

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

NASA ADVISORY COUNCIL

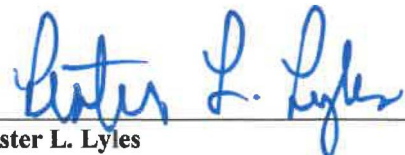
May 30-31, 2019

**NASA Headquarters
Washington, DC**

MEETING MINUTES



Executive Director



**Lester L. Lyles
Chair**

NASA ADVISORY COUNCIL

**NASA Headquarters
Program Review Center, Room 9H40
Washington, DC**

**Public Meeting Minutes
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*Meeting Report Prepared by Elizabeth Sheley
Electrosoft, Inc.*

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PUBLIC MEETING

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Call to Order, Announcements

NASA Advisory Council (NAC, or Council) Executive Director, Ms. P. Diane Rausch, brought the first NAC meeting of 2019 to order, and welcomed Council members and attendees. NAC is a Federal advisory committee, established under the Federal Advisory Committee Act (FACA). Under FACA rules, the meeting was open to the public and formal meeting minutes were being taken; these would be posted to the NAC website, www.nasa.gov/offices/nac. All presentations and comments would be part of the public record. Most of the NAC members were appointed due to their subject matter expertise and serve as Special Government Employees (SGEs). They are therefore subject to Federal ethics laws and must recuse themselves should they encounter a conflict of interest (COI). Ms. Rausch informed members, attendees and speakers that all presentations and comments would be part of the public record.

Welcome and Introductions by NAC Chair

Gen. Lester L. Lyles, NAC Chair, thanked the Council members for their participation. Attending this meeting in person were two new members, The Honorable Bill Nelson, former U.S. Senator, and Ms. Krista Paquin, former NASA Deputy Associate Administrator. A third new member, Mr. James Free, Senior Vice President, Peerless Systems, was participating remotely. General Lyles then led introductions of the individual Council members and welcomed the NASA Administrator, Mr. James Bridenstine.

Remarks by NASA Administrator

Administrator Bridenstine thanked Gen. Lyles and the NAC members. NASA has accelerated going forward to the Moon, which will be done in a sustainable manner. There are questions about why NASA is doing this, and he sees two risks to deal with as an Agency. The first is technical risk, which Mr. Bridenstine believes NASA can manage. The second is political risk. There have been previous efforts to return to the Moon and to go to Mars, and these ran into political resistance. When programs go long, past the life-cycle of politics, this creates political risk. NASA therefore needs to accelerate this campaign in order to reduce the political risk. The Agency is accelerating the plan to ensure success.

When NASA received the new direction to go to the Moon in five years, by 2024, the Agency sought a Fiscal Year 2020 (FY 2020) budget increase of \$1.6 billion via a budget amendment. Congress had already been working on the NASA budget from the FY 2020 President's Budget Request, but the budget amendment is separate. Mr. Bridenstine sees a lot of bipartisan support to go to the Moon. The House markup provides great support to NASA overall, especially the Science Mission Directorate (SMD). Now there are questions about the Senate. In an early sign of support, Sen. Gerald (Jerry) Moran, Chair of the Senate Subcommittee on Commerce, Justice, Science and Related Agencies, tweeted in favor of the

return to the Moon. This is early in the process, and it is not true that the proposed budget amendment is dead on arrival just because of the House markup. NASA is sharing its ideas with Congress and making the effort to retire the political risk. This need to retire the political risk is one of the reasons he wanted Sen. Nelson as a member of the NAC. Sen. Nelson has extensive experience with bipartisan efforts, and he has also been very involved with NASA and the Nation's space efforts.

Invited Remarks

Sen. Nelson said that he felt honored to be part of the NAC, and also felt honored to be asked to be part of the NASA family. While the future is exciting, this is a tough time for the NASA Administrator. The Apollo program had both extraordinary success and extraordinary political support in the Space Race environment of the mid-20th century. The Soviets had launched first, while the United States was still trying to get off the ground. However, the United States then made history with the Moon landing and other accomplishments. The whole nation was galvanized behind the U.S. space program, and the political will was there. The environment is quite different now.

NASA is still a bipartisan and nonpartisan agency. The current partisan acrimony and rigidity creates a Herculean task for Mr. Bridenstine as he seeks additional funds. The White House has offered support through the National Space Council. The additional \$1.6 billion being sought will support acceleration of the return to the Moon, but getting those funds will be difficult. Many of NASA's most prominent Congressional supporters are no longer in office. However, he believed when the United States launches Americans on American rockets, there will be renewed excitement, as the effort gathers the attention and admiration of the American people. There are already cheering crowds on hand for the launch of commercial rockets, and these people are ready to see American astronauts on American vehicles again. Sen. Nelson said he feels privileged to be part of it.

Gen. Lyles thanked Sen. Nelson for his remarks, and said that the NAC was excited to learn from and work with him.

President's FY 2020 Budget Request for NASA; NASA Budget Amendment (Humans to Moon 2024)

Mr. Brian Dewhurst from NASA's Office of the Chief Financial Officer (OCFO) explained that the FY 2020 President's Budget Request was written under the assumption that NASA would once again land on the Moon in 2028. However, two weeks after that budget was submitted to Congress, the timeline was accelerated to have a 2024 Moon landing. Two weeks before this NAC meeting, NASA had sent the Congress a budget amendment seeking an additional \$1.6 billion for this accelerated campaign, resulting in a total Agency budget of \$22.6 billion for FY 2020.

Within the FY 2020 budget, \$12.3 billion is allocated to build key components of the exploration campaign. The budget amendment refocuses the Lunar Gateway (Gateway), and commercial launch capabilities will be key to this effort. Typically, NASA projects the out-years of the budget to be flat and notional, which means there is no political commitment to those numbers. This year, however, the projections show year-by-year growth, reflecting the broader commitment. Mr. Bridenstine added that the amendment includes an additional \$651 million to get the Space Launch System (SLS) back on track. Another \$723.7 million will go toward lunar landers. The Space Technology Mission Directorate (STMD) will receive an additional \$132 million to develop the exploration technology needed to live and work on the lunar surface while using lunar resources. SMD will receive an additional \$90 million for Commercial Lunar Payload Services (CLPS) to get small payloads of 15 to 20 pounds to the Moon, enabling astronauts to do real work once they land. This budget amendment is for FY 2020; NASA will need additional funding for the years after that.

Gen. Lyles asked if it is possible to recover the SLS schedule. Mr. Bridenstine replied that NASA can do that. There is a possible process in the Human Exploration and Operations Mission Directorate (HEOMD) with the “green run test” and the timelines. NASA is looking at trades there and expects to work this through in the next six weeks or so. The Agency has tried to identify development items that can be removed or retired from the critical path. The integration process is well underway with SLS. NASA did slip there and is trying to get back on track.

Mr. Dewhurst explained that the FY 2020 budget also shifts funding for wind tunnels and similar infrastructure from the Aeronautics Research Mission Directorate (ARMD) to Safety, Security, and Mission Services (SSMS). The Agency is trying to invest in construction that will refresh its capabilities. Exploration campaign highlights from the original FY 2020 President’s Budget Request include CLPS, the Lunar Surface Innovation Initiative (LSII), lunar rover capabilities, and International Space Station (ISS) activities. Everything the Agency needs for its low Earth orbit (LEO) work is funded for FY 2020 and the out-years. NASA is trying to determine what might follow ISS in order to make a smooth transition. The science program is strong, with general science work continuing. Mr. Dewhurst made note of Mars 2020, the Europa Clipper, the Mars Sample Return (MSR) campaign, and the James Webb Space Telescope (JWST). There will be no funding for the Wide Field InfraRed Space Telescope (WFIRST) until JWST is built. The budget eliminates funding for the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission, the Climate Absolute Radiance and Refractivity Observatory Pathfinder (CLARREO-PF), and NASA’s Office of STEM Engagement (OSTEM). Aeronautics highlights include flight demonstrations, air traffic management improvements, and replenishment of resources.

Gen. Lyles asked Mr. Bridenstine his thoughts on how NASA could continue to emphasize STEM without the OSTEM being in the President’s Budget Request. Mr. Bridenstine replied that NASA is funded by Congress, which has directed the Agency to continue operating OSTEM. In addition, there are many activities outside of OSTEM that aim to inspire the next generation of scientists and engineers. He gave as an example the FIRST robotics competitions, which SMD funds to support students from elementary through high school to build robots. Many of the technologists involved in today’s SMD missions participated in FIRST robotics, and it is quite likely that current FIRST robotics participants will work in these areas in the future. This is an example of how the NASA Mission Directorates can support STEM.

Dr. Meenakshi Wadhwa expressed concern about the reprioritization of the NASA budget. Mr. Bridenstine explained that this process has begun, noting the reduction in the size and scope of the Gateway, which is a critical element for lunar exploration. Not all of its elements will be necessary in 2024, and NASA can bring in international and commercial partners. One question is how to transition from ISS, which cannot last forever. NASA wants industry to drive those capabilities; many of the uses for habitation in LEO can be driven by the private sector, and NASA capabilities should go towards things that only the Government can do. The Agency may create a Moon and Mars Division within HEOMD, which will cover habitation and landing capabilities, among other things.

Mr. John Borghese observed that in aeronautics, new technologies are creating a revolution that enables new types of vehicles. NASA leadership is essential in addressing this growth, and he wanted to know the vision for this. Mr. Bridenstine noted the ways in which space and aeronautics capabilities feed off of and need each other. Aeronautics is a key piece of NASA’s identity as an agency. In the area of electrical propulsion, for example, finding the best ways to store large volumes of electricity for long periods of time will apply to space, lunar, and Earth needs. Also, we will need autonomy on the Moon, and inertial navigation systems are essentially autonomous. There are other examples. ARMD provides a key piece of NASA’s space flight work, while a technology designed for the Space Shuttle has saved lives in air travel. Sometimes aeronautics is dismissed, but it is critical. Sen. Nelson added that the first “A” in NASA is aeronautics. All of the next-generation flight controls are essential for air travel in this country. Congress

just passed a five-year Federal Aviation Administration (FAA) appropriations bill, instead of taking the usual year-by-year annual approach.

Ms. Paquin pointed out that the NASA infrastructure replacement cycle already lagged by many years, and creative funding tactics can only go so far. To move ahead to the Moon and Mars, there will be heavy demands on the Mission Support community, which concerns her. Mr. Bridenstine agreed that this critical point is rarely heard. People think of launch pads, but not the buildings, roads, and other infrastructure needs. Gen. Lyles said that NAC has not looked at that in detail, and he will make it a mandate that they take a closer look, and come up with questions and advice.

Remarks by NASA Administrator

Mr. Bridenstine began his remarks by noting that the Gateway will allow the nation to get to the lunar surface quickly, and so it is critically important. The SLS, Orion, and European Service Module (ESM) can get us to the lunar surface, but not off of it. Therefore, the Gateway will function as a reusable command and service module that will enable access for at least 15 years. NASA wants more access to more parts of the Moon than ever before, which calls for a maneuverable module, and that is the Gateway. This lunar campaign will also incorporate sustainability in returning to the Moon. It will provide more access to more parts of the Moon than ever before, and will also help retire risk in the effort to get to Mars. NASA is in a unique position now, with an opportunity to go forward with many missions simultaneously, either robotically or with humans in the loop. The lunar campaign will not cannibalize the rest of NASA.

Mr. Bridenstine noted, “When we think of our pride in the Apollo program, all of the astronauts had been fighter pilots and test pilots. There were no opportunities for women. Now, 50 years later, the astronaut corps is diverse. In Greek mythology, Apollo had a twin sister, Artemis. Therefore, NASA is naming the lunar return program Artemis, and this is the Artemis Generation.” Gen. Lyles noted the need for strong messaging, and pondered how to communicate the importance of this program and the need for it. There will be a challenge in getting the message out to those who were not alive in 1969 for the lunar landing. Mr. Bridenstine suggested asking the NAC members in real-time for their opinions on why we want to go to the Moon. He has seen that within NASA, no two answers are the same.

Gen. Lyles responded first, explaining that he had been involved in a National Academy of Sciences (NAS) study that found that people have a natural desire to explore. However, that is not a sufficient message to the person on the street. NASA needs to make sure that the U.S. space program is connected to what is going on and relevant to people today. Ms. Paquin spoke next, stating that this is the right time, as the NASA brand is incredibly strong. There is an excitement, and the Agency has tremendous resources and great commercial partners. Mr. William (Tony) Cole made two points. First, there is the importance of the exploration and science that comes out of NASA efforts, along with the technology transfer. Second, nothing would unite us more than to see someone on the Moon in an international effort with commercial contributions. Mr. Bridenstine said that the unity message is very important. The first lunar landing enthralled the entire world, not just the United States.

Dr. Elisabeth Paté-Cornell said that exploration is a human instinct, and space is today what the sea was in ancient times. It is a necessity. We have to do it, and NASA is best equipped to lead and integrate the effort. Mr. Wayne Hale recalled a history class he took while studying to be an engineer, in which he learned that that great nations grow when they explore and expand. When they do not do that, they decline. Lt. General Lee Levy observed that humans are exploratory creatures by nature, and that quest helps make our quality of life better. In addition, the United States is an aerospace nation, going back to the very first flight. The technology and innovation poured into our aspirational goals is astounding, and it becomes the beacon on which to focus. Dr. Patricia Sanders said that the Moon was once the destination;

now the Moon is on the journey to Mars. She said would have wanted to be an astronaut in the Apollo generation, but that was not open to her because she is female. Now younger women do have that opportunity.

Mr. Miles O'Brien said he was 10 at the time of the Apollo first lunar landing in 1969. He said that there is a very important component in how the space effort moves technology forward and develops future technologists. We need to send them a message. As a journalist, he has learned that space commands positive global attention. In the middle of the Cold War, 16 nations came together in a partnership to build the ISS. Space brings people together, and that has to be in the messaging. Dr. Aimee Kennedy stated that there is no better way to inspire the next generation with STEM than to pursue lunar exploration. Dr. Alan Epstein observed that NASA is about exploration, which it does extremely well. We now have commercial space companies transforming our capabilities. These organizations take NASA-developed technology and use it in innovative ways. NASA needs to continue developing the technology.

Dr. Wadhwa noted that there are science drivers in going to the Moon, beyond the measurements and new technologies. This is about understanding our origins. We can advance some of our fundamental science questions and inspire the next generation. Mr. Borghese explained that he always wanted to be an engineer, and that NASA sped the development of integrated circuits. There will be more technologies developed and matured on the Gateway. Finally, Dr. Penina Axelrad agreed with much of what had been said. As a teacher, she sees that people draw on their creativity when dealing with something really difficult, so the lunar campaign will inspire people in this way, while providing solutions. It is tremendously powerful.

Mr. Bridenstine observed that it is not the "how," it is the "why" of exploration that we need to communicate to the world at large. There is so much about our Solar System that we can learn from the Moon. It is a repository of amazing history and science that is largely untouched. It is also important from the science perspective, because the far side of the Moon is very quiet and so enables unique science on wavelengths, along with many other activities that cannot be done elsewhere. SMD and the NASA Office of the Chief Scientist have numerous opportunities for science on the Moon. For human exploration, there are resources on the Moon that will allow us to learn how to live and work on another world, as a precursor to going to Mars. We have learned so much about Mars in the last two years, finding liquid water under the surface and evidence that there used to be an atmosphere, a large ocean, and other building blocks of life. We need to learn more, and to get there, we need to get to the Moon first.

There are more opportunities now than ever. The diversity of the NASA astronaut corps will enable people to see themselves as they have never done before. When we look at Apollo and think of what came from it, we see that the way we communicate has been transformed by it. NASA innovated all of these capabilities. The way we navigate, produce food and energy, provide disaster relief, predict weather to save lives – all that was enabled by NASA technology. The Agency has done this while receiving less than one-half of one percent of the Federal budget. So how will we benefit from the Artemis program?

Mr. Bridenstine thanked Gen. Lyles and the NAC members, and noted that he appreciates their advice, guidance, and unabashed opinions. Gen. Lyles thanked Mr. Bridenstine for asking for the comments from around the table. He also thanked him for his leadership.

Technology, Innovation, and Engineering Committee Report

Mr. James Free, Chair of the Technology, Innovation, and Engineering (TI&E) Committee, gave his report remotely. He noted that he previously had worked for NASA for a number of years at the Centers and at Headquarters. He is now in industry and appreciates this opportunity to serve on the NAC. He has been very impressed with STMD and the NASA Office of the Chief Technologist (OCT). He pointed out

that the FY 2020 President's Budget Request was submitted with the assumption of a NASA restructuring that was subsequently rescinded when the \$1.6 billion budget amendment went to Congress. The most recent TI&E Committee meeting occurred between those two events. STMD has seven key technology focus areas, all of which at least touch on exploration. STMD has made contributions to CLPS, in-situ resource utilization (ISRU), propulsion and power research that includes solar electric propulsion (SEP), communications and navigation, advanced materials, and autonomous operations.

The FY 2018 enacted budget, the FY 2019 appropriation, and the FY 2020 President's Budget Request, all show that STMD consistently holds a percentage of its budget for early stage innovation and works to encourage such efforts. STMD spans the Technology Readiness Level (TRL) spectrum. SEP is the system that will be qualified for the Power and Propulsion Element (PPE) contract that had been awarded to Maxar Technologies the week before the NAC meeting. Mr. Borghese asked which NASA Mission Directorate is responsible for PPE, noting that the NAC had previously identified a need for 500 kW of power. Mr. Free explained that STMD eventually hands off technologies to HEOMD, after taking the research through to qualification. In the case of the Maxar contract, STMD is handing off directly to the developer. There will be discussions of Nuclear Thermal Propulsion (NTP) as well. STMD has contracts out to look at 100 kW engines; the 500 kW was for high-powered transit to Mars.

NASA's Congressionally-mandated Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs reside within STMD, which aligns their themes with Agency missions. He was not aware of any substantive changes NASA might have made to align SBIR/STTR with the 2024 timeframe. However, the programs were already supporting exploration. As they are on the front end of development, they might set the stage for work beyond 2024. Mr. Free said that he would take an action to speak with Mr. James Reuter, STMD Associate Administrator, about SBIR/STTR and the maturity of the technologies.

During the TI&E Committee meeting, Mr. Reuter had offered some comments. He noted that technology drives exploration, and gave a sampling of current investments in four categories: Orion and SLS, the Gateway, Lander and Surface Operations, and Mars. Gen. Lyles said that the National Space Council had noted that the National Academy of Sciences (NAS) had done a study on technologies for space exploration in the future. He asked if there were similarities between that list and the STMD technologies. Mr. Free said that he was not familiar with the NAS study. Independent technologies are among the drivers of these missions, with landers being an example. He took an action to look at the crossover between the two lists. Dr. Prasun Desai of STMD also offered some comments. He stated that there is indeed overlap, by and large. STMD had done a map to identify the gaps, some of which are things they do not yet know how to do. However, many of the technologies are covered within STMD. Mr. Free explained that much of what goes into the first element of the Gateway was already on track. STMD is developing the specifications for the second element and will likely use some of these technologies, many of which already exist. Dr. Desai added that when STMD sets priorities, SMD and HEOMD are at the table to identify their needs and timeframes; this input helps guide STMD investments. While many current SBIR investments will not be ready for 2024, STMD has realigned the topic areas. Mr. Free then listed priority technologies for flight demonstration, including SEP, ISRU, Cryogenic Fluid Management (CFM), lunar surface power, high performance spaceflight computing, and precision landing. LSII incorporates ISRU, sustainable power, extreme access, extreme environments, surface excavation/construction, and lunar dust mitigation.

The TI&E Committee also heard from Mr. Ben Reed, Deputy Director of the Satellite Servicing Projects Division, about satellite servicing and the technologies that meet the Division's eight objectives. NASA uses these technologies on missions, then pushes them out to industry via STMD technology transfer and infusion programs. Mr. Free gave examples, including the lessons learned from the Robotic Refueling Mission 3 (RRM3), which was launched in late 2018 to demonstrate zero boiloff and prove out the

system. An April power loss to the liquid methane cryocooler meant that the mission objectives will not be addressed. However, some tools were used and proven. Restore-L, which has been a budget line item for a number of years, will service a Landsat spacecraft. The tools and technologies will be transferred after the demonstration. It is possible that Restore-L will fly Dragonfly, an on-orbit assembly demonstration. The decision from STMD is pending.

The TI&E Committee produced a finding on satellite servicing for the STMD Associate Administrator. After deliberation, the Council approved the following finding:

The Council was impressed by continued progress of satellite servicing with respect to commercialization. For example, the industry events seem to be generating excellent awareness and dialogue. The Committee would like to encourage continued focus on the technology infusion to commercial industry as a focus for NASA.

General Lyles asked if there has been any cooperation with the Department of Defense (DOD) on satellite servicing. This is an area of importance to multiple agencies, and it would be appropriate for NASA to coordinate it. Mr. Free replied that there is coordination. STMD has had a great deal of interaction with other government agencies, such as the Defense Advanced Research Projects Agency (DARPA).

Also at the TI&E Committee meeting, Dr. Douglas Terrier, NASA Chief Technologist, provided the committee with an update on OCT activities. Prominent among these is the Digital Transformation Initiative (DTI), which is agency-wide. The goals include advancement of digital transformation (DT) through strategic initiatives; establish and infuse an Agency-wide, high-impact DTI; and coordinate and align with mission-enabling, secure, agile enterprise IT services. The TI&E Committee produced a finding on the DTI. After Council deliberation, the Council approved the following finding to the NASA Chief Technologist:

The NAC Technology, Innovation and Engineering Committee was impressed by the Office of the Chief Technologist (OCT) efforts thus far in formulating and implementing a plan for a Digital Transformation Initiative: a strategy for NASA to employ digital technologies to transform its processes, products, and capabilities yielding substantial performance improvements. The Committee believes OCT's current work is notable, but could also benefit from incorporating input from academic institutions and laboratories, which could be leveraged to enhance the agency's progress and ultimately, its implementation plan.

The TI&E Committee also heard from Mr. Sonny Mitchell on Nuclear Thermal Propulsion (NTP), which has become a key technology for deep space exploration. The evolution of NTP testing over the years has resulted in greater costs. However, there are substantial cost saving opportunities in using Low Enriched Uranium (LEU), which also offers more flexibility. Mr. Hale said that one way to help mitigate the human health costs of space travel in the area of radiation exposure is to reduce trip time. NTP might therefore enable long-duration exploration. Mr. Free said that the Department of Energy (DOE) and many other organizations are involved in determining LEU feasibility and affordability. Challenges include nuclear fuels and reactors, engine design, and integrated stage design. However, these are comparable to other challenges associated with exploration beyond Earth orbit. Gen. Lyles said that he and Dr. Kennedy recently heard a presentation from the Idaho National Lab (INL) at Battelle. He suggested that TI&E Committee ask INL for a presentation on its technology efforts. Mr. Free made note of that. He explained that there are two concepts for the first step in demonstrating NTP: FD1 and FD2. FD1 is the nearer term, targeting a 2024 flight hardware delivery; that presents some challenges. FD2 will take longer. A study will develop mission content review-like products. Mr. Free then presented a TI&E Committee finding on NASA's NTP efforts. After deliberation, the Council approved the following finding to the STMD Associate Administrator:

The NAC Technology, Innovation and Engineering Committee believes that a Nuclear Thermal Propulsion (NTP) system could reduce crew transit time to Mars and increase mission flexibility which would enable a human exploration campaign. The Committee finds much progress has been made by STMD's NTP project which is addressing the key technology challenges related to determining the feasibility and affordability of a Low Enriched Uranium (LEU)-based NTP engine. For example:

- *The project is maturing technologies associated with fuel production, fuel element manufacturing and testing*
- *The project is developing reactor and engine conceptual designs*
- *The project is performing a detailed cost analysis for developing an NTP flight system*

The Committee notes there is considerable stakeholder interest in doing a near-term NTP flight demonstration mission. STMD is responding by initiating a "mission concept-like study" which will bring together industry and other government agencies to evaluate concepts to execute a flight demonstration mission in the near-term timeframe. Once current STMD NTP assessments and studies are completed, the Committee encourages Agency leadership to provide clear direction on the future course of NTP development.

Gen. Lyles explained that what the NAC normally does for these reports is to have findings and recommendations from the committees, which they were seeing in the TI&E report. The NAC then reviews what they would forward to the Administrator. Typically, the Council sends actionable recommendations to him, as well as the occasional finding. The NAC also makes recommendations to the Mission Directorates. Mr. Hale observed that the reduction in transit time is the key in this finding. He would like to see actionable recommendations to do more in this area. Mr. Free replied that the TI&E Committee had discussed that, determining that they wanted the team to get through the study before making a recommendation. Gen. Lyles pointed out that the NAC can also make recommendations to the Mission Directorates. He thought they could recommend that STMD provide more specificity next time on the future course of NTP development.

Mr. Free presented the final TI&E Committee recommendation, which repeated the NAC's March 2018 recommendation about the NASA restructuring, though with the addition of the words "and protects":

The Council recommends that the NASA Administrator task the Acting Associate Administrator to develop and present to the Council mechanisms and/or a hybrid organization that promotes and protects appropriate levels of investment in early and mid-stage technology development and University grants and fellowships. This includes defining metrics to assess effectiveness.

During the discussion, it was noted that the need for this finding had been obviated by the fact that the restructuring is now off the table. In addition, the Agency had responded when the finding was first presented.

Aeronautics Committee Report

Mr. Borghese, Chair of the Aeronautics Committee, said that the Committee had met on March 20, 2019, and had covered a great deal of material. The Supersonic Technology Demonstrator (X-59) aircraft low-boom flight demonstration is providing data to inform the community responses for regulatory organizations. ARMD is advancing next generation technologies for subsonic transport; accelerating research on safety and operations in urban air mobility; air traffic management demonstrations with FAA;

and transfers of the Aerospace Evaluation and Test Capabilities (AETC) to SSMS. When the facilities are transferred, the individuals involved will remain with the work. The X-59 is on schedule. This is NASA's first supersonic aircraft in decades. Overall, there is good Congressional support for NASA's aeronautics budget. The Aeronautics Committee produced a finding on the AETC transfer:

While very optimistic regarding the 2020 proposed budget, the Committee expressed concern about the transfer of the Aerospace Evaluation and Test Capabilities Project (AETC) from Aeronautics to the Mission Support Directorate. The main concern is ARMD's utilization of these facilities in terms of the agency priorities in the future. Given the focus by NASA to establish a presence in the Moon, the Committee has concerns over ARMD's future ability to resolve scheduling and related resource conflicts when it comes to wind tunnel facilities.

In discussion, Dr. Epstein noted that the NASA wind tunnels have always been a national asset for which other projects sometimes override NASA use. General Lyles shared the committee's concern but agreed with Dr. Epstein and would like to see some concrete examples of what might be pushed off. Ms. Paquin noted that an existing governance process addresses this situation and suggested that the Aeronautics Committee conduct a review that could lead to a finding that the documentation be shared. Mr. Borghese said that he foresees conflicts, most likely in the area of hypersonics. It would be better to understand how the governance works, as that might alleviate the committee concerns. After deliberation, the Council did not approve this finding; it was tabled until the Aeronautics Committee could return in the future with specific examples.

Mr. Borghese described the NextGen system initiatives for air traffic management, as navigation systems migrate from radar to the Global Positioning System (GPS). Air traffic conversations are very complex, and the data community could help in that area. The network of information to aircraft could give pilots greater awareness. NASA has transferred four technologies to FAA to address this. Airspace operations are about to expand from up to 60,000 ops per day to millions. For examples, new technologies are spawning opportunities such as small and medium unmanned air vehicles, thin and short haul operations, Urban Air Mobility (UAM), Unmanned Aerial Vehicles (UAVs), and others. This may be beyond what is scalable. NextGen will not address all of this. The nation needs safe and efficient airspace access for all users, vehicles, and missions, and this should be anchored around service-oriented architectures. Research needs to stay ahead of this. Dr. Epstein pointed out that FAA has very small research organization, and NASA has provided the ideas and focus. Safety is paramount, politics are important, and small countries could move faster in this area. The opportunity here is that all of the new activity is in an area where NASA can lead and have a profound impact on how the world changes. Congress might consider bolstering this part of NASA's aeronautics budget. Mr. Borghese said that new companies are investing in vehicles, but there is no investment in the airspace, and that must be changed to address these new vehicles. NASA should lead in service-oriented architecture, and it is important to note that the current air traffic control system cannot handle the projected growth. There has been a great deal of technology development. However, it is important to note that a 1977 helicopter crash resulted in the end of commercial helicopter flights in New York City, illustrating the need to get this right in order to have further opportunities.

ARMD is not doing maturity levels for UAM, but there has been much focus on enabling UAM operations and market entry. The National Airspace System (NAS) is transforming into a federated service-oriented architecture. Standards and certification will be a huge issue, and FAA's certification approach will not suffice for the future growth. There is a pathway to airspace transformation, leading to increased autonomous operations, as well as operations in higher-altitude airspace. In moving ahead, it is important to have community engagement, building on NASA and other government agency relationships, as well as leveraging industry relations. The Aeronautics Committee produced the

following finding. After deliberation, the Council approved this finding for the ARMD Associate Administrator:

The Aeronautics Committee finds that NASA lacks a well-understood return on investment on the Airspace Technology Demonstration (ATD) project that defines the future benefit for the nation. If the Airspace Operations and Safety Program is not successful, we may not have a competitive urban air mobility (UAM) industry. The advancements in the air traffic control system are necessary for achieving a safe and reliable national air transportation capability. The Committee encourages NASA to continue demonstrating the technologies long-term to obtain more data on the impacts of the UAM integration into the airspace. The Committee noted the reduction of the NASA ARMD budget starting in 2023 and suggested that the success by NASA in these new markets for autonomous vehicles and supersonic flight could justify a higher budget.

The Universal Leadership Initiative (ULI), which was briefed to the NAC a couple of years previously, supports universities in setting their own research path along one of ARMD's six thrust areas. These are to involve multiple universities working together on a complex problem. In the two years since the NAC briefing, the Initiative has been released, and there is now progress to report. Mr. Borghese showed the first round of ULI awards, in 2017. The universities choose their teams and the other universities with which they work. When asked about minority-focused universities, Mr. Borghese gave an example in which someone suggested that a university team with a minority-focused university and was met with silence. It was noted that DOD routinely requires that universities broaden their horizons to include Historically Black Colleges and Universities (HBCUs) and Hispanic Serving Institutions (HSIs). There were both strengths and areas for improvement. The peer review process is an issue, with uneven quality, time issues, and less help than is optimal. NASA wants to establish diversity of portfolio and proposers; increase continuity of reviewers and effectiveness of external peer reviewers; support Principal Investigators (PIs) in defining global context surrounding their work; work toward industrial partners continuing ULI research; and better define the ULI value proposition. The Aeronautics Committee produced a finding addressing the need for diversity:

The Aeronautics Committee applauds NASA on its flexibility on trying to find the optimal mechanism on the University Leadership Initiative. The Committee emphasized the need to assure diversity when selecting proposals from the universities and to track and show statistics. The Department of Defense agencies require Historically Black Colleges and Universities (HBCU) participation in certain research solicitations to ensure diversity. The Aeronautics Research Mission Directorate may want to consider an approach along these lines. The Committee also found that there is a need to drive the message that aeronautics is not only relevant, but serves as a pioneering application for 21st century technology innovation. NASA needs to be more proactive when engaging with and advertising these opportunities to the university community.

Mr. Borghese noted that ARMD intends to do this. Gen. Lyles thought this finding might be better as a recommendation. Dr. Epstein suggested the committee recommend that NASA review the program process, compare it to comparable DOD programs, and take advantage of lessons learned. After deliberation, the Council approved it as a finding to the ARMD Associate Administrator.

The Aeronautics Committee also produced a recommendation for NASA in the area of human capital:

The Aeronautics Committee is excited about the budget and the direction of NASA Aeronautics. The Committee recognizes the need to find a mechanism for NASA to hire engineers and technologists from non-traditional disciplines that are shaping the next generations of aeronautical systems. The Committee recommends that NASA actively engage in bringing on-

board innovators to work on the difficult problems that the industry and academia are facing through a new, more flexible hiring and retention process.

In discussion, Mr. Borghese noted that DARPA and other organizations do not have the same retention issues. Ms. Paquin described the Excepted Service model, a hiring system that NASA is studying, which would require White House approval. Gen. Lyles said that the NAC would benefit from understanding the Excepted Service model, and it could apply across all of NASA. Gen. Levy made reference to the nationwide talent shortage. Nonetheless, an exciting program can draw the right people, with low turnover and great enthusiasm. This Aeronautics Committee recommendation was deferred. The NAC will seek a briefing on the Agency's human capital strategy at a future meeting.

STEM Engagement Committee Report

Dr. Aimee Kennedy, Chair of the STEM Engagement Committee, presented the Committee's finding. After deliberation, the Council approved the following to the NASA Administrator:

The Office of STEM Engagement (OSTEM) brings a continuous improvement approach to its work and is making good progress on the work plans previously presented (i.e., Business Services Assessment (BSA) findings, NASA STEM Engagement strategy, Federal Five-Year STEM Plan).

Gen. Lyles said NASA should explain to the NAC how the STEM work will continue in the absence of OSTEM, since the office had been zeroed-out in the President's Budget Request for FY 2020. Dr. Kennedy explained that the BSA implementation was completed six months in advance of the deadline and despite a 35-day U.S. Government shutdown. This led to an architecture that enables student opportunities, while also driving the Mission Directorates to push the work across the educational spectrum. The result is systemic and programmatic transformation across a broad range. Following the BSA, the focus areas were narrowed down to: enable contributions to NASA's work; build a diverse, skilled, future workforce; and strengthen STEM through connections to NASA. OSTEM's \$110 million budget funds many such activities in the engagement portfolio, but Dr. Kennedy was unsure about the contributions of the Mission Directorates. It was noted that while the Administration has proposed closing OSTEM, Congress has not yet acted. In addition, there are activities and funding areas within NASA that benefit both STEM and other purposes, with the latter possibly being primary. The Agency has evolved an enterprise approach so that if the funding disappears, the activity will not be zeroed-out with it. Dr. Kennedy listed a number of partnerships and described the Apollo 50th Anniversary events that are catalogued from across the country. OSTEM is tying museum awards to the Moon to Mars theme.

Science Committee Report

Dr. Meenakshi Wadhwa, Chair of the Science Committee, described upcoming changes to Science Committee membership. At its last meeting, the SMD update noted a number of science highlights. Among these was the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission, and its discovery of Marsquakes, which tell us that Mars is geologically active. The Origins Spectral Interpretation Resource Identification Security - Regolith Explorer (OSIRIS-REx) mission is orbiting the asteroid Bennu, and will return samples. Because of Bennu's size and surface characteristics, it will be difficult to find a landing spot. The sampling will inject nitrogen into the soil and the resulting material will be collected. The New Horizons spacecraft captured the farthest object investigated by a spacecraft thus far. The Lunar Reconnaissance Orbiter (LRO) found variations in the abundance of water on the Moon in terms of both terrain type, and time and temperature. The Orbiting Carbon Observatory 3 (OCO-3) has just launched. Dr. Wadhwa showed a graphic of three weeks of Ice, Cloud and land Elevation Satellite-2 (ICESAT-2) observations over Antarctica. ECOSystem Spaceborne

Thermal Radiometer Experiment on Space Station (ECOSTRESS) studies urban heat islands. In the area of astrophysics, discovery of the shadow of a black hole involved coordinated observations from around the world. The Transiting Exoplanet Survey Satellite (TESS) has discovered a number of exoplanets, including one that is Earth-like aside from its extremely high temperature. Finally, the Parker Solar Probe (PSP) has made its second close approach of the Sun.

The new launch readiness date for JWST is now March 2021. The spacecraft just completed thermal vacuum testing, and integration of the telescope and spacecraft elements will occur in late summer. Mars 2020 is on track for a July 2020 launch; this mission is the first step in NASA's Mars Sample Return campaign. Delivery of the instruments and systems is pending. In terms of lunar science by 2024, Dr. Wadhwa noted the landers and rovers, both polar and non-polar; the Artemis 1 cubesat program; orbital data; and ISRU initial research. Beyond 2024, the focus will be on robotic and human exploration of the lunar surface, via the Gateway. The Science Committee continues to have joint meetings with the Human Exploration and Operations (HEO) Committee, one of which is planned for the fall 2019, at which many of these topics are discussed. Lunar water tends to be found in higher terrain. The near side of the Moon has the plains known as "maria" which are relatively flat. The highlands are more rugged. The differences remain to be researched further, but it is believed that there is a water cycle and subsurface activity. The greatest abundance is in the higher terrain near the poles, and the water is near, if not on, the surface. These are cold traps, so the work will present a huge technical challenge. NASA is already implementing the Lunar Discovery and Exploration Program (LDEP), which involves the CLPS landers. The Science Committee reviewed two documents, the Science Strategy for the Moon, and the Science Plan. Another activity is current initiatives in the Mars Exploration Program and the human landing site study, which had identified 47 candidate sites. The Science Plan for the period 2019-2024 lays out an ambitious program.

Following NAC and NAS advice, NASA has established a Planetary Protection Independent Review Board (PPIRB). The Board will assess current planetary protection guidelines in the context of the current space exploration landscape, and formulates recommendations; review and recommend updates to biological contamination guidelines developed by the Committee on Space Research (COSPAR); and provide direction to inform future planetary mission activities and possible future Mars sample return missions. There are also plans in work for the NAC Science Committee to have a Science of the Moon Subcommittee, whose chair will be a member of the Science Committee. Candidates are under review; the subcommittee will include 10 to 20 lunar science experts. Finally, the Science Committee had formed a Task Force on Diverse Teams and Safe Environments, whose members reviewed best practices and reported on specific institutions.

The Science Committee had one recommendation and 12 findings; most of the latter were for SMD, as they were edits to the two science documents noted above. The recommendation was to go to the SMD Associate Administrator, advising SMD to develop a multi-tiered strategy to facilitate diverse teams and safe environments. After deliberation, the Council approved the following recommendation to the SMD Associate Administrator:

The Science Committee recommends that the NASA Science Mission Directorate (SMD) develop a multi-tiered strategy to facilitate diverse teams and safe environments. To achieve these goals, the Science Committee recommends the following actions:

- *We strongly encourage the development of a 5-year strategic plan for diversity, equity, and inclusion (DEI), as a first step in the process.*
- *We strongly endorse the continuation of the "Principal Investigator 101" and "Principal Investigator Incubator" programs recently developed by NASA SMD.*

- *SMD should continue its DEI-enlightened proposal review processes, including diverse review panels, providing DEI training at the beginning of every proposal review, the clear explanation of evaluation criteria, and the enforcement of these policies and criteria throughout the panels.*
- *SMD Announcements of Opportunity should include a required element of how the proposed activities and proposal team aligns with NASA's DEI goals.*

The Science Committee produced a series of four separate findings following its review of NASA's draft Science Strategy of the Moon. After deliberation, the Council approved the separate findings and asked that they be combined into one finding to the SMD Associate Administrator:

The Science Committee finds the following regarding the draft Science Strategy of the Moon:

- (a) *Why Return to the Moon - The Committee finds that the draft Strategy's introduction lacks a well-articulated narrative regarding the opportunity presented by returning to the Moon at this time, which could invite the perception that it is simply an "it's about time" endeavor. A narrative, perhaps around the scientific and technological advancements that have occurred over these past 50 years, could highlight NASA's progress and articulate why now is a rich environment in which to return to the Moon to further our exploration capabilities and scientific understanding.*
- (b) *Science Goals - Three of the four Science Goals in the draft Strategy are derived from multiple community-based documents and are well-articulated and well-justified. However, one of the goals (Science Goal #3; particularly subgoals 3A and 3C) is based primarily on outcomes from a single workshop (Deep Space Gateway Concept Science Workshop, held on February 27 - March 1, 2018). The science areas in this goal were not as well-justified or as clearly stated as for the other goals. For instance, it was not clear what was meant by "identical sensors", and what the level of "high temporal frequency" would be. It was also not clear what was "novel and unique" about the science in the areas of heliophysics, astrophysics, and Earth science enabled by going to the Moon.*
- (c) *Partial Gravity - In the NASA Science Role section of the draft Strategy, there is no mention of the fact that lunar exploration will also provide the first opportunity for scientific study of the effect of partial gravity on human health and performance. Such research is expected to fall under the purview of NASA's Human Exploration and Operations Mission Directorate (at Johnson Space Center's Human Health and Performance Directorate) and is not referenced in this document. Mention of this research in this document would be informative to readers of this important NASA scientific activity.*
- (d) *Priorities and Principles - In the Priorities and Principles section of the draft Strategy, the third bullet is redundant with the second bullet. Also, for the fourth bullet, it is unclear what is meant by "providing situational awareness." If referring to space weather, this could be clarified.*

Priorities and Principles (DRAFT)

- Achieve the decadal survey objectives across the disciplines that can be addressed at the Moon or near the Moon
- Perform all research to the standards of NASA Science, including competitive selections, open data policies, etc.
- Enable competitive research through Mission of Opportunities or otherwise on or around the Moon
- Actively enable human exploration through providing situational awareness

The Science Committee also produced a series of seven separate findings following its review of NASA's draft NASA Science Plan. After deliberation, the Council approved the separate findings and asked that they be combined into one finding to the SMD Associate Administrator:

The Science Committee finds the following regarding the draft NASA Science Plan:

- (a) Introduction and Future State – *The Science Mission Directorate (SMD) is in an exciting era when there is transformational potential for a science strategy that enables excellence and innovation. We see inspirational language that speaks to this in each of the Focus Areas, and in the “2024 Future State” summary of the Science Update presentation, but find the introduction section to be merely descriptive by comparison. An introduction and conclusion that capture the visionary and ambitious plan for the future would provide much needed context for the document. It may also be useful to identify the SMD divisions in the introduction below the description of the key science themes.*
- (b) Rename “Protect and Improve” Theme – *One of the three themes, “Protect and Improve Life on Earth” (highlighted in the Introduction and the SMD Mission Statement) does not inspire the same level of wonder and excitement as the other two themes; as written, it implies an applied science focus rather than the discovery science implied by the other two themes. This theme could be re-worded along the lines of the following:*
- “Unlocking the mysteries of our planet”
 - “Advancing the frontiers for humanity”
 - *The first of these options conveys the excitement for exploring the many unknowns of our interconnected planet (Earth system). The second of these options conveys the message that NASA SMD pushes the forefront of knowledge for applications that benefit life and society.*
- (c) Interconnectivity and Partnerships – *While there is discussion of collaboration with the Human Exploration and Operations Mission Directorate (HEOMD) and the Space Technology Mission Directorate (STMD) specifically in the context of the exploration initiative (in Strategy 1.2), the document does not sufficiently or broadly highlight the areas and mechanisms for interconnectivity and partnerships between SMD and the other Mission Directorates.*
- (d) Foster Innovation – *The SC finds the use of the word “create” in Strategies 2.1 and 2.2 of the draft NASA Science Plan to neglect the work that is currently being done to seed a culture that embraces innovation and collaboration. Use of words such as “foster” or “grow” would communicate the need for progress, while acknowledging that work has already begun in these areas.*

STRATEGY 2.1: Create a culture that encourages innovation and entrepreneurship across all elements of the NASA Science portfolio.

STRATEGY 2.2: Create a culture that encourages collaboration in pursuit of common goals.

- (e) Diversity, Equity and Inclusion – *While referencing the importance of diversity (e.g., in the Teamwork section and in Strategy 4.1), it was noted that there is not adequate emphasis on equity and inclusion in the document. Diversity alone is not sufficient to ensure the best outcomes in driving excellence and innovation.*

- (f) *Human Health in Space – This draft NASA Science Plan document covers the activities of SMD. The Space Life and Physical Sciences Research and Applications (SLPSRA) Division, part of HEOMD, supports research on the effects of spaceflight on human health and performance and on biological and physical systems. These scientific activities are discussed in SLPSRA’s strategic plan and could be referenced here to increase readers’ awareness of the full scope of science at NASA.*
- (g) *Portfolio Summaries – The draft NASA Science Plan portfolio summaries for the programs within each division should include all programs listed for each division in SMD’s Science Budget Request Summary table. In the planetary science portfolio summary, the Outer Planets and Ocean Worlds Program was omitted.*

The Science Committee also had a separate finding on Science and Technology Definition Teams (STDTs):

The Science Committee is concerned about the switch to Federal Advisory Committee Act (FACA) authorization for Science and Technology Definition Teams (STDTs) for upcoming mission concept development. This means that STDTs cannot recommend any implementation strategies, but instead only make recommendations on the science investigations and measurement requirements necessary to address these objectives. This has several negative ramifications. One impact is that this slows the process of NASA science mission development. SMD must now conduct an implementation analysis after the STDT, rather than doing this as part of the STDT process. Another impact is the potential for cost growth. The development of science objectives and measurement requirements independently from technical implementation concepts and associated cost analysis could lead to financially unfeasible missions. When these steps are integrated, cost targets can be included in the science objective formulation discussion.

The SMD Associate Administrator, Dr. Thomas Zurbuchen, attending remotely, noted that there are negative ramifications to the structure of STDTs as FACA advisory committees. This structure had been initiated by the NASA Office of General Counsel (OGC), but because it is proving unworkable on several fronts, SMD and OGC are examining alternatives. Dr. Zurbuchen said that he will report back on the results. After deliberation, the Council approved this finding for transmission to the SMD Associate Administrator.

Adjournment

The meeting was adjourned for the day.

May 31, 2019

Call to Order, Announcements

Ms. Rausch opened the second day of the meeting with a review of FACA regulations and guidance. The agenda for the day included time for public input.

Remarks by NAC Chair

Gen. Lyles thanked those present for joining the meeting. He noted that on the previous day, there had been a good discussion with the NASA Administrator, Mr. James Bridenstine, in addition to reports from the TI&E Committee, Aeronautics Committee, STEM Engagement Committee, and Science Committee. On this day, the NAC would be hearing reports from the Regulatory and Policy Committee, and the Human Exploration and Operations Committee. Mr. William Gerstenmaier, HEOMD Associate Administrator, would also be updating the Council on NASA's human spaceflight program. Then there would be time for final discussion and wrap-up by the Council.

Public Input

Mr. Keith Kelly, speaking remotely, said that the meeting had devoted a lot of time discussing public engagement and what the public wants regarding NASA's plan to return to the Moon. However, the meeting had allotted a mere five minutes for public input, and that was scheduled for 8:40 am EDT, which was 5:40 am on the West Coast, and hence very inconvenient for people there. He wondered why the NAC did not use a more accessible means, such as Twitter. He said that it did not seem that the NAC really wanted public input. Gen. Lyles thanked Mr. Kelly for his comments, and noted that the NAC is interested in public engagement. As for the timing, he apologized for the inconvenience, and said he will take it into consideration for NAC future meetings. The NAC will also look into other avenues, such as Twitter, for receiving public input.

Regulatory and Policy Committee Report

Mr. Michael Gold, Chair of the Regulatory and Policy Committee, began his report by noting that a lot has been happening and this is an extraordinary time in the U.S. civil space program. In 2019, two commercial entities will be conducting space tourism for the first time. Meanwhile, NASA is planning its return to the Moon. He said he finds the Artemis program and the Gateway very inspiring, as they infuse NASA's work into the commercial sector to inspire innovation. There is a parallel level of activity in rulemaking and regulations. Aggressive regulatory reform is occurring so fast that industry has told NASA to slow down.

The Regulatory and Policy Committee has had two meetings since the NAC last met. First was a non-public fact-finding preparatory meeting in March 2019, which included an dial-in opportunity for explanatory discussion with NAC members. The committee hopes to continue reserving time for NAC members to dial-in and get more information. The May 2019 public meeting had received updates from the Department of Commerce and the Committee on Space Research (COSPAR). Gen. Lyles asked whether there might be too many people looking at space policy and regulatory issues. At the last National Space Council meeting, the Secretary of Commerce reported on regulatory work, the Users' Advisory Group (UAG) has looked at regulatory work, and the NAC Regulatory and Policy Committee is also looking at it. Mr. Gold said that there is so much to do that there are still not enough people involved. Many of the discussions at these meetings are about coordination. There have been some Science and

Technology Policy Institute (STPI) activities that generated concern, but now they are now on the same page. STPI's work has been very helpful. There is enough to keep everyone busy.

Mr. Gold presented several proposed committee recommendations. The first referred to Intellectual Property reform:

The Council recommends that NASA endorse efforts to obtain legislative relief to ensure that the Agency can, at its discretion, waive Intellectual Property rights related to commercial R&D on the ISS and future destinations for the U.S. Government as a whole.

Mr. Gold noted that it is important to get all possible value from ISS to act as a pathfinder for the private sector, especially the pharmaceutical companies. If they cannot enjoy the fruits of their labor, they will not invest. These companies are being asked to take a leap of faith, and the benefits could be worldwide. The committee wants Mr. Bridenstine and the NAC to go on record in support of this. NASA has raised the issue with Congress to no avail, so the committee hopes to arm Mr. Bridenstine and others with a NAC endorsement. It was noted that NASA has tried similar legislative proposals for several years. However, this is a government-wide law, and other parts of the government are resisting giving NASA special consideration. Gen. Lyles thought it would be most appropriate for the NAC to say they fully endorse this, rather than have it be a recommendation. They might state that the NAC endorses legislative relief and recommends aggressive initiatives in working with Congress. Mr. Gold agreed to revise the recommendation, and make it a finding. After deliberation, the Council approved this as a finding. Gen. Lyles added that he would also like to see this as a UAG recommendation to the National Space Council, which would elevate it and make it cross-agency.

Mr. Gold noted that the next committee recommendation referred to due priority for access to private sector hardware:

When determining how limited resources for supporting commercial activities on the ISS should be utilized, projects that required substantial private sector investment in hardware aboard the Station should be given due priority during the consideration process.

In order to make the point explicitly without being prescriptive, the committee used the term "due priority" to allow NASA room for interpretation. It is envisioned that a minor investment would have less priority than a large investment. Dr. Axelrad was concerned that this might force or encourage NASA to prioritize high-cost efforts over low-cost projects on the ISS. Mr. Gold replied that that was not the intent, that the committee wants NASA to have the flexibility to balance the work and enable new entities to come in. He gave the example of a committee member who found that he cannot go to investors and guarantee access on a regular basis. Mr. Hale noted that he has been the decision-maker in these situations. The most difficult job is planning crew time in the face of competing priorities. There will never be a guarantee of access to the ISS because things will happen. Some of NASA's human research projects could be top priority. ISS has limits on crew time, space, etc. The commercial interests might consider putting up their own space station to solve this issue. Some commercial proposals do not fit NASA's criteria. There is also a new policy coming out that will enable special access for a fee. NASA is not allowed to give special consideration to anyone, by law. Mr. Gold replied that this recommendation was felt to be sufficiently generic without unduly restricting the Agency. Gen. Lyles suggested that it be accepted by the NAC to show concern that there is consideration in the process. It was noted that this recommendation would fall to the HEOMD Associate Administrator to implement, not the NASA Administrator. In addition, if NASA is coming out with a change or clarification in the next few weeks, the committee might want to consider the wording in light of that change. Mr. Gold said that the committee was already holding off on two other recommendations because of the pending change. This one is more aspirational and they believe it would still be relevant. Gen. Lyles suggested sending it as a

committee recommendation to the HEOMD Associate Administrator rather than a Council recommendation to the NASA Administrator. The Council approved this recommendation as a recommendation to the HEOMD Associate Administrator.

Mr. Gold presented the next committee recommendation concerning orbital debris mitigation:

The Council recommends that, within the U.S. Government, NASA should advocate for a unified, government-wide, performance-based approach to orbital debris mitigation that avoids regulatory redundancy and conflict, and integrates expertise from all relevant agencies.

Mr. Gold noted that there has been an effort to centralize this effort at the Federal Communications Commission (FCC), but the committee believes that others, such as NASA, DOD, and Department of State, should also be involved. His committee believes that this is relevant for the NAC, and wants to arm Mr. Bridenstine with this endorsement for discussions within the National Space Council and in other groups. They are trying to avoid having one agency take control of the process, and also avoid redundancy. There are innovative ideas to repurpose debris to make it useful, a debris mitigation strategy. It was suggested that if this were a finding, it would not require action, but it would arm NASA with the advice of the NAC. After deliberation Council approved this as a finding.

The next finding was not in Mr. Gold's written presentation. Mr. Gold read aloud the proposed finding:

The Committee compliments Mr. Bridenstine for condemning the Indian Space Research Organization's (ISRO's) Anti-Satellite (ASAT) weapons test.

Mr. Gold explained that human lives could have been at stake on the ISS, and the ISRO predictions on orbital debris are not proving true. The FAA Commercial Space Transportation Advisory Committee (COMSTAC) had made that point, and had asked the FAA to analyze debris from the test. NASA also needs to speak out and be consistent on this issue. Gen. Lyles said he was in favor of the finding, and noted that the topic had also come up at the National Space Council. Mr. Gold thought it would be good to have a finding commending Mr. Bridenstine's proactive leadership on this topic, and stating that the NAC condemns activities creating dangerous orbital debris. Gen. Lyles said he agreed with the first part, but was not sure about the NAC condemning anything. After deliberation, the Council approved the inclusion of the commendation in the finding.

The next committee recommendation pertained to human-tended payloads:

The Council recommends that NASA address several open regulatory and policy questions regarding NASA-funded human tended payloads, including:

- *Identify NASA's liability concerns, if any, under the current statutory construct;*
- *Clarify any NASA requirements for informed consent and reciprocal waivers for NASA-funded researchers; and*
- *Clarify the NASA Administrator's authority to designate a "government astronaut" considering such factors as employer, safety-critical flight responsibilities, research funding source, and flight funding source.*

The Council recommends that NASA should work with industry and the FAA Office of Commercial Space Transportation to identify any additional statutory and/or legal authorities NASA requires to address open regulatory and policy questions.

In discussion, it was noted that STMD is working on this with the FAA, and that the committee had sought an STMD briefing, but it had not yet happened. General Lyles advised that the committee continue to work with STMD to have more dialogue and discussion before presenting either a finding or recommendation to the NAC. Mr. Free agreed to help ensure that this briefing occurs. This recommendation was tabled.

Mr. Gold then noted that he and Mr. Hale had talked about achieving the 2024 Moon landing and the Artemis campaign. To do so, the procurement process needs to undergo substantive change, and NASA must have the power to move flexibly and more quickly. It should take less time to hire the right people. In addition, people will take a pay cut to work at NASA, but only to a point; the Agency must be able to provide salaries that are somewhat competitive. Along with this should be greater flexibility in firing so that managers can create the best teams. Gen. Lyles stated that the NAC needed an in-depth presentation on NASA's human capital strategy at a future meeting.

Dr. Wadhwa asked if the Regulatory and Policy Committee could look into the SMD Science and Technology Definition Teams (STDTs), and the general "FACA-ization" of activities that has been occurring in the NASA Mission Directorates, and ways to avoid having to do that, noting that having so many groups required to meet FACA criteria slows down the process. Mr. Gold agreed, noting that he has heard this concern elsewhere. He would be happy to take this to his committee.

NASA Human Exploration and Operations Update; NASA Humans to Moon 2024

Mr. William Gerstenmaier, HEOMD Associate Administrator, provided an update on HEOMD activities, with a focus on the 2024 lunar campaign. NASA is about ready to mate the European Service Module (ESM) with Orion, and is preparing to mate the Boeing crew module with the engine module. Most of the work in mating the SLS hydrogen tank has been completed, and the Agency will conduct an Orion altitude abort test in July 2019. The amount of physical hardware in flow is the greatest since Apollo. There are six crew on ISS, the launch of commercial crew is pending, habitation procurements are out, and NASA is moving to put the first woman and next man on the moon. A Broad Agency Announcement (BAA) allows the Agency to move at speed. The planned items for 2024 were already on the schedule and have been moved up quickly. This shows what NASA can do with direction and support. There has been consideration of the risks in this acceleration. NASA has discussed whether it has the right data, for example. HEOMD is doing descent and other studies in parallel to procurement. The studies embed prototype hardware, so the Agency will participate with industry and pull in NASA technologies and other work as needed. There will be some mistakes but NASA can recover from them; these will not be fatal flaws.

The focus is on urgency and the 2024 date. There is always risk. Teams will make the hard risks decisions if the goal is reasonable. With no urgency, things spread out. Sen. Nelson congratulated Mr. Gerstenmaier on his leadership, then asked what the lunar campaign will need beyond the additional \$1.6 billion in the first fiscal year. Mr. Gerstenmaier replied that the additional \$1.6 billion being requested for FY 2020 did not come from other programs. However, he is concerned that the FY 2021 budget will require NASA to make internal cuts, find efficiencies, and reprioritize. NASA was working hard before, with a solid plan for the 2028 date, but the extra funding and accelerated plan motivates his teams and moves them forward.

HEOMD addresses exploration in context of eight strategic principles. Prominent among these is fiscal realism, specifically the need to determine how to build programs that are responsive to fiscal realities. Commercial and international partnerships constitute another strategic principle, creating the fabric to do great things. Science exploration is crucial because science provides information on what human exploration will be able to do. Science helps identify the locations for human exploration efforts, and is a

key component for in-situ resource utilization. STMD technology efforts will support both the 2024 campaign and technologies of the future, such as CFM. The gradual buildup of capabilities will help avoid dead-end hardware. Anyone will be able to use the Gateway, which will be key infrastructure enabling the innovative activities of NASA and its partners. Architecture openness and resilience will allow the Gateway to add new items into the future.

Mr. Gerstenmaier noted that the Artemis program will not be a repeat of Apollo. NASA will leave things behind on the Moon in order to have infrastructure for subsequent efforts, enabling sustainability. While there has been much focus on “how” to go to the Moon, the question of “why” needs to be discussed, with the answers tested to see whether they are relatable outside of the space community. The Artemis program begins a new era of exploration. U.S. leadership in space exploration has been on a continuum, starting with Earth orbit, moving to lunar orbit and the lunar surface, and to Mars and beyond. These phases on the continuum are being worked on simultaneously and they feed on each other. It is not a linear progression.

For Artemis Phase 1, NASA has made strategic changes to features of the 2028 mission in order to make the 2024 target date. The Gateway had been conceived as a multi-element significant platform to an absolute minimum configuration for Phase 1, with Orion as a backup. The plan has dropped from four crew on the lunar surface, to two crew on the surface and two crew on orbit. Lunar access has gone from global to the South Pole first. Partnerships that were to involve commercial and international opportunities and interoperability standards now emphasize commercial engagement soon, though international opportunities. Interoperability standards will enable all partners. There is already European involvement, NASA is open to having the Canadian Arm if it is ready, and the Agency is having discussions with the Japanese Space Agency (JAXA) regarding potential contributions. Launch vehicles were to be the SLS and commercial, and now there will be more of the latter. Mission duration for the 2028 campaign was to be seven-day lunar sorties. Those will now be shorter if necessary. NASA will require organizational streamlining, which will involve breaking down some internal barriers. However, the Moon to Mars effort is based in HEOMD, which will work closely with STMD and SMD. NASA is backing out the requirements to determine synergies for commercial contracts.

As noted, the NASA budget amendment seeks an additional \$1.6 billion for FY 2020. This funding breaks out as \$1 billion to accelerate development of human lunar transportation systems to take astronauts to the lunar surface and back to the Gateway; \$651 million towards the completion of SLS and Orion; \$132 million for new technologies that help astronauts live and work on the lunar surface and in deep space; and \$90 million for science to increase robotic exploration at the lunar South Pole in advance of astronauts. Some Gateway activities were deferred to allow focus on Phase 1. NASA will not do an uncrewed demonstration of the lunar lander. The descent will be able to abort via the ascent vehicle at any point. The vehicle components will be flown uncrewed extensively.

Mr. Gerstenmaier reviewed the planned phases of Artemis, as well as the landers and payloads. An open acquisition architecture will allow adaptation and continuous learning mode. The NASA concept for the human landing system incorporates ascent, descent, and transfer vehicles. Some industry proposals combine two of these three vehicles. It is possible the Agency will choose dissimilar concepts from multiple providers; the plan is to select at least three, as there will be a need to take two to the end. The BAA facilitates seamless progress from design to study to development to hardware. The next step BAA enables a model contract from the beginning. An uncrewed Artemis flight will launch in 2020 or 2021 to orbit the Moon, conduct check out, and test the heat shield. NASA made some major changes in how it uses teams and in the SLS assembly. Many challenges remain for areas like wiring and testing, but things are moving forward. Mr. Gerstenmaier described each phase of the integrated Artemis manifest through 2024. There is some flexibility on launch vehicles, though the Gateway is essential for 2024. SMD will contribute via lunar science, specifically in the areas of polar and non-polar landers and rovers, orbital

data, and ISRU. CFM, SEP, and other crucial technologies are already in the STMD budget. Phase 2 of Artemis will emphasize sustainability at the Moon and on Mars via repeatable operations with reusable systems. Refueling will be investigated and optimized; it is the least mature area and needs a lot of work. The years 2025-28 will take the lunar campaign through Artemis 8.

This program has been discussed with the National Space Council, and Mr. Gerstenmaier has had informal discussions with staffers for the Congressional authorizing committees. There is much work to do with members of Congress, who have not yet been able to put their stamp on it. Gen. Lyles noted that the UAG hopes to go through this program in great detail and look at the trades that have been made. There is a misconception that NASA has not made enough trades, but that is not true. Mr. Gold said that a common misperception he hears on Capitol Hill is that NASA is sacrificing sustainability, and yet it sounds like that is the priority. He has also heard that there is insufficient international involvement, which seems to be another misconception. Mr. Gerstenmaier said that this is a large, extremely challenging endeavor that requires the best from everyone. Even universities can participate by looking at ballistic trajectories and other elements.

Human Exploration and Operations Committee Report

Mr. Wayne Hale, Chair of the Human Exploration and Operations (HEO) Committee, noted that the NASA Aerospace Safety Advisory Panel (ASAP), led by Dr. Patricia Sanders, can do “deep dives” while in closed session. He asked that the NAC recognize this. The committee wants NASA to be clear-eyed about human risk. While Artemis is the twin sister of Apollo, the Apollo Program lost three crew members on the ground and had additional close calls. Everyone needs to be aware of the possibility that Artemis will have similar losses.

Space Policy Directive-1 (SPD-1) calls for a sustained presence on the Moon. Sustainability requires that it be affordable, which in turn calls for reusability. The real question for the NAC to address – a question that the HEO Committee has addressed – has to do with the trade studies associated with the acceleration. NASA has been studying how to go to the Moon for decades, and there are now hundreds of hard engineering trade studies. The committee believes NASA is taking the right approach in using what it has. Some of the commercial rockets in development promise great capabilities, but SLS is the only one far enough along to be useful. Therefore, the committee reviewed all of the trades, and has come to believe that HEOMD is on the right track. In looking at the lunar architecture choices, it becomes clear that there will be more international involvement in 2028 than in 2024. If the lunar water can be used, that will revolutionize space travel. Regarding the lunar campaign stages, the current thinking is that the lander will have a transfer vehicle from the Gateway to the descent vehicle, which may be left behind. The ascent vehicle will go to the transfer vehicle, which will then return to the Gateway.

Among the key takeaways from initial internal architecture studies is that a single-stage human lander is not viable. The first element of the Gateway, the Power and Propulsion Element (PPE), is on contract with Maxar Technologies. Maxar’s PPE approach offers Electric Propulsion (EP), communications, solar, and navigation and control capabilities. It will be reusable and refuelable, and will serve as the keystone architecture for a number of years. Habitat testing is ongoing, with several companies involved. For Artemis 1, the SLS engine section assembly is nearly done and the “green run test” decision is pending, while core booster assembly has begun for Artemis 2. If conducted, the green run test would shift the schedule back somewhat; there are trades in terms of information, speed and risk. There is analysis showing the green run test might not be needed, but the concern is the “unknown unknowns.” Mr. Gerstenmaier explained that his internal recommendation is to do the test. If something goes wrong at Stennis Space Center, NASA can address it there, but not at Kennedy Space Center. Mr. Hale said that it is unlikely to affect the Artemis 2 schedule. SLS has started ordering long lead items. The MLP-1 is complete and about ready to roll to the launch pad for checking. Ground systems and software are on

track with the schedule. The question about the large upper stage is whether it can be ready in time. The Exploration Upper Stage (EUS) development is slow, and it is in negotiation for Artemis 3. Current SLS metrics indicate that things are on schedule, providing some confidence that it will come together.

ISS management is enabling great science and increasing time on research. They are now making provisions to allow spaceflight participants (formerly “space tourists”) in coming years. In the Commercial Crew Program, SpaceX had a successful uncrewed demonstration test flight (“Demo 1”) to the ISS in March 2019, and the Boeing Starliner uncrewed test flight is scheduled for August 2019. Both commercial providers would like to have crewed test flights by end of 2019. SpaceX is working through some anomalies, and both have testing and other work to complete. ISS has Soyuz seats available through 2020 if the commercial launches are delayed. The ISS is crewed by Increment 59 right now. For Increment 61, there could be an international seat available, which could go to a spaceflight participant. The Human Research Program (HRP) path to risk reduction for long-duration spaceflight shows a lot of work still to be done. NASA will need to continue the ISS for some time after 2024. The termination language is coming out, which will address that. There is a lot of work going forward. The committee also heard from the HEOMD Space Communications and Navigation (SCAN) office about their radio frequency/spectrum needs.

Mr. Hale noted that the HEO Committee recommendations are for the NASA Administrator, and some reinforce activities that are already occurring. The first recommendation addressed lunar plans:

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.

Discussion centered on whether this should be a finding or a recommendation. Mr. Hale explained that his committee wanted a stronger endorsement, but Mr. Borghese pointed out that other NAC committees produced findings to reinforce ongoing activities, and that is what this seems to be, rather than an actionable recommendation, i.e., for NASA to change actions and return to the NAC with an Agency formal response. Dr. Sanders said that there is a concern that NASA might not be able to continue in this direction if there are insufficient resources or other external influences that do not support it.

Gen. Lyles said he was leaning toward having this as a recommendation, then reviewing the Aeronautics Committee findings to see if any original recommendations that became findings should really be recommendations. The NASA response to a recommendation could be that the Agency is taking the action already. Sen. Nelson advocated being as strong as possible. Mr. Borghese pointed out that the Aeronautics Committee issue was that of a finding becoming a recommendation, with another recommendation on hold until the committee receives more information. Mr. Free asked that the TI&E Committee finding that the NAC changed to a recommendation stay as a finding. This was agreed upon. After deliberation, the NAC approved this recommendation.

The next HEO Committee recommendation was to continue use of ISS until other, commercial platforms become available in low-Earth orbit (LEO):

Continued 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.

Mr. Hale explained that commercial replacements for ISS will likely not be available by 2024. NASA had about a dozen people look at ISS commercialization, and the results were not encouraging: NASA would have to be the anchor tenant and a significant funder. There are commercial entities contemplating a station-like platform, but not in the near term. The HEO Committee felt strongly that ISS needs to operate past 2024. There was discussion of the wording, as “other commercial platforms” implies ISS is commercial, which it is not. Mr. Hale agreed, though the point remains that ISS will not last forever. Mr. Borghese observed that a previous NAC Chair would not send forward recommendations that required NASA to obtain extra funding, and both HEO Committee recommendations add costs to the current budget profile. Gen. Lyles was not sure this was ready to be a formal recommendation, as Mr. Bridenstine has already been explicit about the importance of LEO and NASA’s ability to do research in that environment. Mr. Hale agreed to table the recommendation and return with a more focused recommendation at the next NAC meeting.

The next HEO Committee recommendation had to do with streamlining NASA decision making.

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.

The current processes and culture are not appropriate to the new accelerated lunar program. In discussion, it was noted that other parts of NASA face similar challenges, and this recommendation from the NAC should go beyond HEOMD, to the NASA Administrator. However, NASA is taking steps to address this issue, and it was suggested that the NAC first learn about these activities. In light of the discussion, Mr. Hale responded that he would then make this a recommendation to Mr. Gerstenmaier, as some important decisions will be made about the lunar landing before the next NAC meeting. Gen. Lyles advised him to focus the recommendation on the need to better understand what is going on, with the immediate concern being the lunar lander. After deliberation, the Council approved this recommendation to the HEOMD Associate Administrator.

The final HEO Committee recommendation addressed NASA’s STEM activities:

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.

In discussion, it was noted that this recommendation was similar to Dr. Kennedy’s STEM Engagement Committee recommendation. Mr. Hale responded that there were subtle differences, and agreed to work with Dr. Kennedy on the recommendation from the STEM Engagement Committee to combine the two recommendations into one. After deliberation, the Council approved combining the two STEM-related recommendations into one recommendation from the Council to the NASA Administrator.

The HEO Committee also had a finding, commending the HEOMD Commercial Crew Program office and the Space Communications and Navigation office for their work in helping commercial programs address interagency bureaucracies. After deliberation, the Council approved the following finding:

NASA’s Commercial Crew Program office and the Space Communications and Navigation office have done excellent 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 U.S. 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 U.S. Government.

Council Discussion and Final Wrap-Up

Gen. Lyles noted that the next NAC meeting may take place at the NASA Stennis Space Center and may include a visit to Michoud Assembly Facility, probably during the last week of September 2019. He will be polling the NAC members in the near future for their availability on specific dates. He then asked Council members for their final thoughts.

Ms. Paquin said that for an “elevator speech,” they need to make sure they have the same questions in mind. Mr. Cole said that this NAC meeting was a good discussion, but they need more than 1.5 days for these meetings. Mr. Hale agreed. He would like to have more committee time and hear from someone other than just the top-level people. Gen. Levy thanked Ms. Rausch and her NASA support team. He agreed about the need for more time, which is more acute at a NASA Center where they usually have a tour. He wants to make decisions at NAC meetings, and have more candid dialogue. Dr. Sanders said she appreciated the opportunity to participate on behalf of ASAP. Gen. Lyles thanked Sen. Nelson for his participation, and he responded that it was a privilege to be a member of the NAC. Dr. Wadhwa said it was important to stay on top of the NASA budget reprioritization and avoid cannibalization of other NASA programs. Mr. Borghese stated that all of the presentations were very good. NASA’s ability to react quickly to the new lunar mandate for a 2024 landing is impressive. He also would like more discussion time, noting that other committees have had presentations sent out in advance so the members can read and think about them, then coming to the meeting prepared for debate. Dr. Axelrad asked for deeper discussions beyond the “motherhood and apple pie” talking points. The presentations could be tighter, starting with the recommendations and allowing Council members to read the other materials on their own. Gen. Lyles agreed to try to make it tighter.

In closing, Gen Lyles thanked the Council members for their dedication and time, and stated that he appreciated the opportunity to be part of the NASA Advisory Council.

Adjournment

The meeting was adjourned at 12:15 pm.

Appendix A

AGENDA

NASA ADVISORY COUNCIL

**NASA Headquarters
Program Review Center, Room 9H40
Washington, DC 20546**

May 30-31, 2019

PUBLIC MEETING

Thursday, May 30, 2019

10:30 am	Call to Order, Announcements	Ms. Diane Rausch Executive Director NASA Advisory Council
10:33 am	Welcome and Introductions by NAC Chair	General Lester Lyles Chair, NASA Advisory Council
10:40 am	Remarks by NASA Administrator	Mr. James Bridenstine NASA Administrator
10:50 am	Invited Guest Remarks	The Honorable Bill Nelson Former United States Senator (State of Florida)
11:00 am	President's FY 2020 Budget Request for NASA; NASA Budget Amendment (Humans to Moon 2024)	Mr. Brian Dewhurst Senior Budget Analyst NASA
11:30 am	Remarks by NASA Administrator	Mr. James Bridenstine NASA Administrator
12:00 noon	Lunch	
1:30 pm	Technology, Innovation and Engineering Committee Report	Mr. James Free, Chair
2:15 pm	Aeronautics Committee Report	Mr. John Borghese, Chair
3:00 pm	STEM Engagement Committee Report	Dr. Aimee Kennedy, Chair
3:30 pm	Science Committee Report	Dr. Meenakshi Wadhwa, Chair
4:15 pm	Council Discussion	
4:30 pm	Adjourn	

NASA Advisory Council Meeting, May 30-31, 2019

Friday, May 31, 2019

8:30 am	Call to Order, Announcements	Ms. Diane Rausch Executive Director NASA Advisory Council
8:32 am	Remarks by NAC Chair	General Lester Lyles, Chair NASA Advisory Council
8:40 am	Public Input	
8:45 am	Regulatory and Policy Committee Report	Mr. Michael Gold, Chair
9:45 am	NASA Human Exploration and Operations Update; Humans to Moon 2024	Mr. William Gerstenmaier Associate Administrator Human Exploration and Operations Mission Directorate, NASA
10:45 am	Human Exploration and Operations Committee Report	Mr. Wayne Hale, Chair
11:30 am	Council Discussion and Final Wrap-Up	All
12:00 noon	Adjourn	

Appendix B

NASA Advisory Council Membership

NASA Advisory Council Members:

General Lester L. Lyles, *Chair*

Dr. Penina Axelrad

Mr. John Borghese

Mr. Tony Cole

Dr. Alan H. Epstein, *Ex Officio*

Mr. James Free

Mr. Michael Gold

Mr. N. Wayne Hale

Dr. Aimee Kennedy

Lt. Gen. Lee Levy, II

The Honorable C. William Nelson, II

Mr. Miles O'Brien

Ms. Krista Paquin

Dr. Elisabeth Paté-Cornell

Dr. Patricia Sanders

Dr. Meenakshi Wadhwa

Ms. P. Diane Rausch, *Executive Director*

U.S. Air Force (Ret.)

University of Colorado, Boulder

Collins Aerospace

Attivo Networks

Chair, Aeronautics and Space Engineering Board

Peerless Technologies

Maxar Technologies

Special Aerospace Services and NASA (Ret.)

Battelle

U.S. Air Force (Ret.)

Former U.S. Senator, State of Florida

Independent Journalist

NASA (Ret.)

Stanford University

Chair, NASA Aerospace Safety Advisory Panel

Arizona State University

NASA Headquarters

Appendix C

Attendees

NASA Advisory Council Members:

General Lester L. Lyles, *Chair*
Dr. Penina Axelrad
Dr. Tony Cole
Mr. John Borghese
Dr. Alan H. Epstein, *Ex Officio*
Mr. James Free (*virtual*)
Mr. Michael Gold
Mr. N. Wayne Hale
Dr. Aimee Kennedy
Lt. Gen. Lee Levy
Mr. Miles O'Brien
Ms. Krista Paquin
Dr. Elisabeth Paté-Cornell
Dr. Patricia Sanders
Dr. Meenakshi Wadhwa
Ms. P. Diane Rausch, *Executive Director*

U.S. Air Force (Ret.)
University of Colorado, Boulder
Attivo Networks
Collins Aerospace
Chair, Aeronautics and Space Engineering Board
Peerless Technologies
Maxar Technologies
Special Aerospace Services and NASA (Ret.)
Battelle
U.S. Air Force (Ret.)
Independent Journalist
NASA (Ret.)
Stanford University
Chair, NASA Aerospace Safety Advisory Panel
Arizona State University
NASA Headquarters

NASA Attendees:

Ken Bowersox, NASA Headquarters
Kris Brown, NASA Headquarters
Ben Busran, NASA Headquarters
Steve Clarke, NASA Headquarters
Elaine Denning, NASA Headquarters
Prasun Desai, NASA Headquarters
James Favors, NASA Headquarters
Michelle. Gates, NASA Headquarters
William Gerstenmaier, NASA Headquarters
Beverly Girten, NASA Headquarters
G. Michael Green, NASA Headquarters
Christopher Ingraham, ISS National Lab
Marcia Joseph, NASA Headquarters
Mike Kincaid, NASA Headquarters
Chris Moore, NASA Headquarters
Toni Mumford, NASA Headquarters
V. Porshi, NASA Headquarters
Ursula Rick, NASA Headquarters
Irma Rodriguez, NASA Headquarters
Sam Scimemi, NASA Headquarters
Bette Siegel, NASA Headquarters
Roy Tiefex, NASA Headquarters

Other Attendees:

Neha Aggrud, Student
Alex Till, Student
Sirsha Bandla, Virgin Galactic
Alexia Boggs, Maxar Technolgies
Francesco Bordi, Aerospace
Kate Brownmiller, VACONS
Mary Floyd, Electrosoft, Inc.
Phoebe Kinzelman, National Academy of Sciences

NASA Advisory Council Meeting, May 30-31, 2019

Debra Moyer
Tommy Sanford, Commercial Spaceflight Federation
Elizabeth Sheley, Electrosoft, Inc.

WebEx Attendees:

Thomas Zurbuchen, NASA Headquarters
A.C. Charania, Blue Origin
Alanna Carnevale, Student, Georgia Tech
Ally O'Rourke, NASA
Alicia Brown, Senate Commerce Committee
Allison Leinder, NASA
Amir Delami
Ashley Wilkins, Health and Science Committee
Barbara Adde, NASA Headquarters
Ben Kall, Lewis-Burke Associates
Betty Siegel, NASA Headquarters
Bill Peterson, Self
Bobby Treece, Lockheed Martin
Brian Harvey, B&A Associates
Brian Safe, Exocent
Carol Hamilton, NASA Headquarters
Chris Gilbert, VE Consultant
Christin Sam, NASA
Christopher Ingraham, ISS National Lab
Darrell Branscome, NASA Consultant
Debra Moyer, Public Participant
Decia Woods, Dall
Doug Plata, Space Development Network
Ellen Grant, NASA Headquarters
Gene Mikulka, Talking Space
George Komar, NASA Headquarters
Gloria Carter-Cortez, NASA
Hashima Hasan, NASA Headquarters
Helen Grant, NASA Headquarters
James Dean, No Affiliation
James Lochner, Universities Space Research Association
James Miller, NASA Headquarters
James Zimmerman, International Space Services
Joan Collins
Joan Higginbotham, CAS
John Karct, Office of Management and Budget
John Rummish, SCT Institute
Johnny Behrens, AIP
Kaza Cortes
Keith Cowing, NASAwatch.com
Kelly Fast, NASA Headquarters
Kurt Lindstrom, Space Telescope Science Institute
Laura Chappell, Maxar Technologies
Linda Billings, NIA
Linda Karanian, Karanian Aerospace Consulting
Lisa Wood, Ball Aerospace
Logan Faulconer, Faulconer Consulting Group
Lucries Beck, George Washington University
Lynda Karanian, Karanian Aerospace Consulting
Marcia Smith, SpacePolicyOnline.com
Marla King, NASA (Ret.)

NASA Advisory Council Meeting, May 30-31, 2019

Marybeth Davis, Boeing
Mat Allen, Deep Space System
Michael New, NASA Headquarters
Naomi McGill, Researcher
Rachel Smith
Rob Landis, NASA
Robert Zimmerman, Symbiotek Systems
Sarah Noble, NASA Headquarters
Simera Fills, NASA
Steve Clarke, NASA Headquarters
Theodore Kronmiller, Law Office
Xaivian Raymond, NASA
Aedis Fole, Boeing
Al Tadros, Maxar Technologies
Amy Crane, NASA Glenn Research Center
Ann Yelle, NASA SLS Program
Ashley Edwards, NASA Headquarters
Barbara Addy, NASA Headquarters
Bethany Payne, NASA
Bob Dulli, Boeing
Chris Becek
David Hitt, NASA Marshall Space Flight Center
Denise Hill, NASA Headquarters
Dwayne Harvey, Dwayne Harvey and Associates
Eric Berger, Ars Technica
Erin Bozack, NASA
Erin Mahoney, NASA Headquarters
Glenn Guzick, ARAA
James Rice, Planetary Science Institute
Jeff Foust, Space News
Joan Higamock, Collins Aerospace
Jonathan Deenhart
Joshua Brost, Relativity
Katelyn Kuhl, NASA Headquarters
Kathryn Hambleton, NASA
Kay Anderson, Northrop Grumman Communications
Kelly O'Rourke, NASA Headquarters
Ken Shields, ISS National Laboratory
Kirstin Vanwychen
Loren Grush, The Verge
Marcia Lindstrom, NASA SLS
Miriam Karmer, AXIOS
Monica Vidaurri, NASA Goddard Space Flight Center
Nick Cummings, Space Tech
Pamela Workings, Boeing
Patricia Moore, NASA
Patricia Soloveichit, Boeing
Peter Montgomery, Jacobs
Rachel Kraft, NASA
Richard McKinney, Independent consultant
Sallie Bilbo, NASA
Sarhg Saikia
Simon Lobdell
Steve Chance, NASA
Steven Witkowski, MOOG
Tracy McMann, NASA

Appendix D

List of Presentation Materials

- 1) President's FY 2020 Budget Request for NASA; NASA Budget Amendment (Humans to Moon 2024) – Mr. Brian Dewhurst
- 2) Technology, Innovation and Engineering Committee Report – Mr. James Free
- 3) Aeronautics Committee Report – Mr. John Borghese
- 4) STEM Engagement Committee Report – Dr. Aimee Kennedy
- 5) Science Committee Report – Dr. Meenakshi Wadhwa
- 6) Regulatory and Policy Committee Report – Mr. Michael Gold
- 7) NASA Human Exploration and Operations Update; NASA Humans to Moon 2024 – Mr. William Gerstenmaier
- 8) Human Exploration and Operations Committee Report – Mr. Wayne Hale