National Aeronautics and Space Administration
Washington, DC

NASA ADVISORY COUNCIL

July 27-28, 2017

National Institute of Aerospace
NASA Langley Research Center
Hampton, VA

MEETING MINUTES

P. Diane Rausch
Executive Director

Lester L. Lyles
Chair

NASA ADVISORY COUNCIL

National Institute of Aerospace
NASA Langley Research Center
Hampton, VA

Public Meeting Minutes
July 27-28, 2017

Table of Contents

Meeting Report prepared by
Joan M. Zimmermann, Ingenicomm, Inc.

NASA ADVISORY COUNCIL

National Institute of Aerospace
NASA Langley Research Center
Hampton, VA

PUBLIC MEETING

July 27-28, 2017

Thursday, July 27, 2017

Call to Order, Announcements

Ms. Diane Rausch, Executive Director of the NASA Advisory Council (NAC or Council), called the second NAC meeting of 2017 to order, and extended a welcome to Council members and attendees. She explained that the NAC is a Federal advisory committee established under the Federal Advisory Committee Act (FACA), and as such, is subject to relevant Federal regulations and laws. The meeting is open to the public. She noted that formal meeting minutes would be taken and posted to the NASA website, *www.nasa.gov/offices/nac*, soon after the meeting. She further noted that each NAC member had been formally appointed by the NASA Administrator based on the member's individual subject matter expertise. All members are Special Government Employees (SGEs), subject to Federal ethics laws and regulations, and must recuse themselves from discussions on any topic in which there could be a potential conflict of interest. Ms. Rausch informed members, attendees, and speakers that all presentations and comments would be part of the public record.

Opening Remarks by NAC Chair

Ms. Rausch introduced the NAC Chair, General Lester L. Lyles, who welcomed all meeting attendees. He reviewed the day's agenda and led introductions around the table, adding that he was pleased to serve as Chair to the NAC's distinguished body of experts.

Welcome to National Institute of Aerospace

Dr. Douglas Stanley, President of the National Institute of Aerospace (NIA), the host institution for the NAC meeting, presented an introductory briefing. NIA is a 15-year-old research institute founded by seven different universities, including the Virginia Polytechnic Institute and State University, the University of Maryland, and the Georgia Institute of Technology. The staff on site is composed primarily of PhD-level researchers in areas such as planetary atmospheric modeling, materials, boron nitride nanotubes. NIA also supports a graduate education program with 40 students, and 10-15 faculty with laboratories. NIA has a rich history of research and presents a unique educational opportunity to its graduate students, in that they are able to take diverse courses from different universities. NIA produces NASA 360TV, and hosts a Facebook page with millions of followers, using these platforms to broadcast NASA events. NIA also produced large events like NASA's Langley's recent Centennial Gala and the 40th Anniversary of the Apollo program. NIA has roughly 100 full-time employees and students, and with its technology incubator, about 200 total participants. NIA was birthed by the NASA Langley Research Center. The Institute also does about $3M research annually with the Federal Aviation Administration (FAA), works via a Cooperative Agreement (CA) with the U.S. Army, and conducts low-Technology Research Level (low-TRL) research with major aerospace companies, such as Boeing Corporation. NIA currently holds no CAs with the U.S. Air Force (USAF), but would love to work with the Air Force Research Laboratory (AFRL).

Welcome to NASA Langley Research Center

Dr. Clayton Turner, Deputy Director of NASA Langley Research Center (LaRC), offered remarks about the Center's work. The Center's major focus areas lie in support for NASA Aeronautics; Earth Science; Technology; Mars Human Exploration; Space Launch System (SLS) testing; the utilization of the International Space Station (ISS) for the Earth Science Division (ESD) and technology development; Entry, Descent and Landing (EDL) systems; and Planetary Research. LaRC also performs basic research to mature technologies for industry, Department of Defense (DoD) partners, and the NASA Centers. The Langley vision statement includes on-demand air transportation concepts; understanding, adapting to and mitigating the Earth's climate system; and humans on Mars in the 2030s. LaRC plays a key role in materials and structures development for future Mars habitats. From a radiation protection standpoint, the Center also leverages the knowledge acquired from its long experience in aeronautics, monitoring the radiation exposure of high-altitude pilots. Dr. Turner displayed an excellent video depicting various research areas at the Center. He added further details on LaRC's air traffic operations laboratory, in which research moves forward on optimizing navigation, and the behavior of smart vehicles with human interaction. LaRC is being used as a city testbed simulator, in which the Center partners with the USAF to evaluate control algorithms in this sensitive airspace. For the NASA Journey to Mars, the Center is testing launch-abort systems, as well as a vehicle developed at the NASA Johnson Space Center (JSC) using ESD-developed laser/lidar technology, both to navigate terrain and to learn the parameters of energetic landings. Technology also drives exploration, and LaRC leads research in in-space assembly, and is partnering with other Centers in evolving robotic arms for low-Earth orbit (LEO) operations.

Dr. Turner described a number of advanced projects, including a current demonstration for industry for on-orbit assembly of an ISAAC robot, working with carbon-reinforced fiber. LaRC collects Earth Science data from airborne, shipborne, and orbital assets are monitoring sea rise and its effects on coastal cities, providing information to policy makers. From NASA's development of flexible, lightweight shields for EDL, LaRC leveraged this research to a create protection pack concepts to shield fire fighters in the field. The protection pack is being tested in southern Canada, under controlled fire conditions, and the U.S. Forest Service is evaluating it for use. The Center participates in NASA projects such as the SAGE-III instrument, and programs such as Orion, and is looking at both water- and Earth-landing concepts for space vehicles. LaRC is also trying to ease LEO models for industrial use and private industry, with the goal of making operations in orbit as safe and navigable as commercial aviation. Dr. Turner described his experience with his excellent team as generating much excitement and enthusiasm. General Lyles asked how LaRC was doing in terms of diversity, noting that the USAF currently has fewer minority pilots today than in the days of the Tuskegee Airmen. Dr. Turner replied that while there is always more to do, he felt that LaRC has changed the mindset, particularly in valuing different training experiences, and other points of view. Over time, he reported that he was seeing encouraging results in this area.

Remarks by NASA Deputy Associate Administrator

Ms. Lesa Roe, NASA Deputy Associate Administrator, as well as former Director of LaRC, delivered an update on the Agency. Since the last NAC meeting, NASA received its full Presidential Budget Request (PBR), representing a top-line total of $19.1B for Fiscal Year (FY) 2018. Congress is at present in the process of budget deliberation and mark-up. NASA believes that the overall Budget Request demonstrates the President's full confidence in NASA's direction and mission. The PBR bolsters Human Exploration deeper into space with support for SLS, Orion, the first un-crewed flight (EM-1) in 2019, and the building of a cadence of missions into deep space. The budget also continues to leverage NASA's unique missions into Science, Technology, Engineering and Mathematics (STEM) education areas; NASA remains committed to inspiring the next generation of scientists and engineers. Science funding is stable, but the PBR does direct termination of a number of Earth Science missions: Deep Space Climate Observatory (DSCVR) Earth-observing instruments Earth Polychromatic Imaging Camera (EPIC) and National Institute of Standards and Technology Advanced Radiometer (NISTAR), and termination of the Orbiting Carbon Observatory-3 (OCO-3), Plankton, Aerosol, Cloud, ocean Ecosystem (PACE), and Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder (CLARREO-PF) missions. NASA remains committed to studying the home planet and the universe with a wide range of science. The Asteroid Redirect Mission (ARM) has been terminated, but advancement of its supporting technology, solar electric propulsion (SEP), will continue, SEP being seen as vital for future deep space missions. The budget also supports continued work in advanced aeronautics programs,

such as X-plane. The National Space Council (NSpC) has been re-established by the Executive Order signed on June 30, 2017, by the President. It will be chaired by the Vice President, and will include representatives from NASA, the Department of State, and other Federal agencies in the Executive Branch, to coordinate matters of space policy and security. On July 6, 2017, Vice President Pence stated that first NSpC meeting would occur before end of summer 2017. Dr. Scott Pace, who has extensive experience with NASA, has been appointed to serve as Executive Secretary of the NSpC. There will be also be established User Advisory Group, a Federal advisory committee which will provide industry advice directly to the NSpC. The re-established National Space Council is considered to be important for the economy, the nation, and the planet as a whole.

Ms. Roe recounted recent NASA accomplishments of note. Astronaut Peggy Whitson broke her record stay aboard ISS, and is now in the process of extending it. Two hundred-one extravehicular activities (EVAs) have been performed on ISS since its inception. The ISS recently had two commercial resupply missions launched by Orbital Sciences and Space X. There are 330 distinct research tasks ongoing at ISS, including DNA sequencing and other fundamental biology and physics experiments. Commercial crew providers are making progress in securing successful, consecutive flights. This year 12 astronaut candidates were selected from over 18,000 applicants, while the NASA Kennedy Space Center (KSC) continues its transformation in order to accommodate SLS and Orion. Numerous related tests have been carried out at KSC. ICPS, the core stage components of SLS, has been delivered. Orion is undergoing assembly now, in preparation for Exploration Mission-1 (EM-1) test flight. NASA had briefly considered putting crew on EM-1, but ultimately decided against it. While the overall scenario is positive for Orion, much has been learned during the latest six-week testing period. NASA will be working this summer to set a new launch time for EM-1. Work also continues in space communications and the Tracking and Data Relay Satellite (TDRS), advancing space technology, small spacecraft, technology demonstrations, and commercial partnerships. A recent joint selection of the NASA Human Exploration and Operations Mission Directorate (HEOMD) and the NASA Space Technology Mission Directorate (STMD), the COBALT autonomous landing and hazard avoidance demonstration, is scheduled to hold a preliminary design review in August, to evaluate its SEP capability. Other small spacecraft demonstrations of optical communications, solar array, and cubesat proximal operations are also under way. NASA has selected 399 research and technology proposals to this end. In Aeronautics, a significant milestone in the Quiet Supersonic Transport (QUEST) project was reached, which is targeting a 2021 flight. NASA is also working with FAA in flying unmanned aerial vehicles (UAVs), with a series of tests held in June. More demonstrations are planned for 2018. Feasibility tests of a new electric propulsion architecture for hybrid electric propulsion technologies have recently been concluded.

Ms. Roe reviewed some of NASA's 104 missions currently in space, including the Galactic/Extragalactic Ultralong-Duration Balloon Spectroscopic Terahertz Observatory (GUSTO), the first balloon-based mission of opportunity in Astrophysics. The Earth Science Division's novel eight-cubesat constellation, Cyclone Global Navigation Satellite System (CYGNSS), has begun to make measurements of surface winds, thereby improving cyclone forecasting. In addition, numerous Juno science results have been published, generating interest across a broad spectrum of the public sector. Excellent images of Jupiter are being released, many of which have been created by "citizen scientists" using Juno data. The Cassini mission is in its terminal phase, and will be heading into Saturn's atmosphere in September 2017; the spacecraft is still making discoveries and finding evidence of life-supporting chemistry on the Saturnian moons. Planet candidates from the Kepler mission continue to add up. The James Webb Space Telescope (JWST) is proceeding apace to launch in 2018, and is currently being tested under thermal vacuum at JSC. NASA is also busy preparing numerous activities for a total solar eclipse in the U.S. contiguous states on August 21, 2017.

In closing, Ms. Roe stated that NASA is in good shape across the board, aided by millions of people engaged with the Agency through social media. She noted that NASA takes NASA Advisory Council advice very seriously, and thanked the Council for its close, focused attention to the Agency's programmatic and policy matters. Ms. Roe noted with regret that one of the Council members, The Honorable Marion Blakey, Chair of the Aeronautics Committee, would be resigning from the NAC in October 2017, after eight years of exemplary service. Ms. Blakey and her Committee have provided many excellent forward-looking recommendations, and excelled in forging consensus among diverse groups. NASA has been truly honored by her participation in the NASA Advisory Council. Ms. Roe then presented Ms. Blakey with one of the highest honors NASA bestows on a private citizen, the NASA Exceptional Public Service Medal. Ms. Blakey expressed her appreciation for

the high honor, noting her great admiration for NASA, its programs and people, and noting that receipt of the NASA Exceptional Public Service Medal was one of the true highlights of her professional career.

General Lyles thanked Ms. Roe for an outstanding, comprehensive report with an impressive list of NASA accomplishments. He asked her what more NASA might do to get the word out to the public on its programs, in addition to its excellent social media presence. Ms. Roe cited NASA public engagement through Instagram, Twitter, public school outreach, mission activities, internships, university leadership initiatives, and ISS, but added that NASA was always looking for new ways to tell its story. She welcomed more advice from NAC and its committees to better publicize NASA and its "civilization-changing" discoveries. General Lyles thanked Ms. Roe and the NASA Acting Administrator, Mr. Robert Lightfoot, for their outstanding work on NASA's behalf.

Institutional Committee Report

Mr. James Jennings, substituting for the Chair of the Institutional Committee, Ms. Kathryn Schmoll, provided a briefing that chiefly dealt with recommendations related to LaRC's Geographic Information System (GIS), a cost-saving practice of maintenance monitoring, and commendations regarding LaRC's leadership in innovation. Mr. Jennings noted there had been much activity in the Agency associated with the new Administration, dealing with reorganization and budget matters. Significant progress has been made in the development of the Agency Reform Plan, which has undergone public and legislative input sessions, and inputs from the Government Accounting Office (GAO) and the Office of the Inspector General (OIG). In parallel with the continuing Business Services Assessment (BSA), the Implementation Plan is now moving from the study phase to implementation. The Institutional Committee believes it important to have management involved in implementation, with communication a high priority. The Institutional Committee looked at strategic workforce planning efforts at LaRC, which was working on changing the mission versus support ratio. Of particular interest was LaRC's approach to increasing expertise in cybersecurity, using strategic viewpoints. General Lyles asked if there were a standard ratio at NASA. Mr. Jennings noted that the Institutional Committee had started to look at the ratios at NASA Headquarters after LaRC changed their ratio to 30% mission support. Right now, NASA Headquarters is 45% mission support. Industry tends to be about 25%. For mission support architecture to be managed functionally, Federal agencies should carefully transition to this state. At the end, good government is the primary goal. Future mission support criteria to create more efficient government must also, ideally, create room for investment. Mission support today is 17% of the annual NASA budget at $3.2B; the Institutional Committee thinks this number a little high. Going forward 10 years, mission support criteria should include: provision of more standardized services, with greater quality, accuracy, and flexibility at reduced costs; more reliance on shared service providers, and more operations working across geographic boundaries leveraging centralization, regionalization, and interdependence. NASA Headquarters should enable more integration and governance; provide more efficient resource trades across Centers and functions; create smaller infrastructure with fewer facilities; strive for a smaller total mission support workforce; and attain more flexibility to evolve the size of services through a higher percentage of contractors.

In considering the Office of the Chief Information Officer (OCIO), one question for the Institutional Committee had been about the reactive stance, or patching of IT problems, that are now being treated more centrally; e.g., increasing the cybersecurity effort along with an increased budget to support it, and restructured Center CIO reporting. Key drivers and input to these OCIO changes include BSA results, and input from the Office of Management and Budget (OMB), the Government Accountability Office (GAO), the Congress, and the NASA Executive Council tiger team. As a result, the Office of Government Reform (OGR) biennual Federal Information Technology Acquisition Reform Act (FITARA) scorecard for the NASA OCIO has increased from F to C+. Thus, the Agency can be said to making progress overall. General Lyles was surprised to see that the DoD score was the worst in the Federal government.

Mr. Jennings submitted a proposed Institutional Committee recommendations to the Council. Following discussion, the Council approved the following recommendation to the NASA Administrator:

> *The NAC Institutional Committee recommends that the Office of the Chief Information Officer (OCIO), in collaboration with the NASA Information Technology (IT) Council: develop and determine the content/methodology of a cybersecurity scorecard to be applied to each Center; limit the scorecard metrics to those that would foster continuous improvement to the Agency's overall cybersecurity posture, and complete the scorecard on a quarterly basis.*

Mr. Jennings submitted a second recommendation to the Council. Following discussion, the Council approved the following recommendation to the NASA Associate Administrator for the Mission Support Directorate:

> *The NAC Institutional Committee recommends that NASA develop and implement an Agency-wide strategy to utilize the Geographic Information System (GIS) to assist in managing NASA's aging infrastructure. The strategy should leverage the existing NASA Langley Research Center model and include Conditioned Based Monitoring (CBM) strategies and applications.*

Mr. Jennings explained that this second recommendation was based on LaRC's unique usage of GIS in a "best of breed" fashion. LaRC's GIS identifies such things as the presence of a foreign national in a building. General Lyles suggested that the Institutional Committee provide in the "major reasons for the recommendation" section an additional description about how it is used at Langley.

The Council then turned to a more general discussion on NASA's cybersecurity posture. Ms. Blakey asked how NASA treats mission security, noting that some of this discussion might have to be classified; some appropriately cleared NAC members might want to dig deeper. General Lyles cited an enterprise protection initiative, which is ongoing and mission-specific. Dr. Patricia Sanders, Chair of the NASA Aerospace Safety Advisory Panel (ASAP), related that security is not uniform across NASA, although some good work is being done in HEOMD, largely program by program. On the mission side, however, it is not as prevalent. NASA is beginning to take a cohesive look at it. Dr. Sanders agreed that NAC certainly needed to get into the classified arena to identify specific threats and technology. She stated that NASA still has a long way to go. General Lyles felt the NAC should identify what additional information would be necessary to obtain a greater understanding of cybersecurity at NASA, and possibly create a NAC subcommittee to look into it. There are both national and civil security implications to the answers. Dr. Elisabeth Paté-Cornell strongly supported a more uniform, coherent approach to cybersecurity. General Lyles suggested the NAC obtain a Defense Science Board study on the issue. Dr. Paté-Cornell remarked that there is also a National Academies study on the same subject. General Lyles said he favored the idea of a subcommittee. Dr. Alan Epstein suggested that the NAC read up on relevant, unclassified documents before its next meeting.

STEM Education Task Force Report

Dr. Aimee Kennedy, Chair of the STEM Education Task Force, began her report by providing a general overview briefing on the state of STEM in the U.S. Using Batelle as a case-study, she describing the Battelle STEM engagement strategy as a parable of learned lessons. The Battelle mission is to translate scientific discovery advances into societal benefits. As a large nonprofit, Battelle can invest in science and technology. Dr. Kennedy noted that she had worked on the technical challenges of STEM engagement as a school principal, teacher, and as a parent of a child at a STEM school. The state of STEM in the U.S. is middling; test scores in math and science, and reading, range in the middle of the pack globally. It is well-known that STEM and digital literacy are critical today and in the future. Future workers need a skill set that can solve problems for all jobs in all sectors. Parents want STEM education in their children's schools, but only half of parents believe it is a reality in their own child's school. Battelle feels effective grant-making changes this scenario. Battelle once took the broader "peanut butter spread" approach to grantmaking, but it lacked impact and did not create innovation. Resources were spread too thinly, and subsequently led to feelings of entitlement, dependency, and even resentment among grantees. Battelle therefore decided to employ "strategic philanthropy," in concert with strategic partners who demonstrate financial integrity. The current Battelle portfolio on STEM-focused philanthropy is $6.6M, which in turn is leveraged to manage $220M, to spread across country. The lesson here is: "Know your vision." Battelle regards the meaning of STEM also as "Strategies That Engage

Minds." In effect, the Battelle approach asks students to identify what to do with STEM knowledge. Another critical part of the Battelle strategy is to "pressure test" or pilot the idea, and get it right before scaling up. The first STEM school in Ohio was the Metro High School, which used a lottery to accept students. The school has a 100% graduation rate, with 85% of its graduates earning college credit. The school's ACT scores are above the state average. To expand, Battelle partnered with the Bill and Melinda Gates Foundation, which initially resulted in four new schools. Today, there are 40 STEM schools in Ohio. Expansion is now under way in Tennessee, with five new schools. Battelle's most recent national effort is STEMx, which counts 21 states/territories as members. The goal of STEMx is to amplify the STEM agenda. A Battelle-led consortium has since won a $185M, 10-year award to manage this effort as part of the Army Education Outreach Program.

Dr. Kennedy detailed Battelle's use of various data typologies in gauging the effectiveness of its programs. It's hard to get teacher effectiveness data, for example, but quantity matters. Quality also matters, as well as positive publicity and accolades from respected sources such as the White House, National Science Foundation, and National Public Radio. The ideal situation is to partner quantity and quality. Across divisions, Battelle also manages National Laboratories and makes use of their experience to advertise STEM careers. Battelle does not control the Laboratories' education and outreach strategies; instead it reports out what the Laboratories are doing both in terms of numbers, and in advertising such things as best practices, and detailed profiles of professionals working at the Labs.

Future STEM efforts at Battelle include a program featuring lightweight materials in advanced manufacturing, a maker-minded venture that uses fun and games to problem-solve. Battelle has partnered with Code.org to facilitate computer science training for teachers. These efforts bring STEM to bear as a tool for workforce and economic development. Currently, the timeline for a Federal agenda on STEM lacks certainty, but relationships do matter. One story can make all the difference. Dr. Ballhaus asked if the Ohio STEM schools had degrees appropriate to the subjects they taught, such as physics or mathematics. Dr. Kennedy replied that at Metro, teachers are not necessarily degreed in their fields. Battelle feels that it is better to teach a student how to arrive at an answer, including who or what to consult. Another approach is to bring in expertise and provide independent study opportunities with advanced instructors. Dr. Kennedy added that parents and grandparents often send implicit messages to children regarding their native abilities, and cautioned against inadvertently lowering expectations. Dr. Paté-Cornell supported the utility of linking relevant content to academic content. Dr. Kennedy agreed, describing a student exercise in formulating solutions to the opioid crisis, which delivered amazing results. Mr. Miles O'Brien asked what more NASA could do to support STEM, given the Agency's limited resources. Dr. Kennedy suggested recognizing that "one cannot boil the ocean," that decisions must be driven from clearly defined missions and strategic partnerships, and that transparency and cooperation among the NASA Centers to share what works are all key factors. NASA should also look outside itself and look to the nonprofit sector and to industry, and get mission-aligned in STEM.

Dr. Kennedy presented three findings from the STEM Education Task Force to the Council. Following discussion, the Council approved the first of these three findings:

> *We acknowledge the efforts of NASA and the Office of Education. The team has been executing the FY 2017 plan while simultaneously planning for FY 2018 while completing the process of the Business Services Assessment. The Task Force recognizes the pressure and complexity facing the team and we applaud them for their commitment and efforts to inspire the next generation of the NASA workforce.*

> *NASA has an opportunity to more significantly impact underserved and underrepresented communities through its programs and activities. The Office of Education can continue to work with the Office of Diversity and Equal Opportunity to ensure that we meet the needs identified by the Agency's Diversity and Inclusion Plan. NASA's commitment to reaching underrepresented and underserved communities has been a long-term priority throughout the history of its education activities.*

Our Task Force has had a chance to look at more of the BSA details, and we concur that the BSA efforts are addressing the issues that have been previously highlighted by the Task Force. The Task Force believes that the initial results have the potential to help NASA Education move forward in a more strategic and focused direction.

During the deliberations of these three findings, Dr. Penina Axelrad asked, apropos of the STEM workforce finding: Who is the Office of Education serving? Dr. Kennedy's view was that the mission of the Office of Education was to leverage NASA's ability to inspire teachers. Mr. Miles O'Brien asked if the Task Force had formulated quantitative goals for STEM education. Dr. Kennedy noted that such numbers were a work in progress. Dr. Ballhaus asked more to the point: What is the problem and how do we mediate it? Dr. Kennedy said the finding means to say to NASA: don't lose its engagement with the underserved and underrepresented. Dr. Kennedy noted that by the next NAC meeting, the Task Force will have addressed numbers and specific goals. General Lyles suggested that the second and third findings be combined, to focusing on what the BSA is actually doing, and gave an action to Dr. Kennedy to reformulate the language of the findings in the future.

Dr. Kennedy then presented two recommendations from the STEM Education Task Force:

Integrated Education and Outreach Strategy for NASA -- Regardless of the budget outcome, NASA would benefit from an integrated education strategy that includes HQ mission directorates, the Office of Education, and NASA centers.

The Ad-Hoc STEM Education Task Force should become a regular committee of the NAC.

The Council discussed the implications for action associated with the first recommendation, which had been provided in a slightly different form at a prior Council meeting. Dr. Epstein felt the implication of the recommendation is that an integrated strategy does not exist at NASA. Dr. Kennedy noted that this time the recommendation includes the entire Agency, not just the Office; however, the Task Force will also need to note that Office of Education is being terminated. General Lyles thought it would be more appropriate to reinforce the Task Force findings, recognizing that BSA is still in progress, and emphasize that the NAC will await results of BSA to ensure that each finding of the Task Force is being reinforced. As to the elevation of the Task Force to the NAC level, General Lyles suggested the NAC consider forming a combined STEM Education and Outreach Committee. Ms. Rausch noted that several years prior, the NAC had an Education and Public Outreach Committee, chaired by Miles O'Brien. The Council agreed to take up the idea with the incoming NASA Administrator, while sending formal comments to the current Administrator as to the sense of the Council. Ms. Blakey suggested that BSA go forward, in the meantime, to establish reporting relationships in this area. The two recommendations were not approved by the Council at this time.

NASA Science Mission Directorate Overview

Dr. Thomas Zurbuchen, Associate Administrator of the Science Mission Directorate (SMD), gave an overview of NASA's science mission, concentrating on three main topics: SMD's high-impact integrated portfolio; the role of innovation that enables ambitious science; and opportunities at the nexus of science and human exploration. The SMD consists of five divisions: Earth Science, Heliophysics, Astrophysics, and Planetary Science, as well as a joint partnership with the National Oceanic and Atmospheric Administration (NOAA) to advance weather forecasting models. SMD operates 104 missions, 87 spacecraft, 17 science cubesats and 11 technology demonstration cubesats, in addition to its a far-reaching and challenging research program which funds over 10,000 U.S. scientists through 3000 competitively-selected awards ($600M awarded annually). Innovative projects, such as using a balloon to detect fundamental physics data from ice cover at Antarctica, are emblematic of SMD's creativity and innovative spirit. The SMD portfolio consists of a diverse set of space missions, from the Lunar Reconnaissance Orbiter (LRO) currently operating at the Earth-Moon system, to several orbital assets and rovers at Mars, out to the Voyager spacecraft that is now far beyond the edges of our Solar System. The key science themes of SMD are discovering the secrets of the universe (fundamental research); searching for life elsewhere; and safeguarding and improving life on Earth. Fundamental research is truly interdisciplinary and has given rise to innovative technologies that are

now part of everyday life. Kepler results on exoplanets have transformed textbooks in terms of knowledge of our universe; these are civilization-scale, transformative activities. The Hubble Space Telescope (HST), for instance, has long pervaded the public consciousness through its well-known imagery of galaxies and star clouds. The science theme of searching for life elsewhere also leads to improvements in space weather forecasting and monitoring of near-Earth objects.

Fundamental research in Astrophysics has been enabled by HST, and will be similarly served in the future by the James Webb Space Telescope (JWST), and the next mission in formulation, the Wide Field Infrared Survey Telescope (WFIRST). HST is the most successful science asset ever built, engendering 15,000 scientific publications. All three telescopes were recommended by the Decadal Surveys in Astrophysics. WFIRST is a high-priority mission because of its field of view and increased accumulation times, which will provide a 100-fold improvement over the capabilities of HST to look at structures in the universe, and to identify where the energy in the universe resides. WFIRST's other main purpose is in advancing knowledge in characterizing exoplanets; since 1995, more than 4000 exoplanet candidates have been discovered. WFIRST is currently undergoing an independent review to enable all stakeholders to come to a better understanding of its cost; a final report is due in fall 2017. JWST has a potential conflict related to its scheduled launch time. The European/Japanese BepiColombo satellite is slated for launch at the same slot in October 2018, a problem that remains to be solved.

Dr. Zurbuchen displayed a high-resolution citizen scientist image of the cyclones at Jupiter's South Pole, noting also that Juno data has also yielded one scientific paper that is actually co-authored by a citizen scientist. He also presented images of Enceladus and Europa, highlighting plumes and ejecta that have been found to contain organics and dimolecular hydrogen, along with water. In addition, the Mars 2020 rover continues its development, within the cost limit, marking the beginning of the Mars Sample Return (MSR) program. Mars 2020 will take samples that will be cached and emplaced for future retrieval and return to Earth. SMD continues its progress in safeguarding and improving life on Earth. The Lightning Mapper on the GOES-16 satellite provides high-resolution imagery that will improve the accuracy of storm forecasts. SMD also studies the potential for space weather effects on infrastructure, the charging of ground systems, and means of protecting the power grid from solar events. SMD monitors near-Earth objects and asteroids, such as the large object that exploded over Chelyabinsk, Russia, in 2013. Fireball events happen every day; SMD is marking the first time we can predict and mitigate against such events.

Promoting innovation to maintain the health of the NASA mission, and advancing technological progress, are critical for the future of SMD. SMD is making a new commitment to fostering innovation, which will require a combination of incremental, breakthrough, disruptive, and game-changing events, all of which have varying impacts on the market. Dr. Zurbuchen cited the importance of disruptive innovations such as the advent of laptop computers, initially an underperforming technology, but one that illustrated a need/desire which drove subsequent improvements. SMD is working on game-changers such as deep space optical communications and the emerging small satellite (smallsat)/cubesat market. SMD is coordinated with STMD to take technologies from concept to Technology Readiness Level (TRL)-9; this requires regular coordination and maturation with the aid of the suborbital program. SMD also helps to enhance technology demonstrations, flying science instruments for modest amounts of money. Smallsats and cubesats also provide inexpensive hands-on training for the next generation of scientists and engineers. SMD also collaborates with HEOMD through the positioning of many science instruments aboard ISS, which provide Explorer-class science by measuring ozone levels in the atmosphere and viewing neutron stars. LRO continues to orbit the Moon; NASA has released a Request for Information to explore partnerships with commercial entities to take advantage of NASA's lunar asset. SMD is helping HEOMD to prepare for human exploration at Mars, studying space weather effects to protect the journey outward in a long Mars cruise phase. SMD is also preparing to explore icy ocean worlds. In tandem with HEOMD, SMD can benefit from SLS by getting the Europa Clipper to the Jupiter environment in three years, versus seven. HEOMD is also exploring human servicing and assembly of large space telescopes, and other orbital assets.

General Lyles stated his appreciation for the comprehensive review of the SMD and the NASA science portfolio, and lauded Dr. Zurbuchen's well-packaged and compelling presentation. Dr. Zurbuchen closed by reminding the NAC that he was looking for opportunities to showcase the power of science for all audiences, and welcomed recommendations on how to do this better. General Lyles took that statement as an action to all NAC members.

Science Committee Report

Dr. Bradley Peterson, Chair of the Science Committee, provided an update, beginning with a series of science results. The first coast-to-coast total solar eclipse since 1918, and the first just in the USA since 1778, will be occurring August 21, 2017. The shadow of the Moon moves about 1500 mph from west to east, and the typical duration of the eclipse in each area is about 2-3 minutes. The eclipse provides an opportunity to view the "night side" of the near side of the Moon, and NASA will use its numerous assets to view both the Moon and the Earth. The eclipse will also have a profound effect on the solar grid, expected to be much more significant than cloudiness. The Earth science instrument SAGE-III, which looks at the Sun or Moon as ISS crosses the limb, continues to measure the ozone profile of entire mesosphere; it is important to know these concentrations because chromosome-damaging ultraviolet-B (UV-B) is screened out by ozone. Fortunately, the even more energetic UV-C is screened out by nitrogen. CYGNSS, an eight-cubesat constellation that continuously and passively measures surface winds, will enable more accurate predictions of storm formation and evolution. Several NASA instruments observed the calving of Antarctica's Larsen C ice sheet on July 12, 2017, releasing an iceberg the size of Delaware, which upon melting will eventually cause a small rise in sea level. The 13-year Planetary mission at Saturn, Cassini, has begun its terminal phase, but is still making discoveries of new rings and taking high-resolutions images of Saturnian moons. In astrophysics, HST instruments have used quasar light to probe outflows (Fermi bubbles) in the Milky Way; the latest data indicate a quiescent black hole in the middle of the Milky Way galaxy. The results show that this black hole was once active 6-9 million years ago. HST has also observed recurring plumes on Europa (2014 and 2016), which appear to arise from a relatively hot spot on the icy body's surface. Over a period of years, HST acquired images of a massive, collapsing star that recently winked out, becoming a black hole. Kepler results thus far have shown a bimodal distribution of exoplanet sizes. Planets seem to come in two "flavors"—Neptune-sized and Earth-sized. JWST has been assembled and remains in cryovacuum (40°K) testing at JSC. Astrophysics missions in operations and development include the Neutron star Interior Composition Explorer (NICER) currently operating at ISS, and the 2018 Transiting Exoplanet Survey Satellite (TESS), which will succeed Kepler in surveying a larger field of view for exoplanets.

Earlier in July 2017, the NAC Science Committee held a joint meeting with the NAC Human Exploration and Operations Committee to explore areas of potential cooperation. There is already some coordination between SMD and HEOMD on ISS. The Science Committee and the Human Exploration and Operations Committee are now discussing the servicing and assembly of large space telescopes in LEO and beyond, leveraging its past experience with HST, which has informed the future design of space telescopes. It is now mandated by Congress that any future large telescopes must be serviceable in orbit. The mandate operates on the assumption that large complex systems have an inherent failure rate, thus it would be prudent to design for servicing from the start. These designs must be made robotic-compatible, safe but flexible on human rating, and accompanied by control and configuration documentation. The most advantageous locus for Astrophysics telescopes is the Sun-Earth Lagrange Point 2; there are also other loci that are easier to access, such as Earth-Moon Lagrange points, where telescopes can be assembled and then moved further out by a low-delta-v vehicle. Dr. Paté-Cornell remarked that redundancies are also needed for complex systems. Dr. Peterson agreed, adding that they were needed for such components as gyroscopes and reaction wheels, but not necessarily for instruments. To further elucidate the subject, the newly formed Future Assembly and Servicing Study Team (FASST), led by Dr. Ron Polidan, will be holding a technical interchange meeting at NASA Goddard Space Flight Center in early Novembe 2017..

Budget highlights for the science program include support for WFIRST formulation and the national Space Weather Strategy and Action Plan. Overall, the Science Committee deems the budget as "pretty good," although it notes with concern a 10% cut in the Earth Science budget that represents a devastating reduction for some programs. That the budget decrease was only 10% is a tribute to efforts at NASA Headquarters to explain to Congress and OMB the importance of the Earth Science mission. NASA's recent spinoff of the NAC science subcommittees to become independently chartered Federal advisory committees under the Federal Advisory Committee Act (FACA) has brought about new charges to the NAC Science Committee, one of which is to evaluate the SMD Research and Analysis (R&A) program. The Science Committee expects to have some preliminary findings before the next NAC meeting. The Science Committee is also carrying four specific recommendations from its Big Data Task Force, which it has sent back to the discipline committees to review before being sent up to the NAC. The Big Data Task Force has been taking a comprehensive look at NASA-wide Big Data needs, such as

data-mining, server-side analytics, and the data architectures needed for data-intensive modeling and simulation. Dr. Peterson agreed to pass on reference material and the Big Data Task Force draft report to NAC members in the meantime. In addition, the Science Committee has been asked to give input to what the NASA Office of Space Communications and Navigation (SCaN) and Deep Space Network (DSN) will need over the next two decades, in terms of science data transmission and tracking spacecraft. The Science Committee also heard a briefing by Dr. Anne Verbiscer, on the subject of asteroid 2014 MU_{69}, a Kuiper Belt target that the New Horizons spacecraft will visit in 2019. The briefing described a herculean, coordinated, multi-country effort to capture the occultation with a network of terrestrial telescopes; the data gathered from the successful observations will help to constrain the size and dust environment of the target, which will in turn further refine the trajectory of New Horizons as it passes by.

The Science Committee proposed a finding to be transmitted to the SMD Associate Administrator. Following Council discussion, the finding was approved:

> *The Science Committee (SC) and former Earth Science Subcommittee (ESS) support efforts to better assess socio-economic implications of improved Earth observations from space. Related to this topic, the Science Committee and former Earth Science Subcommittee support efforts to improve integration between Applied Sciences and Research, and the creation of the consortium to assess socio-economic values of improved Earth observations from space.*

The Science Committee and Human Exploration and Operations Committee proposed three joint findings. The first finding would go to the NASA Administrator. After discussion, the Council approved the following finding:

> *It is clear from the presentations and discussions during the joint session of the Human Exploration and Operations Committee and Science Committee that the NASA Human Exploration and Operations Mission Directorate and Science Mission Directorate re working well together, and have already identified opportunities for cooperation on future activities such as the Deep Space Gateway and servicing, and possible future assembly of deep-space telescopes. Both committees believe that this collaboration is beneficial to NASA.*

The second finding would go to the SMD and HEOMD Associate Administrators. After discussion, the Council approved the following finding:

> *Both the Human Exploration and Operations Committee and Science Committee were pleased that the servicing and assembly of large satellites, such as future deep space telescopes or other scientific instruments, is being explored by groups internal to NASA as well as groups representing broader communities that include NASA representation. The Human Exploration and Operations Committee and Science Committees believe that these efforts are valuable contributions for planning for the Deep Space Gateway which could enable or enhance on-orbit servicing or assembly of future space assets and potentially lower costs for large satellites.*

The third finding would go to the SMD and HEOMD Associate Administrators. After discussion, the Council approved the following finding:

> *Both the Human Exploration and Operations Committee and Science Committee commend NASA's efforts to maximize the science benefit of the Deep Space Gateway as specified in the existing Decadal Surveys and other key NASA science planning documents.*

The Science Committee and Human Operations and Exploration Committee issued a joint recommendation on mitigating space radiation risk:

The committees recommend that NASA accelerate efforts to reduce the radiation risk for future crews by exploring novel concepts for radiation shielding and improving deep space propulsion that would reduce transit time.

Dr. Ballhaus lent support to the Science Committee's estimation of the value of NASA's civil servant workforce, having had a similar discussion in his Technology, Innovation and Engineering Committee. Dr. Peterson felt it important to recognize that the NASA Centers exist to preserve knowledge. Dr. Ballhaus thought the NAC may need to look at this, as NASA has been forcing people to compete for resources when they should not have to do so. Dr. Peterson added that the Science Committee is starting to wrestle with the problem in terms of mission criticality. Dr. Ballhaus recommended that the Technology, Innovation and Engineering Committee should meet jointly with the Science Committee to discuss the matter further. General Lyles agreed to inform NAS Acting Administrator Lightfoot that the NAC is considering the problem.

Human Exploration and Operations Committee Report

Mr. Kenneth Bowersox, Chair of the Human Exploration and Operations Committee , reported on the most recent meeting of the committee. Major human exploration events since the last NAC meeting include a decision not to include crew on the EM-1 flight. In July, HEOC held a joint session with SC and discussed in-orbit service and assembly for space telescopes, and space radiation hazards, as partially described by Dr. Peterson. As HEOMD is a large organization, Mr. Bowersox reminded the NAC that this Mission Directorate is also responsible for Deep Space Network (DSN) operations and space communications. The DSN uses a cost-saving "Follow the Sun" operations approach, which is working well. HEOMD also provides launch services for all of NASA. Work is ongoing with commercial crew; at present there are many certification/validation efforts in progress. NASA hopes to see test launches of these new vehicles in 2018. Much work is also under way in preparing ground systems for Orion. On June 15, 2017, an Orion abort motor was successfully tested. Major progress has been made in the SLS program to construct a very large hydrogen tank. There are three crew members on ISS; three more are scheduled to arrive at Station on July 28, 2017. Dr. Whitson is due to come back to Earth in early September 2017; her record stay at ISS will be 8-9 months.

ISS Increments 51 and 52 have carried out many experiments and events. A very slow ammonia leak in External Active Thermal Control System (EATCS) Loop B has finally been isolated and will be permanently plugged once a repair protocol has been identified. The Zero Boil Off Tank investigation was launched on OA-7; it will explore cryogenic fluid behavior in a microgravity glovebox. The Station Explorer for X-ray Timing and Navigation Technology (SEXTANT) payloads is now aboard ISS. SEXTANT has the potential to advance deep space navigation, using pulsars as navigation beacons. HEOMD continues to expand human presence in space, using the strategic principle of fiscal realism. Much of the architecture is currently driven by fiscal constraint. HEOMD is addressing this by re-use of components when possible, thus also adhering to its architecture openness and resilience principle. The human push into space must also remain receptive to international partners and commercial entities, to participate and provide supplies.

A long-duration deep space Environmental Control and Life Support System (ECLSS) integrated demonstration is scheduled at ISS for 2022, while ISS is scheduled for decommissioning in 2024. The Human Exploration and Operations Committee believes with some trepidation that the demonstration will very likely require more than just two years. Mr. Bowersox displayed a notional design of the Deep Space Gateway (DSG), currently envisioned with xenon fuel and solar arrays as propulsion sources. Orion is being designed to dock with DSG for 30-40 day missions, initially. DSG orbits vary. Its default orbit is a near-rectilinear halo orbit (NRHO), but DSG can also orbit the second Earth-Moon Lagrange point, low lunar orbit (LLO), or elliptical lunar orbit (ELO). It is important to note in this context, how the reliability of systems in distant orbit may pose limitations. Some low-altitude-orbits may not support the solar array propulsion that is needed to raise the lower portion of orbit. The DSG schedule is under review. EM-1 is scheduled for 2019, its schedule having been delayed by a tornado at NASA's Michoud facility and other events beyond NASA's control. EM-2 may carry the Europa Clipper. A first crew on EM-3 is slated for the early 2020s, including transport of significant upmass (habitation module, airlock). SEP has not yet been proven for Deep Space Transport (DST), and will be tested with the DSG. DST is envisioned as launching in its entirety on one SLS launch in 2027. A DST shakedown cruise would follow in 2029, with a goal of orbital flight to Mars in 2030s. DST would come back and rendezvous with DSG/Orion. HEOMD is still discussing various future scenarios.

The Human Exploration and Operations Committee and Science Committee had an extensive discussion about radiation exposure, which presents the biggest challenge to humans on the cruise to Mars. Space radiation from both galactic cosmic rays and energetic solar particles damage the central nervous and cardiovascular systems, and increase cancer risk. NASA crew mission doses during Apollo and Shuttle missions ranged between 1-10 millisieverts (mSv). For a two- to three-year Mars mission, crews would receive up to 1000 mSv (one sievert). A day on the Mars surface is more like a day on ISS, in terms of exposure. Exploration of various shielding materials show that most materials improve in effectiveness as thickness increases, but then get actually worse due to scatter and induction of secondary particles. Shielding is not yet a solution to the problem. HEOMD is looking various mitigation strategies, including biological countermeasures, drugs, and selecting candidates with greater resistance to radiation. Mr. Bowersox agreed that the previously discussed Human Exploration and Operations Committee/Science Committee joint recommendation on radiation should be deferred until the whole NAC hears from space radiation analysts and medical officers. Mr. Bowersox stressed that the recommendation is not stating that the risk is unacceptable, and added that radiation is obviously not the only risk in deep space travel.

The Human Exploration and Operations Committee proposed a finding on the timing of the ISS Phaseout. After discussion, the Council approved the following finding:

> *The International Space Station (ISS) is a critical facility for development of systems that will be used for deep space exploration, especially for life support systems. Current projections show approximately two years of run time on deep space life support systems onboard ISS – in preparation for what may be a three-year crewed mission to Mars in the 2030s. While the official commitment to ISS currently ends in 2024, the Committee believes that it is likely that exploration development in low Earth orbit will need to be continued past 2024.*
>
> *Ideally, the end of government support for the ISS would be determined by clear criteria for its required use, availability of commercial alternatives, and would be a gradual reduction in support rather than a sharp cutoff at a fixed date. Early understanding of ISS availability after 2024 will improve the Station's science utilization and improve the likelihood that commercial providers will be able to sustain low Earth orbit operational capability after the government reduces support.*

Mr. Bowersox added that decommissioning ISS into the ocean may not be realistic. The modules are at different ages and in varying states of physical wear. One way to make ISS less expensive to operate is to make it smaller, or to invite commercial entities to add new modules. Dr. Ballhaus asked if an ISS continuation would affect the budgets of SLS and DSG; if this were so, it might be possible to accelerate testing of life support systems. Mr. Bowersox said the point of the HEOC finding was to highlight issues that need to be explored further. The Human Exploration and Operations Committee believes that it is likely that there will more LEO exploration testing beyond 2024. The Committee believess that NASA needs to take a broader look at both science and human exploration associated with ISS. The U.S. segment of ISS is good out to 2028.

General Lyles expressed appreciation to Mr. Bowersox for his report, and commented favorably on the breadth of HEOMD's technical progress.

Aeronautics Committee Report

Ms. Marion Blakey, Chair of the Aeronautics Committee, presented the committee report. She reported being down several of members at its recent meeting, but a robust discussion was nonetheless accomplished. The strategic thrusts for the NASA Aeronautics Research Mission Directorate (ARMD) remain a stable guidance structure which has proven valuable over time. The committee considers all aspects of the strategic thrusts over the year's meeting times. At the last meeting, the focus of discussion was the ARMD budget, the New Aviation Horizons Planning and Management, the University Leadership Initiative, and the Airspace Technology Demonstrator Overview.

Global growth in aviation is increasing dramatically, particularly in Asia and the Pacific region, while simultaneously a diminution in growth is being seen in North America and Europe. There is a real and growing competition for the future of aviation, with the advent of major models such as the Bombardier C series and the COMAC C919. Airbus Europe recently announced a hybrid electric aircraft, and China is doing extensive work in drone development.

Aeronautics is in good shape in the proposed FY 2018 budget. The House mark-up is closer to FY 2017 levels, thus the Aeronautics Committee feels that things are healthy. The budget will allow ARMD to address the importance of emerging markets, with an increased emphasis on electrification, noise, weather, autonomous and human integration, and how to integrate new and evolving technologies into air traffic systems. The budget also supports the development of high-altitude long endurance (HALE), and importantly, recognizes that NASA aeronautics is good business for the U.S.

The Aeronautics Committee proposed a finding to the ARMD Associate Administrator on the FY 2018 budget. After discussion, the Council approved the following finding:

> *The Aeronautics Committee believes that aeronautics is and will continue to be a strong factor for the U.S. economy. The Committee finds that NASA provided an excellent overview of the NASA Aeronautics portfolio and is appropriately supporting the spectrum of what is needed by both the traditional and emerging aviation communities. NASA is making excellent progress on its Low Boom Flight Demonstrator X-plane and the Committee endorses NASA's work in the New Aviation Horizons X-planes initiative and sees concrete benefits to the U.S. industry. The Committee continues to urge NASA to be aggressive in addressing the airspace integration, autonomy and other key needs for emerging aviation users.*

Dr. Ballhaus and Dr. Epstein noted that the finding could be made even stronger, given that aviation is a very strong factor for the U.S. export economy, as well as being critical to national defense and nation's infrastructure. The Council approved the finding without further change in wording.

Ms. Blakey addressed the New Aviation Horizons Initiative, an ambitious plan that will flight-test new technologies. NASA's leadership in new aviation technologies leads the way for the nation, increases confidence for industry, and also helps to train the next generation. Project Maxwell is a small electric vehicle that will fly in 2018, and testing of low-boom supersonic flight over land is continuing; the initial market is expected to be primarily for supersonic business jets, which will then expand to the commercial sector. Asked whether effects on the ozone layer have been assessed, Ms. Blakey did not know, but said she could obtain that information. At present, however, regulations prohibit supersonic flight over land, period. Dr. Epstein commented that this specific low-boom flight demonstration is intended to demonstrate full scale capability, and to generate data to inform the decision to relax the regulatory prohibition. As for the ozone issue, these are planes that are flying lower than 65,000 feet. A climate scientist will need to weigh in on the subject. Dr. Epstein noted that in fact the NOx emissions resulting from supersonic aircraft can actually mitigate the chlorofluorocarbons that are currently accumulated in the atmosphere. Ms. Blakey remarked that Lockheed Martin has done the initial design for the low-boom aircraft, and the understanding is that it is to be open-source. Dr. Epstein noted that the data being accumulated at Lockheed Martin is on annoyance to the population, and no other explicit technologies that are key to the program. Dr. Epstein felt that the annoyance data was the most useful part of the program, as the U.S. already knows how to build supersonic engines that fly for long periods of time (e.g., F-22). He added his concern that there are no FAA or International Civil Aviation Organization (ICAO) regulations on NOx emissions or noise for supersonic aircraft, and no one is going to invest in such aircraft unless there are regulations to follow. Ms. Blakey said that NASA research is covering acceptability studies, field studies, modeling tools, and ground testing.

The Aeronautics Committee proposed a finding to the ARMD Associate Administrator on the New Aviation Horizons initiative. After discussion, the Council approved the following finding:

The Aeronautics Committee strongly supports the NASA Aeronautics budget for X-planes and recognizes that NASA has worked very hard for the current budget levels. The Committee recommends that NASA should consider opportunities to integrate autonomous operations into the New Aviation Horizons initiative. The Committee also finds that NASA should be careful not to sacrifice other investments in emerging market areas (Unmanned Aircraft Systems, Urban Air Mobility, etc.) in the event of X-plane cost escalation.

Dr. Epstein observed that the X-plane program was very resistant to autonomous operations, regarding it as burden that does not directly address the technology they are trying to push forward. Ms. Blakey felt that the nature of the program could be shifted somewhat. Dr. Ballhaus particularly supported the finding language that warns against sacrificing other investments.

Ms. Blakey prefaced a proposed finding on the University Leadership Initiative (ULI) by noting that the latest round of awards were not the "usual suspects," and were better diversified, bringing exciting, unorthodox ideas to the table. In addition, ARMD is considering incentives to set aside some shorter duration awards, and incentivizing successful technology transition through award fees. The Aeronautics Committee proposed this finding to the ARMD Associate Administrator on the ULI. After discussion, the Council approved the following finding:

The Aeronautics Committee commends NASA for the effort to successfully launch the University Leadership Initiative (ULI). The Committee was very impressed with the objective and approach to the initiative, including the competitive award process used by NASA. There was expressed concern about the ability of the U.S. educational system to motivate students to pursue STEM careers. The Committee believes that ULI is a great example of an initiative that can address this issue. NASA has a great reputation worldwide and ULI should be amplified so that more students can take advantage of the opportunities offered.

Ms. Blakey introduced a finding on an air traffic management next-generation initiative, known as Airspace Transportation Demonstration (ATD). ATD-1, a three-aircraft test that used FIM as an arrival and sequencing tool, designed to reduce excessive spacing between planes, and reduce noise, emissions, and fuel usage. ATD-1 is transitioning to FAA at present for further evaluation. United took an aircraft out of service for three weeks to do this, highlighting the importance of FIM to the industry. ATD-3 will bring weather avoidance systems into the test regimen. The Aeronautics Committee proposed this finding to the ARMD Associate Administrator on ATD. Following discussion, the Council approved the following finding:

The Aeronautics Committee finds that NASA should further highlight to the public the contributions it is making to NextGen. The Airspace Transportation Demonstrations (ATDs) are providing tangible benefits to the airlines and flying public that are not widely recognized, but critical to fulfilling the NextGen vision. The Committee encourages NASA to push toward demonstrating higher levels of automation and autonomy to increase the benefits further.

General Lyles thanked Ms. Blakey for her excellent report and set of findings for NASA consideration.

Technology Innovation and Engineering Committee Report

Dr. William Ballhaus presented an update on the Technology Innovation and Engineering Committee. The Committee lacked only one member at its most recent meeting. The Committee heard presentations from Jason Crusan of STMD on the Habitation Capability Development, from Jim Reuter on the Centennial Challenges Program, and from the NASA Chief Engineer. The Centennial Challenges provides $1M in prize money for multi-year awards, and partners only with nonprofits. The program underwent an independent review, headed by Mr. Michael Seablom, which produced 17 findings on goals and objectives, and the cadence of awards. The Committee and STMD concurred on all the findings, which led to a committee observation that the independent review of the Centennial Challenges program appears to have been very effective and all the findings and recommendations are being accepted and implemented. The Committee endorsed the review finding: "NASA's Mission Directorates, in close coordination with the CCP, must significantly increase their roles into the crafting of future

challenges. Past experience in government and industry indicates that the impact and usefulness of the challenges, even those deemed successful, is highly diminished without such buy-in."

Dr. Ballhaus detailed the NASA Capability Leadership Roles activity, recently kicked off by the Office of the Chief Engineer (OCE) to address the issue of decreasing manpower at NASA. OCE is looking at proper alignment and establishing plans on based on strategic needs, and establishing standards and specifications. Ideally, management should start with zero resources and authority; the functional lead should own the process; be able to hire and fire people; and have appropriate tool allocation. In a typical commercial entity, the VP of engineering owns engineering tools, and has some level of check and balance on execution. It greatly benefits an organization to be able to benchmark tools, agree on a standard, and then make block buys based on these standards. If the same systems are used across the board, an organization can send people anywhere to troubleshoot. While NASA can use the NASA Engineering and Safety Center (NESC) for checks and balances, NASA doesn't "own" their people. The Committee believes that getting a broader view across the enterprise would be good for NASA in setting standards. Technical capability areas such as cryogenics, instruments and sensors, and system capabilities have been newly added to the activity. There is less manpower, thus NASA must be more efficient. Dr. Ballhaus and the Committee members believe that much credit is due to the NASA Chief Engineer and the NASA Acting Administrator in establishing this effort. OCE continues to support Agency-level actions and forward work items. The Committee offered thoughts and informal recommendations to the OCE following the update.

STMD briefed the Committee on the Technology Demonstration Missions (TDM) program. Dr. Ballhaus provided brief details of the Hypersonic Inflatable Aerodynamic Decelerator (HIAD), a prototype inflatable heat shield for entry mass at Mars. Major objectives of the TDM are to reduce structural mass by 30%, and costs by 30-50%. STMD has also undertaken a cryogenic fluid management (CFM) roadmapping activity, which resulted in. In July 2017, ARMD issued an RFI with the intent of establishing a public-private partnership with industry for the further development of CFM technologies in the functional areas of: storage, pressure control, transfer, and mass gauging.

STMD has a new strategic framework activity that is being modeled on what ARMD has done in past strategic planning exercises, with a focus on impacts, outcomes and challenges first. The challenge is to define outcomes, then organize the management framework as NASA shifts to customer-oriented, impact-centric focus. Mega-drivers (overarching trends) of the strategic framework are increasing access to space, accelerating the pace of discovery, supporting the democratization of space, and growing the utilization of space.

The Committee proposed finding in support of the STMD Strategic Framework. After discussion, the Council approved the following finding:

> *The Technology, Innovation and Engineering Committee agrees with the revised strategic framework presented by the Space Technology Mission Directorate (STMD). The Committee suggests two additional considerations within the Mega-Drivers: consideration of safety/risk (Increasing Access) and responsible stewardship/debris mitigation (Growing Utilization of Space). The outcomes are currently being defined, and the implementation plan and ownership of outcomes remain to be defined. The Committee will re-engage with STMD at the November 2017 meeting.*

Dr. Ballhaus concluded his presentation with a summary of space technology highlights: the SEP PDR in August 2017; the continuation of Restore-L, a satellite servicing demonstration that had been de-scoped to a ground-based activity, small spacecraft demonstrations in October 2017, DSAC/GPIM December 2017, and a Kilopower demonstration in January 2018. STMD infusion successes in FY 2017 include ROSA (roll-out solar array), which successfully proved the concept; a coronagraph design achievement of TRL-5; and a decision by the Boeing XS-1 project to use STMD-developed composite cryogenic tanks. FY 2018-2019 program highlights included plans to adopt RFID to identify inventory on ISS; the development of MEDLI2 for Mars 2020, to monitor EDL conditions; a high-performance spaceflight computing demonstration in April 2019; a three-year risk reduction activity for developing nuclear thermal propulsion using depleted uranium fuel elements, that would entail rocket engine design and cost estimates.

Friday, July 28, 2017

Call to Order, Announcements

The Council Chair, General Lyles called the meeting to order. Ms. Rausch made administrative announcements.

Opening Remarks by NAC Chair

General Lyles introduced the day's agenda and queried members for feedback. Dr. Paté-Cornell was impressed by the quality of the research presentations and the NASA Langley Research Center staff. Dr. Ballhaus echoed her comments and described great excitement at seeing the high quality of work at the NASA research centers. Mr. Bowersox appreciated the fantastic information and support, and stated he was already experiencing Ms. Blakey's departure from the NAC; Dr. Sanders appreciated the opportunity to be present at the NAC meeting. General Lyles felt that the Nation was blessed by having LaRC and its excellent workforce. Mr. O'Brien praised Dr. Turner's NASA Langley Research Center video for its effective public affairs messaging and educational aspects. He felt there were lessons learned for other agencies in the way the video told its stories, which was important for address the educational gaps. Mr. Hale noted that LaRC had been instrumental in the Return to Flight for the Shuttle program, and employed an impressive group of people in supersonic flight. His only regret that the tour was not longer. Dr. Axelrad said she had enjoyed the NAC meeting very much, and was particularly happy to hear about HEOMD/SMD collaborations. Dr. Epstein noted he was happy to be a part of the NAC.

Public Input

During the public input period, David Garr of Jacobs Technology encouraged NASA to work with NSF on grants management in the area of education.

NASA Langley Research Center "Early Career" Employee Presentations

The NAC heard presentations from three "early career" employees who worked at NASA Langley Research Center.

The first presentation was by Ms. Christy Funk. She presented, *"Cocktails and Dreams: A Bartender's Guide to Creating The Right Stuff,"* recapping and updating her NASA story that had begun in 2014 and which she had presented to the NAC at a previous meeting. Prior to coming to NASA, Ms. Funk had worked in the restaurant and bar management industry, and was at that time also pursuing a nontechnical Master's degree in aeronautics. While living in the area, she described having met many NASA employees who visited her establishment. One of them was Debbie Murray, a Program Manager (PM) for LaRC's Summer Scholars program. After discussing her interest in joining NASA with Ms. Murray, Ms. Funk received an email from Walt Silva, a scientist studying aeroelasticity, who was looking to staff his team with someone who possessed MATLAB expertise. After being turned down for the slot due to lack of such experience, Ms. Funk taught herself the program, after which she asked Dr. Silva to reconsider her abilities and was brought on to his team. Her next step was to pursue a Master of Science in aerospace engineering, after which she was accepted into the NASA Pathways program. NASA made her an offer to stay on and work on the Truss-Braced Wing. Citing the "Art of Strategic Mixing," Ms. Funk described the ability of a vision to pull one along a path as she sought the right mix of skills. In 2015, she was accepted to the NASA FIRST program, a year-long leadership program in which she helped to design the Center's Centennial celebration, including its iconic aerial "100" photo. Continuing her personal theme of investing, seeking growth, and taking risks, Ms. Funk sought a detail in the Regional Economic Development Program, where she learned that leadership is a tricky thing, and credited her mentor Clayton Turner with teaching her that a leader can lead from any chair, and that followers are a direct reflection of leadership style. She still watches other leaders to learn from them, and mimics the habits of leaders that she respects and admires. Describing her current work with Program Managers at NASA Headquarters, she expressed her strong belief in making a positive impact on Agency culture in an era of shifting priorities. General Lyles asked Ms. Funk how she meant to

stir up interest in STEM and technology in more diverse populations. Ms. Funk cited her involvement in the Entrepreneurial Operation Program, which enables researchers to interact with industry; she also participates in Outreach activities, particularly for girls. She further described NASA's local efforts in a regional economic development program, wherein STMD is helping to open gateway to Federal laboratories to help companies overcome obstacles. The effort is seen as a two-way street. The program is in its infancy stage, and LaRC is working to extend out from Hampton to greater Virginia. Mr. Hale lauded Ms. Funk for how she exemplified diversity in thought processes, with her out-of-box background and experience, which leads to better problem-solving. He congratulated the NASA Langley Research Center leadership for bringing Ms. Funk onboard as a NASA employee.

The second presentation was by Mr. Luke Murchison. He presented, *"On-Orbit Autonomous Assembly from Nanosatellites."* Mr. Murchison is structures analyst, and described his early experience with NASA. He discovered NASA's Cooperative Education (Co-Op) Program when he was attending community college. He subsequently transferred to the University of Washington, where he decided he really wanted to be part of NASA's mission after three rotations as an intern. He was hired into the Structural and Thermal Systems Branch in 2011. As a structures analyst who tended to hop on and off projects, he found himself yearning to look at how projects were run across their entire lifecycle. He joined STMD's Early Career Initiative in 2014, which allows participation in a project from proposal through design, assembly, integration, testing, and execution. It is a hands-on, rapid execution experience, which allowed him to grow beyond his original discipline, testing predictions and analyses, and become a better engineer. Mr. Murchison currently has a B.S. in mechanical engineering, and is now considering a M.S. in systems engineering at Georgia Tech; NASA will pay all tuition if his degree aligns directly to NASA work. Dr. Ballhaus noted that 25 years prior, NASA Ames Research Center would send new hires to Stanford University to get their advanced degrees; it was a good model to support diversity efforts. Asked what he would like to do next, Mr. Murchison said he wanted to focus on clear and efficient communication, and hoped to continue to evolve the infrastructure at LaRC to automate data exchanges for more efficient data analysis.

The third presentation was by Dr. William P. Leser. He presented, "*Reducing Uncertainty in Reliability of Structures and Materials."* He is an aerospace engineer who received his Bachelor's through Doctoral degrees at North Carolina State University, recounted his story. He started as a graduate student in 2009 in the Langley Aerospace Research Student Scholars (LARSS) program, followed by Pathways in 2012. He started out in a research project called Sensory Alloys, monitoring structures for damage via passive (acoustic) emission, and improving aluminum alloys with shape-memory materials. For his doctoral thesis, he created a proof of concept, for which he won an ICAS/IFAR award for thesis contributing to advances to aeronautic science. He then applied to ARMD's early career program, a two-year rapid development program, and is now working on Digital Twin in the Convergent Aeronautics Solutions (CAS) program, to improve probabilistic predictions of material failure. Using concepts for F-35 tooling, for example, the program has successfully completed a feasibility assessment. He has been asked to join NESC's Frangible Joint Assessment project to study the physics of frangible joint operation, ultimately to assess their safety for human-rated space flight. General Lyles asked why NASA had been slow to adopt Digital Twin, as the USAF has used it for some time. Dr. Leser felt it might be a case of "doing it the way it's always been done," but that he had been seeing more acceptance. Dr. Ballhaus praised the way in which the Early Career program encouraged technically deep research.

Update on President's Proposed FY 2018 Budget for NASA

Mr. Andrew Hunter, Acting Chief Financial Officer, gave a budget presentation that included Congressional markups. The focus right now is on FY 2018, as the House is moving aggressively to mark up the PBR for NASA at about $220M above the FY 2017 level. NASA considers itself fortunate compared to other agencies. The Senate is being more conservative, and there are still Budget Control Act caps to consider, but its markup is still $437M above the FY 2018 PBR, a very good picture all around. Asked if there were concerns about bundling with the defense package, Mr. Hunter allowed that yes, there have already been some hiccups. NASA knows there is no surefire strategy to getting an agreement on the PBR, and is prepared for yet another Continuing Resolution. There is also serious threat of a U.S. Government shutdown pending future debt limit discussions. The main thing to note about the Congressional markups is that Earth Science benefits more from the Senate markup (which restores terminated missions), compared to an additional reduction to Earth Science from the House

markup. On the other hand, Planetary Science was given an increase by the House. On the Senate side, it should be noted that there is no mention of Europa, but Aeronautics and Space Technology were increased. There is additional language on the Restore-L project as well. There are no major differences for Space Operations or Commercial Crew. While Education was zeroed out by the current PBR, the House put back $90M but did not add back SEAP; the Senate did add back SEAP. All in all, NASA is in relatively good shape given the dramatic conditions on the Hill.

The budgets have a flat runout to FY 2022. NASA now knows the areas that Congress wants addressed. Mr. Hunter's surmised that NASA may go well into the next year with a Continuing Resolution at FY 2017 levels. NASA has made the point that flat outyear budgets are harmful for the contents of the Agency program, and will continue to request levels of funding with inflation built in. NASA intends to do this with the FY 2019 request. General Lyles commented on the hard work of NASA leadership and the value of NASA programs to the country overall as being supportive of a healthy budget. Mr. Hunter added that NASA has been bolstered by strong support from Congress and from the NASA Transition Authorization Act of 2017. Within the broader context of a $54B reduction in nondefense spending, the Department of Veteran's Affairs was only agency that received at a slightly higher PBR, so NASA suffered very little by comparison. $19.1B is a good budget: it continues private/public partnerships; reflects continuity of purpose; supports building infrastructure for deep space; continues development of SLS, Orion, and exploration ground systems, and STMD's SEP and laser communications for future missions; and supports ISS through 2024. It is a good budget for science as it supports both researchers and missions and reinvigorates Europa exploration. The Earth Science program is still substantial despite targeted terminations. The budget does not support a Europa lander, however, though it continues to supports the fly-by concept. The PBR keeps unmanned aircraft systems in play, an expanding area for the nation. The budget also supports the first X-plane flight in 2021, with a cadence for every four to five years. The Agency is reexamining how NASA will deliver education, and will continue to do this through the 2019. The budget also strengthens cybersecurity with a $32M influx. Anticipated accomplishments in 2018 include continuing a Broad Area Announcement (BAA) on developing habitat prototypes; further development of SLS and Orion; the launch of JWST, ICON, Mars InSight, TESS, and Solar Probe Plus; and an STMD laser communication demonstration. NASA missions are well supported out to 2022; there is healthy business ahead in launch activity for the Agency.

NASA will submit its FY 2019 budget in September 2017, and has submitted an Agency Reform Plan, responding to the America First budget blueprint and specific guidance from OMB, including making plans for long-term workforce reductions. Mr. Hunter assured the NAC that there are no reductions in force in sight, but NASA continues planning for absorption of skill sets. NASA's draft Reform Plan was well received by OMB; remarks should come back soon. The Agency also proposed some legislation based on 183 "unbounded ideas" gleaned from NASA employees. NASA is well-ranked within the federal government, and is working to stay ahead of the curve on planning for lean, more effective, efficient, and accountable government. General Lyles remarked that it was heartening to see what NASA is already doing to address reform and maintaining a good business sense. He asked that Mr. Hunter's NASA Mission Launches chart, describing launches from FY 2017 through FY 2022, be expanded to other formats to better present this story to the public.

Council Discussion and Final Wrapup

The Council wrapped up its session. Mr. O'Brien, who had been monitoring Twitter for the duration of the meeting, reported general quietude, and encouraged the NAC to explore video streams as well as other means of improving public engagement. General Lyles said he was anxious to do business differently. Several suggestions arose, including considering venues that are more familiar to the public, such as universities, the Hampton Coliseum, air shows, the National Space Symposium, the Air and Space Museum, Kennedy Space Center, Town Halls, or roadshows. Federal Register advertisement was agreed to be highly insufficient for this purpose. General Lyles suggested having one meeting per year at a more public domain. Dr. Epstein felt that since NASA had no big issues at the moment, little public comment was to be expected. He thought the NAC might focus its agenda on issues that interest the public, experiment with meeting places and topics, and then review lessons learned. Mr. O'Brien noted that NASA has a constituency of uninformed people that it needs to think about.

Reviewing the next few months, the Council explored ways to keep up to date. Mr. Hale suggested that a subset of NAC members attend a Business Services Assessment report session. Dr. Sanders suggested holding "insight" meetings, wherein one or two members sit down with a project or program when a specific area of interest arises. Ms. Rausch updated members on the Congressionally mandated independent review of the NAC by the National Academy of Public Administration (NAPA), per the NASA Transition Authorization Act of 2017. General Lyles stated he may convene a future NAC teleconference on this matter. Dr. Epstein recommended digging deeper with the CFO. Dr. Ballhaus thought an assessment from someone who has oversight of the Standing Review Boards would be valuable, to get ahead of issues before the GAO or NASA Office of Inspector General (OIG) brought them up. Ms. Rausch gave background on the "NAC work plan" concept, in which the NAC received Agency direction on the main issues to focus on in a given year, based on polling from NASA senior management. In the past, the NAC would examine 6-10 "NAC work plan" issues per year. General Lyles then asked each NAC member to send him their top issues for NASA, after which he could socialize a "top ten" list with NASA Headquarters, as a potential "NAC work plan" for the coming year..

A query once around the table revealed no further issues. Ms. Rausch thanked NASA Langley Research Center and the National Institute of Aerospace for their excellent support of the NAC meeting.

General Lyles adjourned the meeting at 11:11am.

APPENDIX A

AGENDA

NASA ADVISORY COUNCIL

National Institute of Aerospace
NASA Langley Research Center
Hampton, VA 23666

July 27-28, 2017

PUBLIC MEETING

Thursday, July 27, 2017

9:00 am	Call to Order, Announcements	Ms. Diane Rausch Executive Director NASA Advisory Council
9:05 am	Opening Remarks by NAC Chair	General Lester Lyles Chair, NASA Advisory Council
9:15 am	Welcome to National Institute of Aerospace	Dr. Douglas Stanley President and Executive Director National Institute of Aerospace
9:20 am	Welcome to NASA Langley Research Center	Dr. Clayton P. Turner Deputy Director NASA Langley Research Center
9:35 am	Remarks by NASA Deputy Associate Administrator	Ms. Lesa Roe Deputy Associate Administrator NASA
10:15 am	Break	
10:30 am	Institutional Committee Report	Mr. James Jennings *(for Kathryn Schmoll, Chair)* Institutional Committee
11:00 am	STEM Education Task Force Report	Dr. Aimee Kennedy, Chair STEM Education Task Force

11:45 am	Council Discussion	All
12:00 noon	Lunch	
1:00 pm	NASA Science Mission Directorate Overview	Dr. Thomas Zurbuchen Associate Administrator Science Mission Directorate NASA
1:45 pm	Science Committee Report	Dr. Bradley Peterson Chair, Science Committee
2:30 pm	Break	
2:40 pm	Human Exploration and Operations Committee Report	Mr. Kenneth Bowersox Chair, Human Exploration and Operations Committee
3:25 pm	Aeronautics Committee Report	Ms. Marion Blakey Chair, Aeronautics Committee
4:10 pm	Technology, Innovation and Engineering Committee Report	Dr. William Ballhaus Chair, Technology, Innovation and Engineering Committee
4:55 pm	Council Discussion	All
5:15 pm	Adjourn	

Friday, July 28, 2017

9:00 am	Call to Order, Announcements	Ms. Diane Rausch Executive Director NASA Advisory Council
9:02 am	Opening Remarks by NAC Chair	General Lester Lyles Chair, NASA Advisory Council
9:10 am	Public Input	
9:20 am	NASA Langley Research Center "Early Career" Employee Presentations:	
	Cocktails and Dreams: A Bartender's Guide to Creating "The Right Stuff"	Ms. Christy Funk Langley Regional Economic Development Lead Office of Strategic Analysis, Communication and Business Development NASA Langley Research Center

	On-Orbit Autonomous Assembly from Nanosatellites	Mr. Luke Murchison Principal Investigator for On-orbit Autonomous Assembly from Nanosatellites Structural and Thermal Systems Branch Engineering Directorate NASA Langley Research Center
	Reducing Uncertainty in Reliability of Structures and Materials	Dr. William P. Leser Principal Investigator for Digital Twin Project, Convergent Aeronautics Solutions Durability, Damage Tolerance and Reliability Branch Research Directorate NASA Langley Research Center
10:00 am	Update on President's Proposed FY 2018 Budget for NASA	Mr. Andrew Hunter *(via telecon)* Chief Financial Officer (Acting) NASA
10:30 am	Council Discussion and Final Wrapup	All
11:30 am	Adjourn	

APPENDIX B

COUNCIL MEMBERSHIP

NASA ADVISORY COUNCIL

Membership – July 2017

NASA ADVISORY COUNCIL

Membership Roster

Position	Council Members
Chair – NASA Advisory Council	**General Lester Lyles,** *USAF (Ret.)*
Chair – Aeronautics Committee	**The Honorable Marion C. Blakey,** *President and CEO, Rolls Royce North America; Former Administrator, Federal Aviation Administration*
Chair – Human Exploration and Operations Committee	**Mr. Kenneth Bowersox,** *U.S. Naval Aviator (Ret.); Former NASA Astronaut*
Chair – Institutional Committee	**Ms. Kathryn Schmoll**, *Vice President, Finance and Administration (Ret.), University Corporation for Atmospheric Research*
Chair – Science Committee	**Dr. Bradley Peterson,** *Professor Emeritus, Former Chair, Department of Astronomy, Ohio State University*
Chair – Technology, Innovation and Engineering Committee	**Dr. William F. Ballhaus, Jr.,** *President and CEO (Ret.), The Aerospace Corporation; Former Director, NASA Ames Research Center*
Member at Large	**Dr. Wanda M. Austin**, *President and CEO (Ret.), The Aerospace Corporation*
Member at Large	**Dr. Penina Axelrad,** *Professor and Chair, Department of Aerospace Engineering Sciences, University of Colorado, Boulder*
Member-at-Large	**Mr. N. Wayne Hale,** *NASA (Ret.), Consultant, Special Aerospace Services*

Member at Large	**Dr. Elisabeth Paté-Cornell,** *Professor and Founding Chair, Department of Management Science and Engineering, Stanford University*
Member at Large	**Mr. Miles O'Brien,** *Independent Journalist*
Ex Officio Members	**Dr. Alan H. Epstein**, *Chair, Aeronautics and Space Engineering Board, National Academy of Engineering* **Dr. Fiona A. Harrison,** *Chair, Space Studies Board, National Academy of Sciences*

APPENDIX C

NASA ADVISORY COUNCIL

MEETING ATTENDEES

NASA Advisory Council Members:	
General Lester L. Lyles, *Chair*	U.S. Air Force (Ret.)
Dr. Penina Axelrad	University of Colorado, Boulder
Mr. Kenneth Bowersox	U.S. Navy (Ret.)
Dr. William Ballhaus	The Aerospace Corporation (Ret.)
Ms. Marion C. Blakey	Rolls Royce North America
Dr. Alan H. Epstein, *Ex Officio*	Chair, Aeronautics and Space Engineering Board
Mr. N. Wayne Hale	Special Aerospace Services, NASA (Ret.)
Mr. James Jennings	*(sub for Ms. Kathryn Schmoll)*
Dr. Aimee Kennedy	Battelle
Mr. Miles O'Brien	Independent Journalist
Dr. Elisabeth Paté-Cornell	Stanford University
Dr. Bradley Peterson	Ohio State University
Dr. Patricia Sanders	Chair, NASA Aerospace Safety Advisory Panel (ASAP)
Ms. P. Diane Rausch, *Executive Director*	NASA Headquarters
NASA Attendees:	
Cockrell, Charles	NASA Headquarters
Denning, Elaine	NASA Headquarters
Girten, Beverly	NASA Headquarters
Gould, Dana	NASA Headquarters
Green, Mike	NASA Headquarters
Healy, Edward	NASA Headquarters
Irvine, Lynn	NASA Headquarters
Kincaid, Mike	NASA Headquarters
King, Marla	NASA Headquarters
Lawson, Donna	NASA Langley Research Center (LaRC)
Mazanek, Dan	NASA Headquarters
Mellado, Ray	NAC STEM Education Task Force
Mullins, Todd	NASA Headquarters
Neil, Doreen	NASA Headquarters
Radford, Amy	NASA LaRC
Reuter, Jim	NASA Headquarters
Roe, Lesa	NASA Headquarters
Rodriguez, Irma	NASA Headquarters
Siegel, Bette	NASA Headquarters
Trotta, Ann Marie	NASA LaRC
Turner, Clayton	NASA LaRC
Williams, Greg	NASA Headquarters
Other Attendees:	
Floyd, Mary	Ingenicomm, Inc.
Garner, David	Jacobs
Zimmermann, Joan	Ingenicomm, Inc.

Telecon (Dial-In) Attendees:

Albert Condes	NASA Headquarters
Allen Teasner	Space Exploration Technologies
Angela Clark-Williams	Ingenicomm, Inc.
Pam Whitney	House Science Committee
Catherine Ham	NASA Headquarters
Catherine Sudris	NASA Langley Research Center
Chris Gilbert	VE Consult
Damara Belson	NASA Headquarters
Dan Williams	NASA Headquarters
David Eisenman	Jet Propulsion Laboratory
Diane Detroye	NASA Headquarters
Doreen Neil	NASA Headquarters
Ellen Gertsen	NASA Headquarters
Felix Sidel	NASA Headquarters
Gale Allen	NASA Headquarters
Gene Mikulka	Talking Space
Gordon Johnston	NASA Headquarters
Hashima Hasan	NASA Headquarters
James Lochner	Universities Space Research Association
Jane Chang	House Science Committee
Jennifer Kearns	NASA Headquarters
Kathryn Schmoll	NASA Advisory Council
Keith Cowing	nasawatch.com
Marguerite Broadwell	NASA Headquarters
Mark Green	Department of Justice
Mark Mozena	United Launch Alliance
Mary Sladek	NASA Headquarters
Moira Katz	NASA Headquarters
Paul Mahaffey	NASA Goddard Space Flight Center
Sarah Barber	House Science Committee
Stephanie Schierholz	NASA Headquarters
Steve Jurczyk	NASA Headquarters
Thomas Zurbuchen	NASA Headquarters
Tony Reichhardt	Air and Space Magazine
William Cirillo	NASA Headquarters
Ethan Hopper	SpaceX
Jane Bigham	CDC Washington
Marchel Holle	National Academy
Marcia Smith	Space Policy Online
Michael Moloney	National Academy of Sciences

APPENDIX D

NASA ADVISORY COUNCIL

National Institute of Aerospace
NASA Langley Research Center
Hampton, VA

PUBLIC MEETING

July 27-28, 2017

LIST OF PRESENTATION MATERIAL

1) Welcome to National Institute of Aerospace – Dr. Douglas Stanley
2) Welcome to NASA Langley Research Center – Dr. Clayton Turner
3) Institutional Committee Report – Mr. James Jennings
4) STEM Education Task Force Report – Dr. Aimee Kennedy
5) NASA Mission Directorate Overview – Dr. Thomas Zurbuchen
6) Science Committee Report – Dr. Bradley Peterson
7) Human Exploration and Operations Committee Report – Mr. Kenneth Bowersox
8) Aeronautics Committee Report – Ms. Marion Blakey
9) Technology, Innovation and Engineering Committee Report – Dr. William Ballhaus
10) *Cocktails and Dreams: A Bartender's Guide to Creating "The Right Stuff"* – Ms. Christy Funk
11) *On-Orbit Autonomous Assembly from Nanosatellites* – Mr. Luke Murchison
12) *Reducing Uncertainty in Reliability of Structures and Materials* – Dr. William P. Leser
13) Update on President's Proposed FY 2018 Budget for NASA – Mr. Andrew Hunter