenmaier on recently receiving his honorary doctorate from Purdue University. He noted that the incoming Aeronautics class at Purdue was roughly 1000, up from 50 in his day. Mr. Bowersox commented that cybersecurity must be an upfront concern for Artemis. Diversity and inclusion are also key. Programs often need extra effort to obtain new ideas; this is a big

effort in the post-Columbia era. Mr. Hale said that ASAP has discussed the diversity issue and will be doing so in a more comprehensive manner at its next meeting.

Commercial Crew Program

Ms. Kathy Lueders, PM for the Commercial Crew Program (CCP), gave an overview of progress and status. CCP continues to make progress to the first Boeing uncrewed flight to ISS in August 2019 and a crewed flight test to ISS in late 2019. SpaceX completed its uncrewed flight to ISS in March 2018; its first crewed flight to ISS date is under review for 2019, and is dependent upon completing abort tests, and final verification and validation (V&V) on parachute systems; these are difficult and necessary complements to the capsule systems. Both companies are making tangible progress toward their goals. CCP is making progress on its top risks: the inability to meet Loss of Crew (LOC) metrics, and DoD Search and rescue training risks.

Safety risks include the inability to meet LOC metrics; aborting into sea with unsafe rescue; and crew entry accelerations and spaceflight-associated neuro-ocular syndrome (SANS) exacerbations. CCP is working through all the trades to develop flight rules, and is getting into the nitty gritty from a launch and flight-readiness perspective. The program is spending a lot of time characterizing vehicles and seat orientations, to accommodate the risk of SANS, and the companies are using anthropomorphic test units (test dummies) to monitor how the vehicle interacts with crew. The Boeing unit is instrumented to take these data. Mr. Lopez-Alegria asked whether it is known whether SANS is caused by entry and not by length of stay on the ISS. Ms. Lueders said CCP was concentrating on testing to be sure crew vehicle pressures didn't make SANS worse, if it is already present. Having test dummies in the seats has helped to refine modeling.

Boeing has completed structural test article (STA) testing; this was an extensive two-year test. STA test reports are in work. Subsystem level-testing is making progress, parachute system qualification testing is nearly complete, and service module hot-fire testing has been resumed after new valves were installed. Boeing is working through different levels of reliability testing. Joint testing and analysis work is under way with ISS, and is about midway through the requisite joint testing, including aspects of docking and undocking. OFT (Spacecraft #3) Crew Module and Service Module will be heading into final acceptance testing in early summer. The CFT (Spacecraft #2) vehicle has completed its environmental qualification test. SC#2 refurbishment flow is now under way in preparation for the CFT mission, which gives Boeing a chance to practice refurbishment for the post-certification period. This is a very dynamic time.

The Atlas V OFT launch vehicle has been arrived at the Cape, as has the CFT Atlas V launch vehicle. NASA operations have had joint ascent simulation exercises with Boeing operations. Boeing has carried out Boeing-only operations simulations, as well as Boeing landing simulations. Numerous tests and dress rehearsals are scheduled for the summer.

SpaceX's Demo-1 mission launched 2 Mar 2018, and was a very successful mission to ISS. NASA and SpaceX are working through all the post-flight activities; this is a gift that helps NASA to work with the provider and exercise the decision-making process in near-real time. The hardware worked really well, and SpaceX is recovering well from the 20 April Dragon static fire test anomaly. Schedule replanning is under way for IFA, Demo-2, and Crew-1 schedule. SpaceX continues to lead the anomaly investigation, with active NASA participation, and continues to apply Lessons Learned, learning what systems may need to be modified. A failure presents a lot of new data from cameras, instruments, and sensor data sources.

The SpaceX Demo-2 vehicle is making much progress. The docking system and propulsion tanks have been installed, while all Demo-2 Dragon dates are under review. All Crew-1 Dragon dates are also under review; the capsule is in the main building cleanroom. SpaceX has met the four crew members at its

headquarters in Hawthorne, California. In operations, SpaceX is doing suited crew training, and dry runs of day-of launch closeout crew procedures, day-of-launch crew operations (including communication infrastructure), and full-scale medical triage exercises with simulated injuries, and training with recovery ships for capsule recovery. Mr. Sieck asked: is it safe to say that for Demo-1, the "CoFR" contractor process worked? Ms. Leuders agreed, adding that the big thing was how the NASA side was going to work, which was a big challenge because of the distributed nature of the NASA elements. There are some Lessons Learned that CCP will incorporate for Boeing. Mr. Gerstenmaier added that shared accountability has been good; some of the systems were not fully certified, and would not have flown with crew. SpaceX understands this, and thought that NASA's review was appropriate. SpaceX is getting the Demo-2 vehicle ready by the end of the year, but the launch date remains under review; SpaceX first needs to close out the anomaly investigation, and there are a few more critical tests to carry out. There are no non-critical tests right now. Mr. Hale commented that CCP has been pretty lean, and asked how the work force has been holding up. Ms. Lueders thought they were okay, and that the best thing to do at present is to work on clear execution plans, focus on concrete actions that get things done, and work out conflicts as they come up. CCP is taking it one week at a time, and has the discussion all the time; CCP does know that the "right help" helps. Mr. Gerstenmaier said he thought that Demo-1 helped clarify what further work needs to be done, and that it has been helpful for Boeing milestones. CCP is going to have to work to keep those critical events and milestones well separated in time. Ms. Lueders commented that the goal is to fly crew safely, and as soon as possible.

CCP is working on Space Act agreements with Blue Origin on such areas as parachute modeling and tank manufacturing, and is looking ahead to New Shephard support for acoustics testing, and a milestone 7 review; this is a New Glenn development update. Sierra Nevada completed an uncrewed Dream Chaser critical design review (CDR) in late 2018.

CCP is helping to facilitate interagency intergovernmental and international partnerships to enable commercial space, and is working with the Federal Aviation Administration on such items as accommodating trajectories, landing crews for SpaceX, and public safety risk. There is significant work to be done for crewed flight. Mr. Hale commented that people don't know how hard it is to do the interagency work, and appreciated Ms. Lueders's work in this vein. Asked about the status of Dream Chaser, Mr. Gerstenmaier said it was getting ready to fly cargo in late 2020. The intent is to land at a commercial airport; he didn't know if a landing site had been selected. The providers are taking the lead on procuring licenses, while NASA has been working with FAA to make sure they're following along to make a seamless transition from NASA mission to commercial mission licensing. The company shadows NASA in the process. FAA and the Department of Commerce are still debating about on-orbit authority. Ms. Lueders noted that NASA has obviously been supporting FAA's draft guidelines, and is hoping to have Lesson Learned ready to hand over to the folks, government or industry, that need them.

Exploration Systems Division

Mr. Bill Hill, Deputy Associate Administrator for Exploration Systems Development (ESD) presented an update on the program, beginning with Artemis-1 specifications. The current priorities for Artemis-1 are to demonstrate the Orion heatshield at lunar-entry velocities, demonstrate SLS ascent and launch vehicle operations, operate systems in a flight environment, demonstrate communications, and demonstrate retrieval of the Orion crew module, including acquisition of data and imagery. ESD is targeting a lighted landing for a first flight to support imagery collection (not required but highly desired). ESD also seeks to certify optical navigation, and demonstrate redundant systems. To date, service module, thermal, and parachute testing are complete. ESD just completed a 45-day risk reduction initiative, and is adopting a test philosophy for Artemis-1 that will allow for some increased technical risk, while judiciously adjusting work force levels. ESD has also placed senior management and engineering staff at the Michoud facility, and is picking up the pace by implementing new tooling

solutions to improve assembly operations, changing core processing from serial flow to parallel flow, and developing storyboards for new work.

Recent progress milestones for the Orion spacecraft include performance of attitude control motor test firing and uprighting systems tests. ESD is getting ready to go to the Plum Brook facility in August/September. There have been some issues with valves that will determine the timing. The Artemis-1 and Ascent Abort systems are doing well; a test is planned for 2 July for the Ascent Abort system. This will be a three-minute test launch to splashdown, with no parachutes, deploying 12 different data collectors. The Artemis-1 crew module should be complete by the end of June, and is making good progress. The Artemis-1 Service Module is complete and is getting ready to be mated by the end of June, with final assembly and test probably in February/March 2020. The schedule has lost about 50 days to the newly accelerated program timeline. Flight software patching and development is in process, and the buildup of Artemis-2 is under way. Some changes have been made to the Artemis-2 Crew Module Adaptor (CMA) that have worked out well.

The SLS is undergoing engine section integration, and EDS is in the process of offloading the Pathfinder from the Pegasus Barge at the Stennis Space Center (SSC), and currently trying to get it onto the test stand. All the motor units are done, and will be shipped in September/October. Artemis-1's interim cryogenic propulsion stage is complete. Most other Artemis-1 stages are complete and will be shipped to Green Run by December 2019. Artemis-1 boosters are on schedule. Artemis-1 engines are complete and in storage, as well as Artemis-1 contingency engines. Software tests are going very well. Artemis 2 SLS core stages are being built up, and liquid oxygen tank domes are being assembled.

Exploration Ground Systems (EGS) is doing tests with swing arms and umbilicals, and is in the process of acquiring a 1.4M-gallon liquid hydrogen tank, and pouring foundations. The Mobile Launcher at Kennedy Space Center (KSC) is looking to roll to the pad on 27 June, and is still under assembly. Multielement V&V will be done at the pad. The Exploration Upper Stage is being built, and contracts have been established to support an EM-3 in 2024. EGS is starting construction of platforms of future missions. Pad 39B has completed a lot of testing, with installation of some extensible columns. Pad ECS testing is to be complete by December 2019. There is now a good concept for emergency egress, using individual seat slide-wires. The Converter Compressor Facility design is complete and will start construction in 2020. A multi-payload processing facility at KSC is doing V&V activities, and Spaceport Command and Control System (SCCS) is doing software testing. Ground flight application software being tested as well. ESD now has its Outreach program up and running, with live websites.

Mr. Hale asked if a Green Run decision had been made. Mr. Hill said that EDS had provided the Agency with the recommendation, and now has a full-time civil servant at the location. EDS also did a line-by-line walkthrough of the schedule; their schedule is based on a single shift, and EDS is looking at making sure they can do two 10-hour shifts. The schedule is constrained by the software used to keep it powered up for 120 hrs. Looking to augment staff as well, trying to get test time down to 6 months or less. Asked about the Exploration Upper Stage, Mr. Hill said that Artemis-3 has been targeted for deploying it, as there are some funding challenges.

Mr. McDaniel commended the program on its efforts in Outreach, especially to the younger generation. Mr. Sieck commented that it is good that EDS is making the effort to send people out to Boeing; the move will pay great dividends. Mr. Hill agreed that consolidating people together is helping the resolution of issues. Addressing the fact that there are to be no parachutes on the Abort test, Mr. Hill explained that as it's not a flight article, per se, they expect to let it sink. Mr. Gerstenmaier commented that parachute testing has been done extensively, and as there are no good interfaces for use of the parachutes during this test, it won't provide useful data. Mr. Hale said he was getting the sense that EDS has turned the corner. Mr. Hill said he believed so; the team at the Michoud Assembly Facility (MAF) is doing amazing work.

Teams on both sides are engaged and on-site. It's been tough, however, and there as to be a better way to do it in the future. In the last few months, Boeing has hit their marks, which is encouraging. Mr. Gerstenmaier commented that there have been a lot of first-time activities that are complicating procedures, as well.

Public Comment

Mr. Hale invited public comments, asking speakers to be relatively concise, and to send longer comments to Dr. Siegel, if desired.

A speaker identifying himself as Dennis Wingo said that he was not seeing a discussion of standards needed for communication, interoperability, or safety, and no discussion of safety thus far on lunar surface operations. He said he would send longer comments by email. Mr. Don Barker, a flight controller at JSC, commented that he was very interested in the return to the Moon, as a geologist, and noted that the catchphrase "sustainability" does not address all the aspects needed for lunar return, and that he hadn't seen anything that breaks down sustainability as a useful term. Mr. Bob Zimmerman commented on his long involvement with NASA's Planetary Protection, asked if there had been any definition of surface stays, rovers, and the difference between current space suits and evolved suits. Mr. Hale directed him to charts on the subject that will be posted on the HEOC website. A final speaker if a single-stage approach to lunar landers was nonviable because refueling was a baseline requirement. Hale answered, that yes, refueling is a later development. He thanked the public and said that HEOC would address these comments at future meetings.

Discussion and Recommendations

Mr. Sieck commented that it sounds like NASA has done enough homework to enable this acceleration, and that it appears that the biggest challenge will be the lander, just as it had been for the Apollo program. Like the core element on SLS, it will require ingenuity and a lot of work. He recommended that NASA give the effort a full court press, while fully acknowledging that things will take longer than expected, and will cost more. Mr. Lopez-Alegria noted that NASA has been working on SLS and Orion for 10 years, and they still have issues: what makes NASA confident that this will be any different? When it becomes clear that 2024 is not realistic, will this erode political support? The team is doing its best, but it is such a hard problem. He did not feel confident that it could be done. Dr. Condon said that it is encouraging to have a finite date, and thought the new urgency of SPD-1 will bring focus to the program that has been lacking in the past. While the program has been developed with foresight, the real challenge for the 2024 date is to institute a program that will survive a different administration. This makes it more critical to garner public support, and Congressional support. In the past, HEOC has expressed support for the Gateway approach and its place in a sustainable program; this may be something it should emphasize again. Mr. Holloway applauded the Agency for working on the bureaucracy problem: NASA needs to delegate more to the people who can get things done, and minimize the number of people required for approving things. Mr. McDaniel reiterated his praise for ISS as a national treasure, and that NASA needed to remind people of the amazing work being done on Station. If we are going to Mars and beyond, then Gateway is critical to sustainability, and it needs to be presented that way. He also reiterated that Outreach is also critical, and that while NASA is doing a better job of it, it needs to do even better at getting the word out. NASA has the right team. The public should know that this is a dangerous program, and that it is not easy. Are stakeholders willing to accept the risks? Dr. Sanders said she had testified on the subject of risk recently, and had made some of the same points— schedule urgency can be good, and can focus the task and increase decision velocity, but it can also lead to dangerous shortcuts. There is a definite risk/benefit tradeoff, with many unknown unknowns. NASA must have constancy beyond just one budget amendment. The resources for this ambitious program must match the will. This is not worth

another whiplash at NASA. NASA learned a lot with commercial crew, and partnerships, and needs to think more about better ways of doing business.

Mr. Hale agreed that ISS is a huge resource, put together at great taxpayer expense, and that it is hard to think that it should be terminated. Commercial use of ISS remains a chicken-and egg-problem. Commercial companies must get some return on investment at ISS in order for commercialization of LEO to be successful. NASA should be encouraged to think of new ways to keep ISS going as long as possible, especially as Commercial Crew is on the cusp of execution. He agreed with Dr. Sanders; that if the intent is to go back is really just "flags and footprints," NASA shouldn't do it. If it is a sustainable effort (politically, economically, technically), and the program means to go on to Mars, then it is worth the effort. HEOC might want to make a recommendation to ensure that the fast-track nature of Artemis does not impede the eventual vision of sustainability. Mr. Holloway commented that it is important to have something meaningful to do (both in an engineering and scientific sense), and to take sufficient time to learn how to do these tasks, and to operate them for an extended period of time. Mr. Hale noted that Administrator Bridenstine had recently cited political, as well as technical, threats to the program, and his points had been well taken. Dr. Condon commented that SPD-1 specifies operating on and around the Moon: do we need to make a recommendation? Or an observation supporting the direction NASA is heading, particularly with respect to Gateway? Mr. McDaniel asked: does the US want to mine the Moon? Use the mission as inspiration? What are we doing there? If NASA can figure this out, HEOC can help deal with the political threat.

Mr. Voss commented that HEOC often tries to support HEOMD by having a finding on whether the path is the right one. A question to ask is: Is Gateway really necessary to all this? Mr. Lopez-Alegria commented that both requiring Gateway and compressing the target date to 2024 seem to be opposed to one another, and that there seems to be a debate in government as to whether Gateway should be in this pathway. Mr. Hale noted that Mr. Gerstenmaier says he thinks Gateway would get us to the Moon faster. Mr. Voss said he needed to see how this is possible. Mr. Bowersox noted that Gateway allows for the launch of simpler, smaller vehicles (e.g., commercial), and allows some tolerance of element failures. Mr. Voss said that landers could wait in lunar orbit; that they don't really need a Gateway. Refueling is all about the sustainability aspect, and a five-year program doesn't justify it. Mr. Bowersox commented that having landers in lunar orbit would require more redundancy and resilience (translating to more mass and cost). Mr. Holloway thought the commercial capability would help Gateway tremendously. Dr. Condon said he had heard enough to believe that Gateway is the right way to go, but that he hadn't heard enough, however, about the detailed plan, and funding profile, to get this done by 2024. Mr. Bowersox said NASA would probably not see a realistic budget profile until the next budget round for FY21.

Mr. Hale asked: How do we feel about commercial doing all the building of modules and rockets? Is there a PM for managing these contracts? Where is the NASA oversight and governance in this scenario? Mr. Bowersox said that the process for establishing oversight is underway. Mr. Holloway commented that the US got to the Moon on time because it was imperative to beat the Russians. This time, NASA must state why we are going to the Moon. Mr. Hale felt that there is no empirical reason right now, comparably. Dr. Siegel suggested that HEOC have a joint meeting with the Science Committee to discuss this. Mr. Holloway felt that the reason should be much more than science. NASA must return to the Moon without embarrassing itself. Why do we want sustainability-what is the global reason? Dr. Condon agreed, that NASA must figure this out and effectively communicate it to the public and to Congress. Mr. Holloway noted that one strong rationale is that the US should be a leader in space exploration. Mr. Hale agreed that there needed to be a clearer articulation, and that HEOC should think of how it can help to advise NASA. Is it a reasonable plan? Is there a better way to do it? Mr. Lopez-Alegria noted an essential question as being: what will make future administrations want to follow the same course? It might be worth saying something to HEOMD, to talk more about human desire to explore, to be more compelling to the outside world. Mr. McDaniel commented that if Gateway is developed and launched, it will be hard to shut down

the program. Mr. Lopez-Alegria said that ISS was saved because NASA made commitments to other countries, but that this reason may not be as viable in the present atmosphere. Mr. Holloway had the impression that there is political support, but there are minor issues with OMB and other agencies. His advice to NASA would be to avoid getting important stakeholders angry. Mr. Sieck hoped that neither NASA nor the CCP contractors ignore the need to finish out the requisite paperwork.

May 29, 2019

Call to order

Dr. Siegel called the meeting to order. Mr. Hale introduced the first speaker of the day, Ms. Elaine Slaugh.

President's Proposed FY2020 Budget

Ms. Slaugh, Deputy Director for HEO's Resources Management Office, gave a briefing on the FY20 budget. The budget was presented in the context of SPD-1, directing NASA to reach the lunar surface by 2024, followed by a sustained presence, "by all means necessary." Why go to the Moon? It is a compelling target, exciting even for the bean counters. The accelerated timeline caused some changes in the program of record, which is now focused on what is needed for a minimal Gateway configuration. On 13 May, the budget amendment was announced: $1.6B above the initial $21B total budget for NASA. $1B is marked for the acceleration of human lunar transportation systems, $651M is applied towards the completion of the SLS/Orion program, $132M for new technology in STMD, and $90M for SMD to increase robotic exploration at the South Pole in advance of astronauts. FY20 provides 10.6B for HEOMD, specifically.

The new budget enables the Artemis program to make innovative procurement approaches. Gateway will continue development as part of the Artemis program, enabling a whole-Moon approach to exploration from a critical exploration platform, focusing on PPE and a minimum habitation capability for 2024. HEOMD will continue to use ISS to prepare for human deep space exploration, encourage economic growth, and reduce reliance on foreign providers. The budget submit also establishes a new Communication Services Program, for purchasing commercially-provided satellite data.

The FY20 Program Financial Plan reflects the new budget amendment, and some outyears to 2024. NASA is in the process of updating the outyear profile, which will be shown in the 2021 budget request. It is expected that the numbers will be commensurate with an accelerated program. Mr. Voss asked what $600M could do for SLS/Orion to allow acceleration, as the program is already working as it can: what will make it go faster? Ms. Toni Mumford noted that the extra funds were not meant to accelerate, per se, but to support schedule assurance, staying on track for the three Artemis missions; schedule assurance depends in part on keeping par with previous budgets. Mr. Hale added that the funding was in response to future decreases in the PBR, instead of waiting for Congress to enact a plus-up. Ms. Mumford commented that the funding also speeds up horizontal integration, and supports long-lead items for Artemis-3. Mr. Hale asked about Upper Stage development funding for 2024. Ms. Mumford said that NASA is still assuming deferral of the Upper Stage, but is working according to what the law currently demands for the Upper Stage. Mr. Hale said that NASA must get agreement from all the stakeholders before the outyears are better defined. Mr. Bowersox noted that there has been money spent on Upper Stage that is not in the current budget submittal, and that NASA was working hard also on improving schedule performance.

Ms. Slaugh enumerated some FY18 achievements, such as completing fabrication for Lunar CATALYST partners, five CRS cargo missions, continued US Human Spaceflight leadership, 12 studies on the future of commercial spaceflight, and the launches of the Transiting Exoplanet Survey Satellite (TESS), the InSight mission to Mars, the Parker Solar Probe, and ICESAt-2. Work in progress for FY19 includes the

completion of lunar landing systems architecture by end of the fiscal year, and completion of work for the lunar surface suit.

Exploration R&D is budgeted at $2.3B in 2020 (including the budget amendment), with outyears still to be defined. This will accelerate development of an architecture that will include a crewed mission by 2024 to the lunar surface, and evolved lunar landing capabilities that focus on human landing systems (HLS). Major changes for 2020 are: NASA is no longer pursuing an FY22-planned 500-kg payload and lander; instead, SMD is requesting funds to buy something of this size commercially. Exploration R&D will continue to work on refinements to the Gateway implementation strategy, with the PPE launch readiness date to be no earlier than 2022, on a partner-provided commercial vehicle.

In Advanced Exploration Systems, $255.6M is budgeted for 2020 to develop the Saffire V and VI fire safety systems, to test radiation sensors for Artemis-1; and to prototype life support systems. There are no major changes for 2020. In the Human Research Program, new risk mitigation research efforts are under way, and work continues on microbial and other standards for space habitats, as well as new studies to understand space radiation effects.

In Exploration Systems Development, there is no funding to complete a second mobile launcher in 2020. Ms. Mumford commented that legislation still requires that NASA fund a second mobile launcher, and that further planning is pending the appropriations process. For the present, NASA will defer the SLS Block 1B Configuration (with EUS). Ms. Slaugh said that major changes to ESD Orion in 2020 are the development of rendezvous and docking for Gateway and surface support; and the design of new valves to meet safety requirements.

Major changes in SLS and Exploration Ground Systems (EGS) include deferring SLS Block 1B and second mobile launcher platform development. In 2020, ISS will continue to foster commercialization of LEO, with major changes beginning in FY23 as ISS direct funding ramps down; this budget profile is contingent on transition to commercial capabilities. For commercial LEO development, there are no major changes in FY20. In Space Transportation: Crew and Cargo, Northrop Grumman has two flights planned under CRS-2, SpaceX has two flights planned; one under CRS-1 and one under CRS-2.

In Space Communications and Navigation have been allotted $611M for 2020. Major changes in this area are the redesign of the optical payload to reduce mass on Orion, and a delay of the Laser Comm Relay Demo launch to August 2020, and the ILLUMA T to 2022. Under the Communication Services Program, $3M has been targeted to explore support from commercial providers, and to begin to formulate future communications architecture based on these purchased services.

In 2020, $46.5M is budgeted for the Rocket Propulsion Test Program, to include SSC, Glenn Research Center, Plum Brook, White Sands, and Marshall Space Flight Center. For Launch Services, $88.6M in 2020 will cover three launches in 2020: Mars 2020, Solar Orbiter, and Landsat 9. In Human Space Flight Operations, $99.8M for 2020 will include a major change, transferring Aerosciences to the Safety, Security and Mission Services account.

Asked what the total NASA 2020 budget request amounted to, Mr. Bowersox put the number at $22.6B, with the only reduction being in the habitation capability for Gateway; there were no other decreases. Mr. Hale remarked of the budget profile that he would expect it to increase more steeply, as in a classic development curve, and expressed some dismay about putting off Upper Stage development. He added that as Artemis is a smaller scale program than Apollo, he did not expect NASA would go back to garnering 5% of the Federal budget. Mr. Bowersox said that NASA still had some heritage from the Apollo years, and would be building on work from previous programs.

Evolving Space Communication and Navigation Technologies

Mr. Badri Younes, Deputy Associate Administrator for NASA Space Communications and Navigation (SCaN), gave an overview of NASA's SCaN Program. NASA has three networks -- the Space Network (SN),the Near Earth Network (NEN), and the Deep Space Network (DSN) SCaN manages a world-class set of capabilities, providing services for over 100 missions a day, carrying petabytes of data per day, and supporting space flight and science in general. SCaN is in the process of upgrading to the Ka-band as the other bands are in demand by the commercial sector. The NEN is the oldest network, upon which NASA relied before the DSN came on-line. This network had many stations, ships, and airplanes to support the network in the Apollo years; it now relies on commercial tracking stations around the world. In the mid-1970s, NASA began to deploy Tracking and Data Relay Satellites (TDRS), as the on-orbit segment of the Space Network. NASA launched the latest spacecraft, TDRS-M, several years ago, and the network is expected to provide reliable communications through the mid-2030s. The SN has seven TDRS in operation, with one on-orbit backup. The agency is now preparing for the future to take advantage of newer technologies. The DSN maintains three stations around the globe separated by 120 degrees, two in the Northern Hemisphere, one in the Southern Hemisphere. SCaN is investing in new capabilities and antennas in Canberra, Australia; Madrid, Spain; and Barstow, California.As NASA's 70m antennas are aging, SCaN is building new 34m beam waveguide antennas at each site that will work as a relay, and will also be able to provide Ka-band.. SCaN is anticipating challenges as space becomes more crowded, and is working to harmonize technologies and standards to support interoperability in space. Cybersecurity is always an issue, and all systems are vulnerable, so SCaN builds security and network integrity into architecture; SCaN's security manager is working constantly with the Chief Information Office (OCIO) in an ongoing effort to deal with an ever-evolving threat. Dr. Sanders noted that ASAP will be spending an entire day on this subject at an appropriate security level; Mr. Younes offered to provide the SCaN security manager, if required, to assist in any way. Mr. Younes anticipated that cybersecurity will become more of a problem as NASA hybridizes with the commercial sector; foreign-owned and -operated sites will also present challenges. The priority will be to provide secure and reliable space communications to all its customers. Mr. Younes stated his strong commitment to support a healthy space industry, which is good for NASA, and to take advantage of technological advances in the commercial sector. Mr. Younes viewed SCaN as ambassadors to the outside world for NASA exploration and science, and it actively engages students and the general public to communicate the value of STEM. SCaN also has a summer intern program; each summer it hosts 60-70 students at the high-school, college, and post-graduate level at its facilities at the Glenn Research Center and the Goddard Spaceflight Center. SCaN pursues advanced communications and navigation technology, looking for orders of magnitude improvements in performance: for example, cognitive technologyenables autoconfiguration of channels in terms of both frequency and waveform. SCaN also works closely with the White House, FAA, DoD, and all the relevant agencies, to ensure that NASA is addressing healthy spectrum management for both government and commercial entities. The NASA Administrator delegates authority to SCaN to serve as the Agency's spectrum manager; Mr. Vic Sparrow, Spectrum Policy Director, is leading an interagency effort to update the 1934 legislation and works closely with the White House National Space Council NASA also plays a critical role in implementing policy and technology related to Positioning, Navigation and Timing (PNT) SCaN coordinates on behalf of NASA with interagency and international agencies on behalf of the Agency's PNT requirements, including close cooperation with the US Air Force, which manages the Global Positioning System for both civil and military users.

Independent of SCaN, NASA is creating a Communications Services Program to maximize benefits from industry communications services, with an eye to fostering an affordable and growing US space industry. Many commercial providers don't have the authorization to support space users, so SCaN is working with them to pave the way. It is also increasing the efficiency and robustness of NASA's networks, working to get to 1.2Gb per second rates, and increase capacity four-fold. Commercial best practices are also being

infused into NASA's business activities, and SCaN works closely with academia to enhance communications and services. NASA will lead a National Spectrum Management Process symposium in Spring 2020 to address efforts in streamlining processes and reducing regulatory impediments.

SCaN continues to provide technical leadership to support lunar exploration in the 2024 timeframe, and is working with STMD with an eye to flying some mini-satellites around the Moon, creating a Lunar Point of Presence. An optical communication technology demonstration will be flown on a cubesat next year, carrying an optical transmitter for transmitting data to ground. Dr. Condon commented on SCaN's impressive display, not only in fulfilling requirements but also identifying future needs, and pursuing collaboration and cooperation. Mr. Younes said that the quantum domain needs to be explored fully as a follow-on to optical communication, and SCaN aims to demonstrate quantum networking, sensor fusion, and encryption on ISS. SCaN would like to proceed with this quickly, to ensure that the US maintains the lead in communications technology. Mr. McDaniel noted that it was good to see NASA taking leadership in communications capabilities.

Discussion and Recommendations

Mr. Hale addressed next steps for HEOC, and said he would like to hold the Committee's next meeting at Stennis/Michoud to see what's going on. Dr. Condon said that the SCaN briefing was very impressive and was the most comprehensive and visionary strategy he had seen; he appreciated hearing their overall approach to communications. He felt that SCaN deserved praise in a finding or observation on their leadership in spectrum management, and collaboration. Communications infrastructure is critical for space endeavors. Dr. Sanders added her support for this statement. Mr. McDaniel said he had not seen any budget lines for Outreach; NASA need funds dedicated to Outreach, particularly to reach into low-income and underserved areas, to inspire the next generation, down to the kindergarten/first grade level. States that have NASA centers have more direct access, but the Agency needs to reach further. Astronauts and NASA scientists and engineers get great reception everywhere they go. It is important to realize that many counties in the US do not have access to computers. NASA has a very positive reputation, and with the push to Moon and Mars, it's time to motivate the next generation. Mr. Hale commented that, given that the NASA Education budget gets zeroed out perennially, and Congress puts the funding back in just as perennially, this is good feedback for the NAC to provide. He asked Mr. McDaniel to prepare a recommendation on the subject.

HEOC Recommendation on Lunar Plans (for the NAC):

HEOC recommends that NASA continue its current planning for human space flight, to include long-term sustainability features. Mr. Holloway noted that many people argue against cost savings associated with current plan. Mr. Sieck suggested adding a praise for progress on PPE. Dr. Sanders cautioned against short-term moon shot diverting attention from the long-term plan. Mr. Voss supported the thought that the plan is the right way; while it is not saving money in the short term, it will in the long term.

Here is the recommendation:

Short Title of Recommendation: Lunar Plans

Recommendation:

The HEO committee recommends that the current planning for human spaceflight to the moon continue along the lines of the recent planning study to include long term sustainability features including reusability, refueling and in-situ resource utilization at a "gateway" or reusable aggregation point.

Major Reason for the Recommendation:

NASA has been doing trade studies on how to return to the moon for decades and the recent acceleration study included the results from all previous trade studies. To ensure the long term viability of human spaceflight, efficient and affordable measures must be taken to reduce costs and enhance flexibility. Having a rally point or aggregation node with human shelter capability appears to be the best way to reduce costs and enhance flexibility. The HEO committee concludes that a dash to the moon without including infrastructure for the longer term would not lead to a sustainable program of deep space human exploration. Near term focus on rapid lunar missions should not distract from the long-term objectives.

Consequence of no action on the Recommendation:

A higher cost program with limited scope and decreased long term viability would most likely result from a different approach. The intent of SPD-1 would not be met.

HEOC Recommendation on continued utilization of ISS until other LEO platforms are available (to the Administrator):
ISS is needed for life science studies, and maintenance and refinement of space operations skills. Early termination would be a waste of taxpayer investment. Mr. Holloway noted that ISS has done much more work, beyond the stated, that has contributed to the world, and has only gotten better and better in terms of efficiency, and in responding to its community. Dr. Condon felt that the recommendation could be a subtle nod to the commercial sector to step up to the plate; NASA will have to continue to fund ISS if commercial does not. Mr. Bowersox said there is no specific direction to terminate in 2024; the future funding profile reflects a transition to commercial rather than a sharp termination of funding. There was some debate about this issue among HEOC members. Mr. McDaniel felt that the recommendation should reflect that ISS is a national treasure, and has returned on its investment many times over.

Here is the Recommendation:

Short title of the Recommendation: Continue utilization of the ISS until other commercial platforms in LEO are available.

Recommendation:

Continues utilization of the ISS with increasing support for commercial LEO activities is recommended for continuity of human presence in space. Plans should be made to continue ISS operations past 2024 while at the same time maximizing the prospect of having follow on LEO platforms available through the private sector.

Major Reason for the Recommendation:

NASA will require services in LEO to resolve issues with life sciences concerns as well as to continue to practice operational skills. The platform provides a facility to do outstanding scientific research, commercial product development, small satellite deployment, and a myriad of other useful activities. The ISS is a major infrastructure element which can continue to provide a platform to do this work. The goal of enabling commercial services platforms and activities in LEO should continue to be a focal point. NASA should take all reasonable steps to encourage and enable commercial activities while continuing to use the ISS until suitable replacement platforms are commercially operated and available for NASA service contracts. This likely will take more time than envisioned decrease in US government funding of ISS in late 2024.

Consequence of no action on the Recommendation:

US government major decrease in funding for the ISS following 2024 without follow on commercial human platforms available will mean that NASA will be unable to resolve critical life science issues for long duration spaceflight and will lose the capability to practice routine operational activities in LEO. The ISS is a significant investment and early termination would be a waste of taxpayer investment.

HEOC Recommendation to Streamline NASA Decision-Making (for the NAC):
HEOC recommends that NASA review and revise governance models, streamline processes, to avoid "analysis paralysis," while retaining attention as a top priority. Dr. Sanders felt the point was more to make a statement about the velocity of decision-making. Dr. Condon commented that processes tend to remain in bureaucracies long past the time they are needed, and that it is good to prune out these outmoded processes. Dr. Sanders added that NASA should use the Technical Authority the way it should be used—today there is too much dithering. She didn't think the recommendation should impede any safety processes.

Here is the Recommendation:

Short Title of Recommendation: Streamline NASA decision making

Recommendation:

To achieve the goal of human landing on the moon by 2024, NASA decision making must be more rapid while still making appropriate decisions. It is recommended that the governance models be reviewed and revised and new organizations (such as the lunar lander program) be organized in such a way to ensure rapid accurate decision making. Decisions should be made at the lowest acceptable level and multiple reviews and 'analysis paralysis' must be avoided.

Major Reasons for the Recommendation:

Currently NASA decision making culture has grown in an environment of slow activities and multiple reviews at a very high level. To ensure the success of large scale and fast paced programs which will be required by the lunar initiative, a return to the type of decision making that was the hallmark of the agency in the 1960's is required. This means that multiple high-level reviews should be reduced to the minimum possible and decision making should be delegated to the lowest level of authority practical. While safety concerns are always a top consideration, the necessity to make rapid and appropriate decisions will be critical and measures must be taken to change the organizational culture as well as the documented processes to accommodate the new time scale.

Consequences of No Action on the Recommendation:

Current programmatic decision-making processes and culture in NASA are not appropriate to the new accelerated lunar program. Without significant change in decision making processes, the new programs will not accomplish the goals required and certainly not within the time frame which has been established

HEOC Finding to Continue to Streamline Commercial Requirements and Regulations (for the NAC):
HEOC finds that the Commercial Crew Program (CCP) has made major strides. Mr. Holloway said that it was a stretch to call some of these programs commercialization while paying $4.2B for it. Mr. Hale noted the understanding that it is that one objective of CCP is to help US industry; what comes across is that commercial gets hampered by multiple interagency requirements. He felt kudos to SCaN should be

included in this finding. Mr. Holloway thought that commercial efforts in cubesat technology seemed to be working well. Mr. Sieck thought NASA's program was a good start, and that treating a commercial entity as a customer is hard for the government to do. Dr. Condon felt CCP had done great groundwork, but that NASA also needs to continue to help companies jump through regulatory hurdles. A meeting participant added that work that has happened in CCP must be ramped up for landers, commercial habitats, and communications, to make 2024 real. Dr. Sanders agreed, adding that it was painful for CCP to get where it is today: efforts must be expanded greatly.

Here is the Finding:

Short Title of Finding: Commendation for streamlining commercial spaceflight requirements and regulations

Finding:
NASA's Commercial Crew Program office and the Space Communications and Navigation office have done yeoman's work to help commercial programs cut through interagency bureaucracy. These organizations are commended for this work. The commercialization of activities in low earth orbit is a goal of the US government yet the multiple interagency bureaucracy surrounding space activities is very difficult to navigate. NASA should continue to help commercial space efforts by providing guidance and advocacy in the streamlining of the complex bureaucracy surrounding space activities. NASA should continue to provide leadership to coordinate responsibilities across the US Government.

HEOC Recommendation on STEM activities (to the NAC):
Mr. McDaniel put forth a recommendation stating that NASA must inspire the next generation through STEM and direct interaction with students, particularly in underserved communities, to build the next generation workforce and should have a budget commensurate with the effort. This is the time to strike, with the new effort in the Artemis Program. Mr. Holloway added that NASA is uniquely equipped to do this. Mr. Holloway felt the effort must go beyond the workforce, to bolster economic development in underserved communities.

Here is the Recommendation:

Short Title of Recommendation: STEM activities

Recommendation:

The HEO Committee recommends that NASA inspire the next generation and encourage them to pursue STEM careers through direct interaction with students, particularly in underserved communities. NASA is uniquely positioned to inspire the next generation. The HEO Committee notes the need for a budget commensurate to meet this requirement.

Major Reasons for the Recommendation:

As NASA pursues Artemis, a long-term sustainable program, now is the time to inspire and build this next generation workforce. The budget required to accomplish this needs to be provided to achieve these goals. This would be helpful to the economic improvement of disadvantaged locations.

Consequences of No Action on the Recommendation:

Lack of workforce in the future and lack of public support for current programs.

Mr. Hale wrapped up the meeting, encouraging HEOMD to come to HEOC with any problems, to help HEOC to provide better advice. Dr. Sanders suggested having a briefing on what worries HEOMD the most. Mr. Hale said he would like to hear from some more PMs, the next layer down in the organization chart. Dr. Siegel adjourned the meeting at 11:27am.

Appendix A
Attendees

Human Exploration and Operations Committee
J. Wayne Hale, **Chair**, Retired NASA
Stephen "Pat" Condon, Aerospace Consultant
Tommy Holloway, Former Space Shuttle and International Space Station Program Manager
Michael Lopez-Alegria, Former NASA astronaut
Patricia Sanders, Aviation Safety Advisory Panel
Robert Sieck, Former Space Shuttle Launch Director
James Voss, Former NASA astronaut (via Webex)
Mark McDaniel, Partner at McDaniel and McDaniel Attorneys, LLC.
Bette Siegel, NASA, Executive Secretary

NASA Attendees
Barbara Adde, NASA/HEO/SCaN
Lindsay Aitcheson, NASA HQ
Jacob Bleacher, NASA/HEO/AES
Kenneth Bowersox, NASA HEO
Steve Davison, NASA HEO
Darcy Elburn, NASA/HEO/ISS
Jamie Favors, NASA ESD
Robyn Gaetans, NASA HQ
Michele Gates, NASA
William Gerstenmaier, NASA
John Guidi, NASA HEO/AES
Nicole Herrman, NASA
Eracenia Kennedy, NASA HEO/AES
Orin Mahoney, NASA HQ
Toni Mumford, NASA HQ
Renee Pullen, NASA HEO
Tara Ruttley, NASA HQ/OCS
Sam Scimemi, NASA
Ron Tickman, NASA HQ/HEOMD
Alex Tyler, NASA HQ

Non-NASA Attendees
Joan Logsden, GWU
Charlie Stegmuller, SAIC
Joan Zimmermann, Zantech IT

Webex Attendees
Franceso Bordi, NASA
Albert Condes, NASA
Alex McDonald, NASA
Alicia Brown, Senate Commerce Committee
Allen Deluna, ATDL Inc.
Amir Deylami, NASA Marshall Space Flight Center
Anne Zulkosky, Lockheed Martin
Ashley Wilkins, House of Representatives

Beverly Perry, NASA
Bill Beckman, Boeing
Bill Harwood, CBS News
Bill Peterson, Independent
Bob Delee, Boeing
Bob Menrab, GSFC
Bradley Cheetham, Advanced Space
Brian Harvey, BAN Associates
Caitlyn Torres, Boeing
Candyce Goodliff, NASA
Carol Hamilton, NASA
Carrie Arnold, Boeing
Charlie Walker, Personal Interest
Chris Bales, Bales Consulting
Chris Gilbert, VE Consult
Chris Moore, NASA HQ
Christian Maender, Axiom Space
Christine Vanecay, Congressional Staff
Christopher Stelter, NASA
Collin Jupiter, NASA HQ
Craig Kundrot, NASA HQ
Damara Belson, NASA
Dan Vergano, Buzz Feed News
Daniel Fenzau, NASA Office of Inspector General
Danny Lentz, Independent
Darrell Branscome, NASA Consultant
Dave Huntsman, NASA Glenn
David Eisenman, NASA
Dawn Stanley, NASA ESD
Dee Russell, Communications Specialist Boeing
Dennis Wingo
Derek Hassmann, Axiom
Devan Bryant, NASA
Dillon MacInnis, SpaceX
Donald Barker, University of Houston
Eblan Sarris, NASA
Ellen Grand, NASA
Eric Teslareti
Eric Berger, Arstechnica
Erin Kennedy, GAO
Erin Mahoney, NASA HQ
Farah Riggs, APL
Frank Ledbetter, NASA Marshall
G. Klein
Gale Allen, ASGSR
Gene Mikulka, Talking Space
George Shoemaker, Retired
Gina Anderson, NASA
Gregory Dorais,NASA Ames
Helen Grant, NASA HQ
Holly Griffith, NASA

Ireen Genus, NASA HQ
James Lynch, NASA HQ
James Miller, NASA
James Rice, Planetary Science Institute
James Spry, SETI Institute
James Zimmerman, International Space Services
Jared Smith, Member of the Public
Jared Stout, Venable LLP
Jeff Foust, Space News
Jeff Patton, FAF
Jerad Bell, Preventable LLP
Jerry Klein, Rocketdyne
Jidendra Joshi, NASA HQ
Jim Free, Technology and Innovation and Engineering Committee
Joey Roulette, Reuters
John Benac, Bradford Space, Inc.
John Hudihurt, NASA
John Karcz, OMB
Josh Finch, NASA
Joy Kim, GAO
Karen Lawler, NASA
Kate Kronmiller
Katelyn Kuhl, NASA
Kathryn Hambleton, NASA
Kathy Laurini, Independent Consultant
Keith Cowing, NASA Watch.com
Kelly O'Roarke, NASA HEO
Kenneth Chang, New York Times
Kevin Fagedes, NASA
Kevin Tolley
Kristin VanWychen, USGAO
Kyle Herring, NASA
Laura Taylor, NASA
Linda Hargrove, NASA
Linda Karanian,Karanian Aerospace Consulting
Lindsay Aitchison, NASA
Liz Warren, ISS National Lab
Logan Faulconer, Faulconer Consulting Group
Marcia Dunn, AP
M Gannett, NASA
Marcia Smith, Space Policy Online .com
Marena Corin, The Atlantic
Marguerite Broadwell, NASA HQ
Mark Carreau, Aviation Week and Space Technology
Mark Seibert, NASA Contractor
Marshall Holly, Chase Foundation
Marybeth Davis, Boeing
Meredith McKay, NASA
Michael Curie, NASA Commercial Crew Program
Michael Earton, AI Solutions
Mike Deklotz, NASA HQ

Monica Vidaurri, NASA
Moriah Lee, NASA Management Analyst Office of Inspector General
Nick Cummings, SpaceX
Pam Whitney, Science Committee
Patricia Foloveichik, Boeing
Philip Sloss, Nasaspaceflight.com
Rick Irving, NASA
Rob Kampen, Oprens Law Attorney
Robert Fraizier, NASA
Robert Proudfoot, NASA
Robert Shishko, JPL
Robert Zimmerman, Symbiotek
Robyn Roy, Citizen
Ron Ticker, NASA
Ryan Faith
Ryan Lester
Ryan Whitley, National Space Council
Sara Shaw, NASA
Sarah Reed, ATL
Scott Spencer, Consultant
Seth Roberts, NASA
Shandy Mcmillian, Office of Safety NASA HQ
Sheryl Reed, APL
Suzanne Gillin, NASA
Tara Ruttley, NASA
Tarod Sankya, Space Bank Technologies
Terry Hunter, NASA
Theodore Kronmiller, Law Office
Timothy Heimann, NASA Marshall
Tony Reichardt, Air and Space Magazine
Victoria Carter-Cortez, ESA
William Horne, NASA
Zachery Pirtle, NASA

Appendix B
HEOC Membership

J. Wayne Hale, Chair
Former Space Shuttle Program Director

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

Leroy Chiao
Former NASA astronaut and International Space Station Commander

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

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

Tommy Holloway
Former Space Shuttle and International Space Station Program Manager

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

Robert Sieck
Former Space Shuttle Launch Director

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

Mark McDaniel, Partner at McDaniel and McDaniel Attorneys, LLC.

Invited guest
Patricia Sanders
Chair, Aviation Safety Advisory Panel

Appendix C

Presentations

1. Human Exploration & Operations Mission Directorate Overview; Kenneth Bowersox
2. International Space Station Status and Transition; Sam Scimemi
3. Human Lunar Exploration Status; Marshall Smith
4. Commercial Crew Program Status; Kathy Lueders
5. Exploration Systems Development Status; William Hill
6. President's Proposed Budget; Elaine Slaugh
7. Evolving Space Communication and Navigation Technologies; Badri Younes

APPENDIX D
AGENDA

Tuesday May 28, 2019

COMMITTEE PUBLIC MEETING

9:30 - 9:35	Call to order and Welcome	Mr. Wayne Hale/Dr. Bette Siegel
9:35 - 10:30	NASA Human Exploration and Operations Overview	Mr. Ken Bowersox
10:30 - 11:30	International Space Station Update.	Ms. Robyn Gaetans
11:30 - 12:30	Lunch	
12:30 - 2:00	Human Lunar Exploration	Mr. Marshall Smith
2:00 - 3:00	Commercial Crew Program	Ms. Kathy Lueders
3:00 - 4:00	Exploration Systems Program	Mr. Bill Hill
4:00 - 4:05	Public Comments	
4:05 - 4:15	Break	
4:15 - 5:30	Discussion and recommendations	
5:30	Adjourn	

Wednesday May 29, 2019

8:00 - 8:05	Call to order	Mr. Wayne Hale/Dr. Bette Siegel
8:05 - 9:00	President's Proposed FY 2020 Budget	Ms. Elaine Slaugh
9:00 -9:30	Evolving Space Communication and Navigation Technologies.	Mr. Badri Younes
9:30 -10:00	Break	
10:00 - 12:00	Discussion and Recommendations	
12:00	Adjourn	

Dial-In and WebEx Information

For entire meeting May 28-29, 2018

Dial-In (audio): Dial the USA toll free number **1-888-324-9238** or toll number **1-517-308-9132** and then enter the numeric participant passcode: **3403297**. You must use a touch-tone phone to participate in this meeting.

WebEx (view presentations online): The web link is; https://nasaenterprise.webex.com/nasaenterprise/ the meeting number is 907 309 794, and the password is **Exploration@2019** (case sensitive).

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