National Aeronautics and Space Administration
Washington, DC

NASA ADVISORY COUNCIL

Human Exploration and Operations Committee

March 2-3, 2016

NASA Headquarters
Washington, DC

MEETING MINUTES

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Kenneth Bowersox, Chair

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Bette Siegel, Executive Secretary

NASA Advisory Council
Human Exploration and Operations Committee
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MEETING MINUTES
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NASA Advisory Council
Human Exploration and Operations Committee
Meeting
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Wednesday, March 2

Call to Order, Welcome, and Opening Remarks

Dr. Bette Siegel, Executive Secretary for the NASA Advisory Council (NAC or Council) Human Exploration and Operations (HEO) Committee, called the session of the HEO Committee to order at 9:30 a.m. She announced that the meeting was a Federal Advisory Committee Act (FACA) meeting and, therefore, would be open to the public. Minutes would be taken and posted online, along with the presentations. There would be an opportunity for the public to make comments towards the end of the meeting, and she asked for any questions or comments to be held until that time.

Mr. Kenneth Bowersox, HEO Committee Chair, welcomed everyone to the meeting. He noted that Dr. Patricia Sanders was present and was representing the NASA Aerospace Safety Advisory Panel (ASAP). Mr. Bowersox explained that NASA Administrator Charles Bolden had expressed an interest in having additional interaction between NASA's advisory committees. Mr. Bowersox noted that he had recently attended the ASAP meeting held at NASA Johnson Space Center (JSC) and that he was very impressed with the depth to which the ASAP delved into programs. He observed that typically the HEO Committee looks further out into the future, while the ASAP concentrates more on nearer term issues.

Human Exploration Progress and Plans--Overview

Mr. Bowersox introduced the first speaker, Mr. Bill Gerstenmaier, Associate Administrator (AA), Human Exploration and Operations Mission Directorate (HEOMD), who provided the Committee with an overview on human exploration progress and plans. Mr. Gerstenmaier discussed a chart showing a graphic on the "Journey to Mars." He explained that the most important aspect of the chart was the reference to the journey's three phases: the Earth Reliant phase, the Proving Ground phase, and the Earth Independent phase. He noted that the Proving Ground would be used for validation and verification. He discussed a chart demonstrating that human exploration of Mars is hard. He noted that the movie, "The Martian," was enjoyable to watch but does not depict the real situation. The crew would be away from Earth between 800 and 1,100 days during which time they would be exposed to radiation and microgravity. Autonomous operations would be necessary due to a 44-minute, two-way communication time delay. Multiple 130-ton, heavy-lift launches per mission would be required. The ability to land large payloads between 20 to 30 tons would need to be developed. Surface operations on Mars would be affected by dust toxicity. The reentry speed upon returning to Earth would be 11.2 kilometers per second (km/s). NASA does not have a heat shield designed for that speed. Mr. Gerstenmaier explained that Mars is achievable in the long view; however, it would have to happen over decades. In response to a question from Mr. Michael Lopez-Alegria, Mr. Gerstenmaier explained that the Moon's gravity could be used to reduce the

reentry speed but would extend the mission by 25 to 30 days. Mr. Gerstenmaier noted that it would be appropriate to begin to define "home" as the Earth-Moon system.

Mr. Gerstenmaier briefly described the Space Launch System (SLS), the Orion Crew Vehicle, Ground Systems Development and Operations (GSDO), Commercial Crew and Cargo Vehicles, the Asteroid Redirect Mission (ARM), and experiments and research being conducted on the International Space Station (ISS). He noted that HEOMD has more human space systems development ongoing at the present time than at any time since Apollo. He explained that four racks on the ISS would be used to test life support systems. It would mean sacrificing space used for storage. He noted that the exercise equipment on the ISS is good; however, it is big and bulky and has to be repackaged into a smaller footprint for deep space exploration.

Mr. Gerstenmaier reviewed a chart on the transition from ISS to cislunar space. Phase 0 covers exploration systems testing on ISS. Phase 1 covers cislunar flight testing of exploration systems. Phase 2 covers cislunar validation of exploration capability. The Asteroid Redirect Crewed Mission (ARCM) marks the transition from Phase 1 to Phase 2. Phase 2 culminates in the mid-2020s with a one-year, crewed Mars-class shakedown cruise. Mr. Bowersox commented that showing the ARCM as the capstone for Phase 1 cislunar flight testing was useful. In response to a question from Mr. Bowersox, Mr. Gerstenmaier clarified that a mission to the Martian moons Phobos or Deimos should be classified as Earth Independent. Mr. Gerstenmaier reviewed a chart on what has been learned thus far and what remains to be learned. He described HEOMD's efforts to fulfill a December 2015 NAC recommendation on preparation for the 2017 transition of presidential administrations. Mr. Gerstenmaier presented a chart showing the capabilities needed for pioneering space in the three phases of the Journey to Mars. He reviewed a chart on capability development, risk reduction for each phase.

Mr. Gerstenmaier discussed System Maturation Teams (SMTs). He explained that SMTs comprise technical experts from across NASA's Centers and programs. He discussed the SMT data hierarchy. He noted that he had not created a formal program office for the Journey to Mars because he did not want to carry its expense. Mr. Bowersox observed that the SMTs had a diffuse reporting structure, which can work but requires the right people "with super high-energy." Mr. Tommy Holloway requested that the Committee be briefed by SMT members. Mr. Holloway asked whether NASA was satisfied with 2024 for the end of Station. Mr. Gerstenmaier responded that NASA is not trying to pick a date and is more focused on choosing criteria. He explained that 2024 is reasonable if progress is made on the criteria. Mr. Gerstenmaier concluded his presentation by noting that NASA had received 18,300 applications for the 2017 NASA Astronaut Class.

Mr. Holloway stated that for NASA to be successful in the 2030s, it would need to learn how to conduct business at a much lower cost. Mr. Gerstenmaier responded that he does not know why "it takes so long to do stuff now, but it does." He noted that the Commercial Crew Program (CCP) is allowing NASA to see a way to do things differently and that he is trying to encourage his team to think the same way. He explained that NASA's heritage makes everyone worry that schedule pressure is a bad thing. Schedule awareness is necessary but should not overwhelm everything else. The NASA culture rewards people for not being fast and dictates that people should never fail. That culture is pervasive and is driven by the external community.

Mr. Richard Malow, participating telephonically, recommended a book entitled "Apollo, the Race to the Moon." Mr. Bowersox expressed appreciation to Mr. Malow for his participation on the Committee and wished him well. Mr. Pat Condon requested a briefing on the role that the International Partners would have in the Journey to Mars.

Mr. Bowersox thanked Mr. Gerstenmaier for his presentation. Dr. Sanders commented that the ASAP would benefit from hearing Mr. Gerstenmaier's presentation.

Human Exploration Progress and Plans—Human Space Flight (HSF) Transition and International Space Station (ISS)

Mr. Bowersox introduced Mr. Sam Scimemi, Director, ISS. Mr. Scimemi briefed the Committee on HSF's transition to cislunar space. He explained that the transition entails shifting from Earth Reliant to the Proving Ground. He reviewed a chart on what would be required to learn how to be Earth Independent. The goal at the end of the 2020s would be a Mars-ready, one-year crewed expedition in cislunar space. Rather than declaring a definite end date for the ISS, NASA intends to focus on:

- executing short-term, crewed-habitation missions in cislunar space while the ISS is operational;
- completing exploration research and development activities that require the ISS as a test bed;
- expanding the commercial market and demand for low-Earth orbit (LEO) based platforms;
- maximizing international ISS partnership and participation; and
- achieving sufficient value benefit and safe sustainment of the ISS.

Transitioning HSF and ISS is expected in the mid-2020s based on current planning and reasonable progress. NASA is working with stakeholders, International Partners, and industry to develop plans for transitioning the ISS and the partnership. Mr. Scimemi noted that NASA alone is spending significant sums on moving beyond LEO. The ISS is certified through 2028 structurally. Some ISS modules would have a longer life. Those modules could be left in orbit and connected to another space infrastructure. Possible outcomes for the ISS platform at its end-of-life include deorbit, disassembly, turning portions over to private industry, and maintaining government ownership.

Mr. Scimemi discussed the framework for the transition from ISS to cislunar space. There would be three phases. Phase 0 is exploration systems testing on ISS. Phase 1 is cislunar flight testing of exploration systems. That phase would culminate with the ARCM. Phase 2 would be cislunar validation of exploration capability. That phase would end with a one-year, crewed Mars-class shakedown cruise. He presented for the Committee's comments a draft chart showing potential top-level objectives for the three phases. Potential Phase 1 flight test objectives were reviewed.

Mr. Scimemi briefed the Committee on the current status of the ISS. He noted that Astronaut Scott Kelly and Cosmonaut Mikhail Korniyenko had returned to Earth after spending 340 days in space. He reviewed a chart showing the current ISS Flight Plan. He described the crews for increment 46 and increment 47. He reviewed the major stage objectives for increment 47. Mr. Scimemi discussed an anomaly that occurred with the short extravehicular mobility unit (SEMU) during

extravehicular activity (EVA) 35. During that EVA, Astronaut Tim Kopra reported that approximately 200 to 250 cubic centimeters of water had collected in his helmet. The EVA was promptly terminated. On-orbit troubleshooting was performed in order to learn more about the failure mechanism. The cause of the failure remains unknown and is being investigated by a Problem Resolution Team. The spacesuit will be returned to Earth for troubleshooting on SpaceX-8. Mr. Gerstenmaier explained that the spacesuit had been designed for continuous maintenance on the ground and had not been intended for continuous use in space. In response to a question from Mr. Bowersox, Mr. Scimemi stated that NASA does not have a current plan to develop a new spacesuit in the near future. In response to a question from Mr. Joseph Cuzzupoli, Mr. Scimemi explained that the backup system on the spacesuit to remove water from the helmet included a pad to collect water, a snorkel, and a purge vent.

Mr. Scimemi presented a chart on increment 45-46 crew utilization time. He described recent ISS research statistics. Over 1,200 results have been published and all are available online. Mr. Scimemi noted that the requirement for crew time on experiments was 35 hours and that 50 hours were being obtained. He attributed that increase to Russian assistance on U.S. science experiments. He reviewed the investigation list from the research plan for increments 47 and 48. He presented charts showing the status of all ISS consumables and the consumables on the U.S. orbital segment (USOS).

Mr. Scimemi described the ISS One-Year Mission. As part of that mission, Astronaut Kelly set the record for the longest-duration American space mission at 340 days. Mr. Scimemi noted that the mission was successful and reflected the benefits from a collaboration between the U.S. and Russia. He presented a chart showing the mission's research objectives. Mr. Scimemi explained that research and data collection from the Twins Study involving Astronaut Kelly and his twin brother, former Astronaut Mark Kelly, would continue over the next year. The study's objective was to begin examining next generation genomics solutions to mitigating crew health and performance risks. The study involves significant privacy and ethics issues.

Mr. Scimemi discussed the HEO Human Research Program (HRP). Its purpose is to develop human health and performance standards, countermeasures, knowledge, technologies, and tools across various disciplines to enable safe, reliable, and productive human space exploration on the path to Mars. It will require ISS utilization to mitigate human health space exploration risks to an acceptable level. Research priorities for the program will be established consistent with recommendations from the National Academies. Mr. Scimemi presented charts showing the program's milestones and the human risks disposition for all design reference missions (DRMs).

Mr. Scimemi described the successful completion of the Orbital-ATK (OA)-4 mission. It represented the first use of the Atlas V401 rocket with the Cygnus Spacecraft. He presented charts showing the status of mission planning for the OA-5 and OA-6 missions. He described the status of planning for the SpaceX-8 and SpaceX-9 missions. He discussed the status of the contract for the second set of commercial resupply services (CRS-2). Contracts for CRS-2 awards had been announced on January 14, 2016. The awardees were OA, SpaceX, and Sierra Nevada Corporation. A minimum of six missions will be ordered from each provider, with launches scheduled to begin in 2019. To bridge the launch gap, the current CRS contracts have been extended. Mr. Scimemi presented a chart entitled "ISS Integration Status of Crew Vehicles." He noted that replacement

batteries that are charged by the solar arrays were being delivered to the ISS. The new batteries are to be installed during EVAs in the fall and are expected to last through 2024. Mr. Scimemi explained that plans for vehicle certification are in progress and that development of operational products has commenced.

Mr. Bowersox thanked Mr. Scimemi for his presentation.

Human Exploration Progress and Plans—Commercial Crew Program (CCP)

Mr. Bowersox introduced Mr. Phil McAlister, Director of Commercial Spaceflight, who briefed the Committee on the status of the CCP. Mr. McAlister noted that the vision of commercial human spaceflight to LEO is a robust, vibrant enterprise with many providers and a wide range of private and public users. He explained that a successful human space transportation system will strengthen the ISS Program, allow NASA to focus on deep-space exploration, potentially reduce the cost of human access to space, and significantly contribute to the national economy. The CCP public purpose is to support the development of non-NASA markets for commercial human transportation services to and from LEO. NASA's purpose for the CCP is to obtain safe transport of NASA and NASA-sponsored astronauts to and from the Station. Mr. McAlister reviewed CCP highlights. He noted that they were in the "grinding" phase, working through the details of final design issues. Over 60 percent of the alternate standards and over 40 percent of the variances have been dispositioned. Post Certification Missions (PCMs) have been awarded to SpaceX and Boeing. Mr. McAlister presented summary charts on Commercial Crew Transportation Capability Contract (CCtCAP) milestones and Space Act Agreement (SAA) milestones. In response to a question from Mr. Robert Sieck, Mr. McAlister stated that all the CCtCap milestones were fee-bearing.

Mr. McAlister reviewed a chart on the CCP's top programmatic risks. He noted that the risks shown were NASA's risks and that the commercial partners had their own risks, which were proprietary. He explained that the CCP had been fully funded for Fiscal Year (FY) 2016 at $1.243 Billion (B). He added that $1.1 B in funding would be necessary for FY 2017 in order to make payments and keep the schedule. In response to a question from Mr. Holloway, Mr. McAlister indicated that NASA has purchased transportation from Russia through 2018. In response to a question from Mr. Lopez-Alegria, Mr. McAlister explained that the risk on the ability to close the loss of crew (LOC) gap could be mitigated by NASA and that operational considerations could be used as mitigations. He noted that 1/270 is the NASA overall requirement and that the contractors' design requirement is 1/200.

Mr. McAlister presented slides describing the SpaceX and Boeing architectures for their respective spacecraft, launch vehicles, and ground and operations segments. He reviewed both providers' accomplishments. Mr. McAlister noted that Boeing and SpaceX were culturally and technically very different from each other. He added that it was helpful to observe how the two companies solved problems.

Mr. McAlister described the NASA CCP certification process. He noted that the CCP Certification and Certificate of Flight Readiness (CoFR) strive to achieve a balance of insight and oversight appropriate for shared government and industry accountability in establishing a safe, reliable, and

cost-effective crew transportation system (CTS). He explained that the industry partner is responsible for design, development, test, and evaluation, which culminates in the certification assertion that its CTS is fit to transport crew to and from the ISS. NASA is accountable for ensuring compliance to the CCP's human spaceflight requirements through evaluation and approval of the contractor's compliance evidence and through execution of NASA's insight into the contractor's solution. This is in accordance with a risk-based, insight approach implemented under a shared assurance model. Mr. McAlister presented a chart showing the allocation of responsibilities between NASA and industry for design certification and flight certification. He noted that the CCP model allocates greater accountability to industry. Mr. James Voss asked what the model means by the term "residual risk." Mr. McAlister agreed to provide the Committee with a formal answer to that question. Mr. James Odom asked whether the signatories for the CoFR had been determined. Mr. McAlister responded that the CoFR statements were still being drafted. Mr. Sieck noted that the CoFR for the Space Shuttle had been revised at least three times during its development.

Mr. Bowersox thanked Mr. McAlister for his presentation

Human Exploration Progress and Plans—Exploration Systems Development (ESD)

Mr. Bowersox introduced Mr. Bill Hill, Deputy Associate Administrator for Exploration Systems Development (ESD) Mr. Hill presented the graphic entitled "Journey to Mars." He reviewed a slide showing the three-phase framework for the transition from the ISS to cislunar space. He noted that the Proving Ground could be compared to a practice field: "a safe place to try new things and new techniques." He presented a chart on flight test objectives (FTOs) for the first phase of the transition. Mr. Hill described the Exploration Mission-1 (EM-1) vehicle stack. A short video was presented showing an artist's conception of that mission. The mission will have 13 CubeSats on board that would be deployed after separation from Orion. There would be a 29-day lunar distant retrograde orbit (DRO) concluding with a burn back to Earth at an 8.9 km/s re-entry speed. Mr. Hill presented a slide showing the ESD EM-1 integrated mission milestone summary. He reviewed a chart showing ESD milestones from September 2015 through August 2016.

Mr. Hill discussed ESD's top concerns. Those concerns include integrated avionics and software verification and validation (V&V), integrated test and verification (T&V), funding uncertainty, schedule threats related to items on the three critical paths, and operations sustainability at the rate of one-flight-per-year after EM-2. He noted that the European Space Agency (ESA) has committed at its highest level to deliver the European Service Module (ESM) on time. In response to a question from Mr. Cuzzupoli, Mr. Hill indicated that V&V would be performed by NASA at its Independent Verification and Validation (IV&V) facility in West Virginia. Mr. Hill reviewed SLS accomplishments and recent performance. In response to a question from Mr. Cuzzupoli, Mr. Gerstenmaier explained that a faring for a Mars lander would not be needed for 15 years and that the faring development time would not take more than 2 to 3 years. Mr. Hill reviewed GSDO and Orion accomplishments and recent performance.

Mr. Marshall Smith, ESD Acting Chief Engineer, described the Cross Program Integration Team (CPIT). He discussed the status of cross-program system integration (CSI). He reviewed CSI technical performance and accomplishments. He presented a chart on metrics for cross program

interdependencies. There are 77 active interdependencies and 155 active cross-program control milestones. He presented charts on the CPIT top technical issues and on emerging cross-program issues and concerns. In response to a question from Mr. Cuzzupoli regarding the need to ensure that the vehicle would be able to operate automatically, Mr. Smith indicated that Orion would require approximately 1.5 million lines of computer software code.

Mr. Hill discussed EM-2 mission planning. He explained that because EM-1 would be a DRO mission, EM-2's goal would be to complete residual FTOs not accomplished on EM-1 and to accomplish risk reduction activities for future, more complex exploration missions. He presented a slide showing EM-2 mission options. A High Lunar Orbit (HLO) is being used as a "baseline" to develop capability. Ms. Nancy Ann Budden suggested using the EM-1as an opportunity to obtain images of the far side of the Moon. Mr. Hill concluded his presentation by describing major ESD CSI independent assessments in progress.

Mr. Bowersox thanked Mr. Hill and Mr. Smith for their presentations.

Human Exploration Progress and Plans—Asteroid Redirect Mission Update (ARM)

Mr. Bowersox introduced Dr. Michele Gates, ARM Program Director, who briefed the Committee on the ARM status. Dr. Gates reviewed recent ARM progress. She presented a slide showing the Mars split-mission concept, where the crew would be transported to Mars by chemical propulsion and cargo would be pre-deployed to Mars by Solar Electric Propulsion (SEP). The ARM would be an early mission in the Proving Ground of cislunar space. The ARM supports human exploration through several objectives:

- transporting multi-ton objects with advanced SEP;
- integrating crew and robotic vehicle operations in deep space staging orbits;
- conducting advanced autonomous proximity operations in deep space with a natural body; and
- conducting astronaut EVAs for sample selection, handling, and containment.

Dr. Gates reiterated that the Asteroid Robotic Redirect Mission (ARRM) would utilize the robotic boulder capture option, previously referred to as Option B. Formulation guidance for the robotic mission has been updated for launch date going in to the Agency's Key Decision Point-B. The target robotic mission launch date has been moved from December 2020 to December 2021, which will likely place the crewed mission in 2026. The ARRM development cost is still capped at $1.25 B for Phase A. This cost cap target excludes launch vehicle and mission operations. Dr. Gates provided an updated chart on the ARM alignment schedule strategy for the asteroid identification segment, the ARRM, and the Asteroid Redirect Crewed Mission (ARCM). She provided an overview of collaborative and participatory elements for the Program. The ARM Formulation Assessment and Support Team (FAST) effort has been completed. The FAST team included 18 scientists and engineers selected from academia and industry and three NASA leaders. An ARM Investigation Team (IT) is planned. The IT will support the ARM through mission implementation, which includes the operational phase of the ARRM and the ARCM. Plans for the IT include domestic and international participation.

Dr. Gates described current candidate "parent" asteroids from which the boulder will be collected. The objective is to capture from the parent asteroid a boulder weighing at least 20 tons and redirect it using a SEP-based spacecraft to lunar vicinity. The current reference ARRM target is asteroid 2008 EV5, which has generated significant interest from the science and small bodies communities due to well-documented investigation opportunities. Radar observations show that it has an extremely pronounced bulge at its equator, suggesting movement of loose material. In addition, 2008 EV5 provides a representative target for a planetary defense demonstration because it is a large, hazardous-size asteroid. NASA continues to look for additional targets in accessible orbits.

Dr. Gates presented an update on the ARRM. The acquisition strategy for the ARRM spacecraft bus leverages existing commercially available U.S. industry capabilities for a high-power, solar electric propulsion (SEP)-based spacecraft. The ARRM spacecraft bus will be procured through a two-phase competitive process. Phase 1 is a set of industry studies for a spacecraft bus and has begun. NASA's Jet Propulsion Laboratory (JPL) has selected four companies to conduct the phase 1. The electric propulsion string includes a Hall thruster and a power processing unit. The procurement effort for the EP string is underway, and an award should be made in late spring 2016. She also updated the NAC Committee on the capture phase for the ARRM. The asteroid boulder capture event is planned as autonomous due to the delay in communications. A microspine gripper is being developed at JPL. A 7 degrees-of-freedom (7-DOF) robot capture arm is being developed at NASA Goddard Space Flight Center (GSFC). A contact and restraint system is being developed at NASA Langley Research Center (LaRC).

Dr. Gates also provided an update on the ARCM. The total mission duration for the current reference ARCM concept is 24.3 days. This includes a two-person crew launched aboard the SLS to travel to the DRO in an Orion Crew Vehicle augmented with ARCM mission kits. The Orion would rendezvous and dock with the ARRM spacecraft in a ~ 71,000 km lunar DRO. The astronauts would conduct two, four-hour EVAs to select, extract, contain and return asteroid samples to the Orion vehicle. Dr. Gates described the planned mission kits for the robotic vehicle and for the Orion. She described crewed mission integrated analyses. The crewed mission will be in pre-formulation for a number of years as the concept is refined and vehicles are developed. Dr. Gates provided an update on the evolution of the Small Bodies Assessment Group (SBAG) engagement including their recent finding. She also relayed an advocacy statement by the Space Mission Planning Advisory Group (SMPAG) on the asteroid orbit deflection demonstration planned by ARM. In response to a question from Mr. Odom on the mechanics of the planned deflection demonstration, Dr. Gates explained that gravity produced by the multi-ton boulder and SEP-based spacecraft will result in a very slight deflection of the large parent asteroid. She concluded her presentation with a chart showing ARM upcoming events.

Mr. Bowersox thanked Dr. Gates for her presentation.

Wrap up and Discussion

Mr. Bowersox reviewed the Committee's observations and top concerns from its last meeting. He reported that the NAC had developed a recommendation to maintain a LEO capability to train astronauts. The Committee discussed possible special topics for future meetings. Dr. Siegel noted

that the next NAC meeting would be an "all hands" meeting. She suggested that the Committee consider holding a joint session at that time with the NAC's Science or Technology Committees. The Committee reviewed its work plans for upcoming meetings. Mr. Cuzzupoli questioned whether anything was done with the Committee's results. Mr. Bowersox responded that the NAC found the Committee's list of concerns to be useful and that the Committee's findings and recommendations for Mr. Gerstenmaier have been helpful. Mr. Gerstenmaier asked the Committee to inform the NAC whether he has been able to satisfactorily address any items on the Committee's list of concerns. Ms. Budden advised that the Committee should not allow the list of concerns to become too long. She also advised the Committee to address only items that are solvable. The Committee decided to hold its fall 2016 meeting at NASA Kennedy Space Center (KSC).

Adjournment

The Committee meeting was adjourned at 5:50 p.m.

Thursday, March 3, 2016

Call to Order, Welcome & Opening Remarks

Dr. Siegel called the HEO Committee meeting to order at 8:00 a.m. and welcomed everyone back. She announced that it would be a public meeting, and that minutes would be taken and posted with all presentations. She introduced Mr. Bowersox.

Budget Status

Mr. Bowersox introduced Ms. Toni Mumford, Director, HEO Resources Management Office. Ms. Mumford provided an overview of NASA's FY 2017 budget submit. The budget submit provides $8.4 B for HEO to pursue NASA goals, consistent with the NASA Authorization Act of 2010. Of that amount, $8.2 B is discretionary and $0.2 B is mandatory. The funds are intended to be used to:

- sustain the capability for long-duration presence in LEO;
- expand permanent human presence beyond LEO;
- enable missions to deep space destinations such as cislunar space, near-Earth asteroids, and Mars; and
- provide critical communications, navigation, launch, propulsion test, and other services to NASA HEO missions and other external customers.

Ms. Mumford explained that the budget provides funds to develop the SLS, Orion, and Exploration Ground Systems (EGS). The budget advances capabilities required to conduct a sustainable campaign of more complex exploration missions in cislunar space on the Journey to Mars. It funds research in human health and performance to enable the crew to travel safely beyond LEO. It provides funds to develop and test technological capabilities, such as habitat system concepts, needed for long-duration missions. The budget continues to provide for formulation of the ARRM.

It establishes a new theme in Space Operations—Space Transportation—that includes the Crew and Cargo Program and the CCP. Funds are provided in that theme to: (i) purchase reliable cargo resupply services from U.S. private sector companies; (ii) develop U.S. commercial crew capability to the ISS by the end of 2017, ending sole reliance on Russia for U.S. crew access to space; and (iii) enable using the ISS and the National Laboratory as a research and technology test platform through at least 2024.

Ms. Mumford reviewed the HEO Program Financial Plan. She discussed the ISS FY 2016 – FY 2020 Operations and Maintenance Plans. She presented charts on FY 2016 budget plans for research on the ISS. She described the FY 2016-FY 2017 plans for the Crew and Cargo Program. She noted that the second set of Commercial Resupply Service Contracts (CRS-2) have been awarded to Orbital ATK, Sierra Nevada, and SpaceX, with a minimum of six flights per provider for flights beginning in 2019. The FY 2016 plans provide for crew transportation for six astronauts via Soyuz and for rebuilding the lost International Docking Adapter (IDA). The FY 2017 plans include five CRS missions and crew transportation on Soyuz. NASA's commercial crew partners will continue to mature capabilities toward securing U.S. crew transportation capability to LEO by the end of 2017. In FY 2016, Boeing plans to complete eight development milestones and SpaceX plans to complete 12 development milestones. FY 2017 milestones include three key certification milestones: the ISS Design Certification Review, the Flight Test Readiness Review, and the Operations Readiness Review.

Ms. Mumford discussed the budget for ESD, which includes Orion, SLS, and EGS. She noted that the FY 2017 President's Budget includes both discretionary and mandatory funding to meet the Agency Baseline Commitment (ABC) for all three programs. It allows SLS and EGS to meet the EM-1 ABC date of November 2018. It allows Orion to continue work toward meeting the EM-2 ABC date of April 2023. It does not provide funding for Exploration Upper Stage (EUS) Development. Ms. Mumford reviewed detailed charts on the FY 2016 and FY 2017 budget plans for Orion, SLS, and EGS.

Ms. Mumford reviewed budget charts for the HRP, Advanced Exploration Systems (AES), and ARM. HRP will experience impacts to FY 2016 activities due to a lower-than-planned appropriation. The joint one-year U.S.-Russia and Twins Studies will be concluded. Ms. Mumford described the AES Habitat Initiative. Its objectives are to: (i) use public-private partnerships to develop concepts, technologies, and systems for a cislunar habitation capability that leads to a long-duration habitat for Mars missions; (ii) conduct flight demonstrations of key habitation systems on the ISS to reduce risk; and (iii) use public-private partnerships to leverage commercial investments and stimulate the development of commercial habitats in LEO. The budget will continue leveraging essential activities that can be utilized on ARM. Those activities include continued asteroid observations, long-lead component technology procurements for the SEP technology demonstration mission, robotic systems and controls for interaction with non-cooperative bodies, and advanced AES technology maturation for portable life support systems. Ms. Mumford presented a chart on the ARRM KDP-B budget profile.

Ms. Mumford discussed FY 2016 and FY 2017 budget plans for Space Flight Support. She reviewed the plans for Space Communications and Navigation, the Rocket Propulsion Testing Program, the Launch Services Program (LSP), Human Spaceflight Operations, and the 21st Century Space Launch

Complex. She described planned rocket tests at NASA Stennis Space Center (SSC), NASA White Sands Test Facility (WSTF), and NASA Marshall Space Flight Center (MSFC). She provided details on the FY 2016 and FY 2017 budget plans for the LSP. She discussed budget plans for Spaceflight Crew Operations and budget plans for Crew Health and Safety.

Mr. Bowersox thanked Ms. Mumford for her presentation.

NASA Program Management Process Update

Mr. Bowersox introduced Ms. Ellen Stigberg, Program Executive, Office of the Chief Engineer (OCE). Ms. Stigberg briefed the Committee on the Program and Project Management Board (PPMB) support in addressing challenges implementing NASA Procedural Requirements (NPR) 7120.5E. She reviewed the PPMB's original charter functions. She described the feedback received from HSF program managers and the Science Mission Directorate Deputy AA, identifying common challenges implementing NPR 7120.5E. Ms. Stigberg asserted that the problem was not caused by the requirements; it was due to implementation disagreements and associated issue resolution. There was a need to provide more support in adjudication resolution. She explained that the PPMB charter has been revised to address the challenges. Pursuant to the revisions, the PPMB would serve as a one-stop forum to adjudicate all NPR 7120.5E issues, waivers, deviations, and tailoring. Its membership was reconstituted to align with that new role. Requirement owners would retain authority to approve tailoring, waivers, and deviations. The PPMB can also form tiger teams, as needed, to proactively support programs and projects and assist with tailoring or any other issues with NPR 7120.5E.

Ms. Shannon Bartell observed that program managers found that the owners of requirements were emotionally attached to the requirements. Mr. Bowersox explained that the Committee had been interested in learning what could be done to make the tailoring process more user-friendly. Mr. Holloway stated that "the whole system is burdensome," particularly if it was not used on a regular basis. In response to a question from Mr. Voss, Ms. Stigberg clarified that specific tailoring required approval from the specific requirements owner, rather than a central authority. The PPMB, however, would help users identify where to go when seeking approval for tailoring when needed. Mr. Wayne Hale, a visiting NAC member, asserted that part of the problem was that project managers "were bogged down." He added that getting owners to tailor requirements has been too much trouble for project managers, and that the new process has become another level for them to work through. Ms. Stigberg responded that there has already been some success in helping proactive program managers and cited ARRM as an example. She noted that tailoring should be implemented in the development stage. In response to a question from Mr. Bowersox, Ms. Stigberg clarified that a program manager having difficulty obtaining approval from a requirements owner could seek adjudication from the PPMB. In response to a question from Ms. Bartell, Ms. Stigberg explained that a program manager could seek adjudication from the PPMB without first appealing a requirements owner's decision to the owner's supervisor. Mr. Bowersox noted that there was potential for improvement if a program manager no longer had to work through multiple levels. Mr. Hale observed that program managers do not want to spend the energy, time, and effort necessary to tailor requirements and that the "overarching bureaucracy is a big problem." He asserted that much of NPR 7120.5E "was not value-added." Ms. Stigberg indicated external stakeholder (OMB, Congress) oversight has increased over time and is tightly

linked to several requirements including cost and schedule, design maturity and risk. In response to a question from Mr. Cuzzupoli, Ms. Stigberg confirmed that the program applies to contractors. Mr. Gerstenmaier explained that the problem now is that there is an organization that has responsibility for detailed technical issues, but does not have the best technical experience or the requisite skill. He suggested stepping back and looking at where NPR 7120 has worked well—primarily smaller programs—and consider making adjustments for application to multiple decadal activities, where long-term operation and production costs are paramount. He concluded that there is a need to find the right balance and that "we are over-gaining on the bureaucracy side."

Committee Discussion, Findings, and Recommendations

Mr. Bowersox asked whether there were any findings or recommendations that Committee members wished to suggest. There were none.

The Committee worked on updating its list of observations and top concerns. Mr. Holloway expressed concern that the Committee lacks sufficient information to know whether there was a strategy to get to Mars in the 2030s. Mr. Bowersox stated that there was agreement that the Committee wanted more details. Mr. Hale reported that the NAC would like to see a plan. Mr. Odem explained that the issue was the level of definition. Mr. Bowersox suggested that additional detail in exploration plans would be useful for the transition of presidential administrations. Mr. Gerstenmaier explained that he does not need to decide what to do about Mars until 2020 and that he needs time to see how SLS and in situ resource utilization (ISRU) progresses. In response to a question from Mr. Cuzzupoli, Mr. Gerstenmaier responded that the decisions about Mars could be made immediately, but doing so would start a debate on what additional details are needed and that he wanted to relieve his team from unnecessary pressure. Mr. Voss observed that NASA treats everything as needing the same level of perfection, which is unnecessary. Ms. Budden commented that NASA has processes that should be streamlined because they consume unnecessary time and resources. The following observations and top concerns, in no order of priority, were approved by consensus:

Here is the list of Observations that were presented to the NAC.

- Progress continues on Commercial Crew capability with full funding in 2016. Critical work and process definition ahead to achieve program goals on the projected schedule with reasonable risk.
- Continued progress on SLS and Orion with no major schedule adjustments due to technical issues.
- HEOMD has added detail to plans for human exploration missions in the 2020's using a buildup approach to develop capabilities beyond low earth orbit.
- HEOMD approach for human exploration planning is reasonable considering current political and economic environment, but the committee is eager to see additional detail in exploration plans beyond 2030.
- ARM planning and development is continuing with completion of the Formulation and Assessment Team's report.

Here is the list of Concerns that were presented to the NAC

- Lack of US launched crew transportation to Low Earth Orbit
- Current level of definition for Mars exploration architecture impedes effort to generate support.
- Bureaucratic processes that NASA imposes on itself do not always add value to balance their load on the organization and are a threat to accomplishment of NASA's exploration mission.

After the committee discussed this list. Mr. Bowersox indicated that he would finalize them off – line after the meeting.

The Committee reviewed its list of additional concerns for discussion from its November 2015 meeting. Mr. Holloway expressed an interest in hearing from the SMTs. That was added to the list. This list of concerns are a working list intended to capture topics intended to focus discussion at future meetings. No other changes were made to the list:

- cumulative effect of content reductions due to cost pressures in SLS and Orion Programs,
- fragility of SLS and Orion programs due to program content,
- imbalance between objectives and funding in SLS and Orion,
- effects of less-than-requested funding for commercial crew,
- conflicting direction for human exploration programs from legislative and executive branches,
- split support for human exploration programs,
- communication of program objectives and accomplishments to build and unify support,
- transition planning for ISS,
- lack of acceptance of current capability driven approach,
- lack of a formal Mars (Human Exploration) Program,
- communication of program objectives and accomplishments to build and unify support, and
- presentation by System Maturation Team members

Mr. Odom expressed concern over who would eventually sign the CoFR. He explained that if one does not know who is going to be responsible and accountable, there is likelihood that there will be a serious problem with little time to resolve it. Mr. Bowersox commented that it would be difficult achieving the schedule with reasonable risk. He added that the problem is the NASA pace, not the commercial pace. He expressed concern that the schedule would slip and that there would be insufficient time to address important technical issues. Mr. Hale suggested that people might have difficulty making certifications with less than 100 percent knowledge. Mr. Cuzzupoli observed that oversight and insight on the CCP had improved tremendously and that NASA is treating Boeing and SpaceX as partners. He explained that more time would be necessary to resolve cultural differences. Ms. Bartell agreed that the CCP was culturally different than the HSF in the past. She recommended that the Committee continue to monitor how NASA adapted to the CCP's culture. Dr. David Longnecker expressed concern about bureaucratic inefficiencies at NASA and noted that it had taken him one hour and twenty minutes to get a badge for the meeting. Mr. Lopez-Alegria expressed concern over the "back-and-forth waffling" attributable to partisan politics. Mr. Gerstenmaier explained that the immediate goal of the U.S. should be to have as many people working in aerospace as possible. Mr. Sieck commented that Mr. Gerstenmaier represented a single point of failure at NASA.

Mr. Bowersox expressed the Committee's appreciation to Dr. Siegel, Ms. Shawanda Robinson, and Ms. Dawn Mercer for their support to the committee. He complimented Mr. David Frankel for his work on the Committee's minutes.

Adjournment

Dr. Siegel adjourned the HEO Committee meeting at 12:30 PM.

NASA ADVISORY COUNCIL
Human Exploration and Operations Committee
MEETING
NASA Headquarters
300 E Street SW,
Glennan Conference Room, 1Q39
Washington, DC 20546

March 2-3, 2016

AGENDA

Wednesday, March 2

NAC HEO COMMITTEE PUBLIC MEETING

9:30 – 9:35 am	Call to Order, Welcome & Opening Remarks	Mr. Ken Bowersox Dr. Bette Siegel
9:35 – 12:00	Human Exploration Progress and Plans	
	• Overview	Mr. Bill Gerstenmaier
	• Human Space Flight Transition	Mr. Sam Scimemi
	• International Space Station	Mr. Sam Scimemi
Noon – 1:00 pm	***LUNCH***	
1:00 – 3:00	Human Exploration Progress and Plans	
	• Commercial Crew Program	Mr. Phil McAlister
	• Exploration Systems Development	Mr. Bill Hill
3:00 – 3:15	***BREAK***	
3:15 – 5:00	Human Exploration Progress and Plans	
	• Asteroid Redirect Mission Update	Ms. Michele Gates
	• Evolvable Mars Campaign Studies & Technology Development	Mr. Jason Crusan
5:00 – 6:00	Wrap up and Discussion	
6:00	***ADJOURN***	

Thursday, March 3

NAC HEO COMMITTEE PUBLIC MEETING

8: 30 – 8:35	Call to Order, Welcome & Opening Remarks	Mr. Bowersox & Dr. Siegel
8:35 – 9:30	Budget Status	Ms. Toni Mumford
9:30 – 10:30	NASA Program Management Process Update	Ms. Ellen Stigberg
10:30 – 10:35	Public Comments	
10:30 – 10:35	Committee Discussion, Findings & Recommendations	
12:30	***ADJOURN***	

Human Exploration and Operations Committee Membership
March 2016

Mr. Ken Bowersox *Chair*	Former NASA astronaut and retired U.S. Navy Captain
Dr. Bette Siegel *Executive Secretary*	NASA Headquarters
Ms. Shannon Bartell	Former Director of Safety & Mission Assurance, KSC
Ms. Nancy Ann Budden	Director for Special Operations Technology, Office of the Secretary of Defense
Dr. Leroy Chiao	Former NASA Astronaut and ISS Commander
Dr. Stephen "Pat" Condon	Aerospace Consultant, former Commander of the Ogden Air Logistics Center, the Arnold Engineering Development Center, and the Air Force Armament Laboratory
Mr. Joseph Cuzzupoli	Former Assistant Apollo Program Manager, Rockwell, and manager of the Space Shuttle Orbiter Project
Mr. Tommy Holloway	Former Space Shuttle and ISS Program Manager
Mr. Lon Levin	President, SkySevenVentures
Dr. David E. Longnecker	Director, Health Care Affairs, Association of American Medical Colleges (AAMC), member of the National Academy of Sciences Institute of Medicine (IOM)
Mr. Michael Lopez-Alegria	Astronaut, Retired US Navy Captain, former President of the Commercial Spaceflight Federation, and now an independent consultant to traditional and commercial space companies.
Richard Malow	Distinguished Advisor at the Association of University for Research in Astronomy (AURA)
Mr. James Odom	Former NASA Associate Administrator for Space Station Freedom
Mr. Bob Sieck	Former Space Shuttle Launch Director
Mr. James Voss	Former NASA astronaut and retired U.S. Army Colonel, Scholar in Residence, Department of Aerospace Engineering Sciences, University of Colorado, Boulder

Human Exploration and Operations Committee
NASA Headquarters
Washington, DC

March 2-3, 2016

MEETING ATTENDEES

HEO Committee Members:

Bowersox, Ken, *Chair*	U.S. Navy *(Ret.)*
Siegel, Bette, *Executive Secretary*	NASA Headquarters
Bartell, Shannon	Aerospace Consultant
Budden, Nancy Anne	Office of the Secretary of Defense
Cuzzupoli, Joseph	Aerospace Consultant
Chiao, Leroy	Aerospace Consultant
Condon, Stephen "Pat"	Aerospace Consultant
Holloway, Tommy (via telecom)	Aerospace Consultant
Levin, Lon	SkySeven Ventures
Longnecker, David	Association of American Medical Colleges
Lopez-Alegria, Michael	Commercial Spaceflight Federation
Malow, Richard *(via telecom)*	Association of Universities for Research in Astronomy
Odom, James	Aerospace Consultant
Sieck, Robert	Aerospace Consultant
Voss, James	University of Colorado, Boulder

NASA Attendees:

McKay, Meredith
Hill, Bill
Thomas, Dan
Greg Williams
Sam Scimemi
Crane, Annee
Mercer, David
Hermann, Nicole
Robinson, Shawanda
Putter, Phil
Carpenter, Brad
Whitmeyer, Tom
Sarafin, Michael L.
Eades, Michele
Jermstead, Wayne
Kisliuk, Erin
Ticker, Ron

Other Attendees:

Hale, Wayne	NASA Advisory Council
Sanders, Patricia	Aerospace Safety Advisory Committee
Frankel, David	P B Frankel, LLC
Slary, Brittany	Stral. Comms.
Logsden, John	George Washington University

Telecon Attendees:

Adde, Barbara	
Anderson, Alicia	Macdonald, Alex
Arrowood, Damara	McNair, Tonya
Balanga R.J.	Miller, James
Besha, Patrick	Muirhead, Ryan
Black, Sam	Neumann, Benjamin
Branscome, Darrell	Powers, Scott
Clark, Stephen	Preston, Erin
Davison, Steve	Proudfoot, Robert
Dittmar, Mary Lynne	Read, Jennifer
Eisen, Howard	Sampaio, Carlos
Foust, Jeff	Schory, Daniel
Gafka, George	Simmons, Nigel
Gelzahler, Barry	Smith, Gwyn
Gilbert, Chris	Smith, Marcia
Gillen, Suzanne	Sofge, Albert
Irving, Rick	Stigberg, Ellen
Johnson, Scott	Thompson, Tabatha
Jordan, Bill	Timm, Marc
Kamm, Sherry	Van Wychen, Kristin
Kuhl, Katelyn	Warner, Cheryl
Ledford, Bruce	West, Dan

Human Exploration and Operations Committee
NASA Headquarters
Washington, DC

March 2-3, 2016

LIST OF PRESENTATION MATERIAL

1) Asteroid Redirect Mission Update [Gates]
2) Human Exploration & Operations Progress and Plans on the Journey to Mars [Gerstenmaier]
3) HSF Transition: A focus on the next steps in cislunar space [Scimemi]
4) International Space Station Status [Scimemi]
5) Commercial Crew Program Status [McAlister]
6) Exploration Systems Development [Hill]
7) Human Exploration and Operations Mission Directorate Budget Status [Mumford]
8) Program Project Management Board (PPMB) 7120.5E Implementation Support [Stigberg]

Other material distributed at the meeting:

International Space Station Benefits for Humanity, 2nd edition, NP-2015-01-001-JSC