

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

NASA ADVISORY COUNCIL

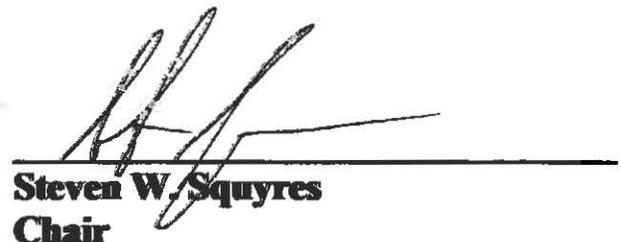
March 31 – April 1, 2016

**NASA Headquarters
Washington, DC**

MEETING MINUTES



**P. Diane Rausch
Executive Director**



**Steven W. Squyres
Chair**

**NASA ADVISORY COUNCIL
NASA Headquarters
Washington, DC
March 31 – April 1, 2016**

**Public Meeting Minutes
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***Meeting Report prepared by
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NASA ADVISORY COUNCIL

NASA Headquarters
Washington, DC

PUBLIC MEETING

March 31- April 1, 2016

Thursday, March 31, 2016

Call to Order. Announcements

Ms. Diane Rausch, Executive Director, NASA Advisory Council (NAC or Council), called the meeting to order and welcomed the Council members and attendees to NASA Headquarters in Washington, DC. She explained that the NAC is a Federal advisory committee established under the Federal Advisory Committee Act (FACA). The meeting is open to the public. A dial-in capability is available for members of the public to listen to the meeting. WebEx is also available. She noted that meeting minutes will be taken and will be posted to the NASA website, www.nasa.gov/offices/nac, soon after the meeting. Each NAC member has been appointed by the NASA Administrator, Mr. Charles Bolden, Jr., based on the member's individual subject matter expertise. All members are Special Government Employees (SGEs), subject to ethics regulations, and must recuse themselves from discussions on any topic in which there could be a potential conflict of interest. Any questions on ethics can be directed to Ms. Rausch. All presentations and comments will be part of the public record. Time has been set aside during the meeting for public comments.

Opening Remarks by Council Chair

Ms. Rausch introduced Dr. Steven W. Squyres, Council Chair, who presided over the meeting. Dr. Squyres welcomed everyone to the Council's public meeting. He introduced Dr. Patricia Sanders from the NASA Aerospace Safety Advisory Panel (ASAP) and stated that she would be sitting with the Council during its meeting. Dr. Squyres reminded the Council members to use their microphones because the public that is listening to the proceedings online wish to follow the deliberations. He reviewed the planned agenda for the meeting.

Remarks by NASA Administrator

Dr. Squyres introduced Mr. Charles F. Bolden, Jr., NASA Administrator. Mr. Bolden explained that the Council's work is important to him personally and that he values the input and feedback, whether it is from the Council as a whole or from its committees. NASA carefully goes over every formal recommendation that the Council and its committees submit, evaluates each one, and develops a formal response. Hopefully, the timeliness of the response has continued to improve with time. The Agency appreciates the Council's and its committees' efforts and the insights provided on NASA's missions and policies. Mr. Bolden noted that NASA has "jockeyed" back and forth on how the NAC committees can most effectively communicate with the specific Directorates they serve, since the Council is a body that advises the Administrator. He asked the Council members to let him and/or Dr. Squyres know if they see that the present practices are not working or if anyone has a concern about the committees' ability to interact with the Directorates.

Mr. Bolden described the NASA key personnel changes that have occurred since the last NAC meeting in December 2015. Mr. Todd May was named Director of NASA Marshall Space Flight Center (MSFC). Dr. Janet Kavandi was named Director of NASA Glenn Research Center (GRC). She succeeded Mr. James Free, who was named Deputy Associate Administrator (AA) for Technical in the Human Exploration and Operations Mission Directorate (HEOMD) at NASA Headquarters. Mr. Bolden remarked that Mr. William Gerstenmaier, HEOMD AA, has been

very busy and somewhat overburdened without a Technical Deputy, and that Mr. Free is the "right person" for that job. Mr. Bolden commented that the people at GRC may feel like NASA Headquarters is "picking on them," but when an organization produces good people, particularly good leaders, it will find that those people are "picked on" for promotion. Mr. Al Condes was named the AA for the Office of International and Interagency Relations (OIIR) at NASA Headquarters after the retirement of its longtime AA, Mr. Michael O'Brien. OIIR is the organization that is responsible for the "care and feeding" of the NAC, the NASA Aerospace Safety Advisory Panel, and NASA's other external advisory committees and boards.

Mr. Bolden reported that he was happy to present the President's Fiscal Year (FY) 2017 Budget in February 2016 to the three Congressional committees at NASA's budget hearing. The FY 2017 President's Budget contains \$19 billion (B) for NASA priorities, Although NASA could certainly use more than \$19B, the budget reflects the best budget that NASA could achieve given the current fiscal circumstances and uncertainties around the sequester. He emphasized that if NASA performs and does what it commits to do, the Agency will find that bipartisan support will continue. The budget is an investment in the future and supports NASA's Journey to Mars, a strong science and technology portfolio, and, most importantly to him as a pilot, increases funding for aeronautics. It gives NASA an opportunity to return the Agency to a position of prominence in the aeronautics community, starting with work on X-planes and demonstrators that are going to be critical for the Nation. He expects that NASA will be "okay" when the new approved budget comes out for FY 2017.

Earlier in the month, Mr. Bolden was honored to welcome Commander Scott Kelly back to the U.S. after he completed his 340-day mission aboard the International Space Station (ISS), which he took along with Cosmonaut Mikhail Kornienko. He explained that during the record-setting One-Year Mission, almost 400 investigations were conducted aboard the ISS to advance NASA's work and benefit all humanity. Astronaut Kelly and Cosmonaut Komienko specifically participated in a number of studies to inform NASA's Journey to Mars, including research into how the human body adjusts to weightlessness, isolation, radiation, and the stress of long-duration space flight. Commander Scott Kelly's identical twin brother, former Astronaut Mark Kelly, participated in parallel twin studies in genomics and human genetics on Earth to help scientists compare the effects of space on the body, including DNA and the brain, down to the cellular level. By becoming the first American astronaut to spend almost a year in space, Commander Kelly has helped the U.S. take one giant leap toward putting "boots on Mars." Mr. Bolden shared his opinion of the incredible value of the One-Year Mission from the standpoint of "soft power" for the U.S. When he was at the "welcome home" ceremony for Commander Scott Kelly in Moscow, Secretary of State John Kerry was in Moscow at the same time. Secretary Kerry asked, "How can you guys do what you do, given the diplomatic circumstances? It seems like you are always achieving these great accomplishments." This provided Mr. Bolden with an opportunity to explain the incredible workforce that NASA has, and that people enjoy what they are doing when they have a common mission on which they are focused. The ISS has pulled disparate nations together for a common goal of trying to understand how humans function in the microgravity environment of space and to work toward sending humans to Mars. He noted that Secretary Kerry used that comment later in the afternoon when he met with Astronaut Kelly and Cosmonaut Komienko. It speaks to the value of international cooperation in space and the value to the Nation.

Mr. Bolden explained that a new commercial space milestone was reached when NASA entered the second phase of commercial resupply to the ISS. NASA awarded three cargo contracts to ensure that the critical science research and technology demonstrations that are informing the Agency's Journey to Mars are delivered to ISS from 2019 through 2024. NASA selected three companies -Orbital ATK, SpaceX, and Sierra Nevada (the latter a new addition to the stable of cargo-providing carriers) -to continue building on the initial resupply partnerships. Expedition 47, with Commander Aleksey Ovchinin of Roscosmos, Flight Engineer Jeff Williams of NASA, and Flight Engineer Oleg Skripochka of Roscosmos, made it safely to the ISS almost two weeks ago to begin their five and one-half month mission. Astronaut Scott Kelly's One-Year Mission made him the record holder for American cumulative time-in-space. Mr. Williams will break that record during his current mission; it is his third ISS increment, and he will become the first American to spend three increments on the ISS.

The fifth Orbital ATK launch of the Cygnus cargo resupply spacecraft last week included research instrumentation to study in space. When Cygnus is detached and deorbits, there is an experiment on board, with cameras and

sensors, that will allow researchers to view the actual process of ignition and burning in a spacecraft during the initial phases of its reentry into Earth's atmosphere. Cygnus is not an intact return vehicle; it is destroyed during reentry anyway, hence it provides a great opportunity to observe something that is always a concern to people involved in space flight- ignition and propagation of fire in a spacecraft. In addition to the research to study fire in space, the Cygnus included research to examine meteors from orbit and delivered a next generation, 3-D printer for manufacturing in orbit. Orbital ATK has now successfully launched two cargo resupply missions to ISS using the Atlas 5 rocket. After the mishap last year, Orbital ATK is on track to return to flight using the Antares rocket this summer. The next SpaceX launch next week, Cargo Resupply Services (CRS)-8, will include the Bigelow Expandable Access Module (BEAM) habitat. It also will include a student DNA experiment and other research to benefit the Journey to Mars. If all goes according to plan, it will be the first time that two commercial cargo spacecraft are docked to the ISS at the same time and will help tie the record for the most vehicles docked simultaneously to the ISS -six in total.

Mr. Bolden was pleased to report that NASA's latest call for astronauts drew 18,300 applicants, by far the most ever. He expects another diverse class when the selections are made next year.

Mr. Bolden described NASA's current and planned endeavors. The next six months will be a particularly active period for Earth science as eight major new research campaigns are begun. Earth expeditions will take researchers around the world on a wide range of investigations from Greenland to Korea to the Great Barrier Reef of Australia and beyond. The first of the new projects currently in the field is an examination of the extent to which the oceans around Greenland and the edges of the ice sheet are melting. New Earth science investigations will put instruments in low orbits to track harmful particulate air pollutants and study the development of tropical cyclones. Observations of small atmospheric aerosols from the Multi-Angle Imager for Aerosols (MAIA) will help determine the toxicity of different particulate matter types in airborne pollutants over the world's major cities. The Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS) investigation will develop and launch a constellation of CubeSats to study the development of tropical cyclones.

The Juno spacecraft is on its way to Jupiter, where it will achieve the first ever polar orbit of the gas giant in July 2016. Juno's principal goal is to understand the origin and evolution of Jupiter, which will help scientists take a major step forward in understanding how giant planets form and the role that those titans played in the formation and evolution of the solar system. Juno is the first outer planet spacecraft powered by solar power, not nuclear power, using new-technology solar panels that have provided the electrical power for Juno's entire journey out to the planet and will continue to do so while it is in orbit. The demonstration has allowed the team that is now looking at the formulation of a mission to Europa – Jupiter's big, icy moon- to be able to consider solar power as opposed to nuclear power for the Europa mission.

NASA's robotic asteroid rendezvous and sample return mission, called "Osiris Rex," will launch in September 2016 to the near-Earth asteroid, Bennu, collect a sample, and return to Earth in 2023. Osiris Rex will help scientists investigate how planets are formed and how life began, as well as improve the understanding of asteroids that could impact Earth. Mr. Bolden noted that when he was talking with the NAC members the previous day about grand themes for the Agency, Mr. Thomas Young was right- the robotic mission is looking for life elsewhere in the Solar System and it is one of the reasons he gives to people for "why Mars?" It is one of those places where we may find life and that would be incredible.

The 18th and final primary mirror segments have been installed on the James Webb Space Telescope (JWST). It is magnificent. The sheer size is incredible. Fortunately, the Council had an opportunity to see the completed mirror assembly during this week and it is really impressive. The telescope is now optically complete. Cryogenic testing on the science cameras and spectrometers is also complete. However, there are still many hurdles left before launch in 2018.

After years of preparatory studies, NASA has formally started the Wide Field Infrared Survey Telescope (WFIRST) mission. It will have a field-of-view 100 times greater than the Hubble Space Telescope (HST or Hubble). WFIRST will aid researchers in their efforts to unravel the secrets of dark energy and dark matter and explore the evolution of

the cosmos. It will also discover new worlds outside the solar system and advance the search for worlds that could be suitable for life.

NASA's Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission to study the deep interior of Mars is targeting a new launch window that begins May 5, 2018, with a Mars landing scheduled for November 26, 2018. InSight was supposed to launch this year, but there was a persistent problem with a leak in one of its instruments, and the international team was not able to satisfy themselves that they could find a workable solution. NASA decided to stop all efforts to launch it this year in order to ensure that there is a good spacecraft that will be able to fly during the next available Mars window, which is 2018. The initial cost estimate of the two-year delay has been assessed and a definitive cost plan will be established in August 2016 once arrangements with the launch vehicle provider have been made.

NASA announced that the first flight of NASA's new Space Launch System (SLS) rocket will carry 13 CubeSats as a secondary payload to test innovative ideas, along with an uncrewed Orion spacecraft, in 2018. NASA successfully tested the first deep space rocket engine, the RS-25, for 500 seconds on March 10, 2016, clearing a major milestone toward the next great era of space exploration. The hot-fire test marked the first test of an RS-25 flight engine for the SLS.

NASA has awarded \$30,000 each to the five, top-scoring teams that competed in the latest segment of the Agency's small satellite CubeSat competition. Cube Quest is a \$5 million (M) challenge that requires teams to design, build, and deliver flight-qualified CubeSats capable of advance operations near and beyond the Moon. NASA selected 135 research and technology proposals through the Small Business Innovative Research (SBIR) Program that will enable NASA's future missions into deep space while also benefitting the U.S. economy.

The Green Propulsion Infusion Mission (GPIM) passed a major flight readiness milestone with a successful completion of functional environmental tests of the systems and software. The spacecraft is scheduled to launch early next year and is safer on the ground and in space as it demonstrates the practical capabilities of the new propellant. NASA's Game Changing Development Program has selected four proposals to develop solar ray technologies that will aid spacecraft in exploring destinations such as Mars and the outer planets. NASA concluded the Environmentally Responsive Aviation (ERA) Project, which determined that successful green technology demonstrations could save airlines more than \$250B between 2025 and 2050. The Project's leaders are meeting right now with industry at the NASA Langley Research Center (LaRC) to discuss how the results could be moved to market.

NASA successfully completed a flight campaign in Florida that required flying the edge of thunderstorms to collect data about high altitude ice crystals that can form in engines and lead to loss of power. The goal is to incorporate the data into future systems that alert pilots to avoid those conditions. Also completed was the first in a series of field demonstrations of technologies that would help integrate small drones into low altitude airspace. A significant funding initiative in the President's FY 2017 Budget Request is \$3.7B over ten years to help NASA aeronautics research, along with complementary work at other agencies, to develop a cleaner transportation system. That augmentation to the aeronautics ten-year investment plan could lower the risk for industry to adopt green aviation technologies and accelerate the adoption of revolutionary breakthroughs in aircraft and air traffic management. The ten-year plan centerpiece is a new aviation horizons initiative. NASA plans to work with industry to design, build, and fly a series of experimental aircraft, or X-planes, to test promising technologies and lower the risk for industry.

At the conclusion of his remarks, Mr. Bolden made a special presentation to two members of the NAC who are completing their terms with the current meeting. He expressed his sincere appreciation for a job extremely well done to Mr. Scott Hubbard and to Mr. Thomas Young, and presented each of them with the NASA Exceptional Public Service Medal, one the Agency's highest honors bestowed upon a private citizen.

Mr. Bolden then invited questions from the Council members.

Dr. Wanda Austin asked Mr. Bolden to discuss how NASA plans to work with the Presidential transition teams to maintain progress on NASA's current programs and activities. Mr. Bolden explained that the Pre-Election Presidential Transition Act of 2010 allows each political party, after their nominating convention, to assemble

transition teams. Beginning in August 2016, NASA will have access to those transition teams. NASA's intent is to be proactive with the transition teams and tell them as much as possible about NASA, its programs, and the President's vision and remind them, similar to the Hippocratic Oath, first of all to "do no harm." The Nation is embarked as the leader of the world on an ambitious space exploration program. NASA has put together a great set of science programs. It has a more robust aeronautics program than at any time in the recent history of the Agency, and a technology development program that is helping to develop the cutting edge technologies that would be needed not just for the Journey to Mars but across the NASA portfolio. NASA will not wait for the transition teams to come to NASA, but will go to them.

Mr. Young complimented Mr. Bolden on his decision to fix the JWST, rather than end it. Mr. Bolden explained that he had concluded early in his term that advertising a 2014 launch date for the JWST at half the current budget was "perpetrating a fraud" because it had no possibility of being accomplished. An outside team was brought in to make recommendations. The Program was restructured with a realistic launch date of October 2018 and an extreme budget increase. The Administration and Congress "chewed out" the Agency, deservedly, but went along with the restructured program. The Program is on schedule to make the 2018 launch, and NASA has sufficient reserves to complete it, thanks to the efforts of Mr. Robert Lightfoot, NASA Associate Administrator, Mr. Christopher Scolese, Director, Goddard Space Flight Center (GSFC), and a commitment to take cognizance and responsibility for JWST in the Office of the Administrator. Mr. Bolden explained that it was a team effort, and he thanked Mr. Young for giving the team deserved recognition.

Gen. Lester Lyles applauded Mr. Bolden and his entire team for their leadership in producing a fantastic budget. Gen. Lyles noted that there were going to be fiscal challenges in other agencies, in particular the Department of Defense (DoD) and the Air Force, and he asked whether Mr. Bolden saw opportunities for greater cooperation, particularly with the Air Force, in space and aeronautics technology. Gen. Lyles added, "There are some similar things that both agencies are working on but they don't always communicate." Mr. Bolden responded that there has been collaboration between NASA, the Air Force, and the intelligence community. There is a quarterly summit where he meets with the Secretary of the Air Force and the head of the National Reconnaissance Office (NRO) to discuss common systems and lessons learned. He added that NASA had taken the lead in the development and facilitation of a commercial space industry, which the Air Force has now turned to for some of its launches. Also, NASA has the most capable fundamental hypersonic research capability in the Nation, if not in the world. Through collaboration with the DoD and the Executive Office of the President, the Nation now has sustained its fundamental hypersonic research capability.

Ms. Marion Blakey asked Mr. Bolden for his thoughts on the potential for the X-plane program. Mr. Bolden noted that, as an aviator, he recalled the work of the National Advisory Committee on Aeronautics (NACA), which was formed in 1915 and was the precursor to NASA. From that came "X-planes galore" because industry alone just does not have the wherewithal to take the kind of risks that the NACA could and that NASA can and should take. He is excited that NASA is getting back into the flight-demonstrator mode again where it can collaborate with industry and "do some of the risky things." He added that industry has been poised for a decade or more to design and build a supersonic airplane for transporting people but has been stymied by regulations that prohibit supersonic flight over ground. The low boom demonstrator project will give NASA a way to get pertinent data into the hands of the Federal Aviation Administration (FAA) so that it can consider modifying the regulations that prohibit supersonic flight over ground. That would keep the U.S. out in front of the rest of the world.

Dr. Squyres noted that Dr. Sanders from the ASAP was present to help implement Mr. Bolden's advice to strengthen the ties between ASAP and the NAC. Dr. Squyres reported that he and Council members Mr. Wayne Hale and Mr. Ken Bowersox had recently attended a three-way meeting at NASA Kennedy Space Center involving representatives of NAC, ASAP as well as the ISS Advisory Committee, and received insight into issues associated with mission assurance for the NASA's Commercial Crew Program. Dr. Squyres asked whether Mr. Bolden had any guidance or suggestions about collaboration between the three groups. Mr. Bolden explained that there had been a disconnect in the opinions from the NAC and the ASAP on technical authority. He was concerned that after working for years with the ASAP to develop the process, the NAC found problems with the technical authority concept. That presented Mr. Bolden with an issue in that his two principal advisory committees are looking at the same thing and

coming up with inconsistent recommendations. Mr. Bolden stated that he does not expect the NAC to be a safety organization like the ASAP, but the NAC does have to consider safety in everything it deliberates. One of the findings from the ASAP was the fact that at the highest levels in NASA's leadership, there is a need to emphasize to people the critical importance of safety. "It is important for the NAC to think safety when it deliberates because budget affects safety, it affects quality, it affects almost everything." The benefit from having his two main NASA advisory committees continuing to emphasize that is important. Mr. Bolden noted that while NAC recommendations do not go to the Congress, Congress pays a lot of attention to the NAC recommendations, so it is helpful to have the NAC give NASA recommendations that are actionable. If the NAC gives actionable recommendations that relate to safety and quality, that gives NASA more ability to pursue funding. There is one thing that budget always helps and that is buying down risk. NASA appreciated having all three advisory committees come together for the recent meeting at NASA Kennedy Space Center. In response to another question from Dr. Squyres, Mr. Bolden affirmed that an increase in the SLS flight rate would buy down risk. He added that the NAC can probably be much more helpful than the ASAP in buying down risk because the NAC has committees that can help. He noted it was very encouraging for him to see that the NAC Science Committee believes that SLS is applicable to more than just human space flight. He cautioned that it is important to be very, very careful when talking about something like that. "Everybody will think that you are going to take their money." NASA would like to find a way to buy down risk, which would mean finding more ways to fly SLS and preferably SLS and Orion for human missions. Dr. Squyres affirmed that the Council would not do the "deep dives" into the technical aspects of safety associated with SLS and Orion. He said, "That's not our job, that's the ASAP's job, but I think we can comment usefully on the dangers associated with inadequate funding of SLS and Orion, the issues associated with too low a flight rate, and how they might affect the Agency's ability to do its job. We'll continue to do that."

Mr. Bowersox described two problems with the Commercial Crew Program (CCP). First, because technical issues in that program are proprietary, the NAC cannot discuss, deliberate, or provide recommendations on those technical issues. Second, the CCP is taking advantage of letting private industry use small teams to work issues so that they can move faster. The small teams will soon be expressing issues to NASA's bigger team and the NASA team is going to need time to get up to speed. NASA is going to have to figure out how to keep the process moving so that it does not delay the launches. Mr. Bolden explained that that had happened over and over and over again in the commercial cargo program. He said, "NASA is going to adjust to 'new space' and 'new space' is going to adjust to NASA." There are some things that NASA will not shortcut. There is a common belief that if you take your time and you're deliberative that you're wasting time, and hence can't be as efficient and effective. There's also a common belief that if you try to do things in rapid fashion like 'new space' wants to do, you can't be safe. Neither of those are true. There are things that NASA is learning and adapting to from 'new space.' NASA is going to have to work through them. Mr. Bowersox advised that NASA needs to start getting ready for how it is going to deal with those issues. Mr. Bolden responded that in buying down risk, it is important to have a robust safety mission assurance organization that is represented at every workspace. He explained that he wants three people around when addressing those issues: a safety and mission assurance representative, someone from the Chief Engineer's Office, and a lawyer. He elaborated that "having a lawyer is going to relieve us of a lot of heartburn later on when we find out that Congress had some sentence in a bill that the lawyers know about and nobody else does."

Mr. Bolden expressed his appreciation for the time given by the Council members. Dr. Squyres thanked Mr. Bolden for attending the Council meeting and for his comments.

NASA Human Exploration Update

Dr. Squyres introduced Mr. William Gerstenmaier, HEOMD AA, NASA Headquarters. Mr. Gerstenmaier briefed the Council on progress and plans on the Journey to Mars. He explained that human exploration of Mars is a different class of mission for humans and is hard. He presented a chart showing the failures and successes for robotic missions sent by spacefaring nations to Mars. Mr. Gerstenmaier reviewed a chart listing the reasons that Mars is the right place for human exploration. He explained that there is a need for humans to be on the Mars surface to understand the Martian environment. The Journey to Mars will not be a "one-time mission," and NASA is developing the capability for multiple human missions to Mars.

Mr. Gerstenmaier reviewed a revised statement on the strategic principles for sustainable exploration:

FISCAL REALISM: Implementable in the *near-term with the buying power of current budgets* and in the longer term with budgets commensurate with economic growth;

SCIENTIFIC EXPLORATION: *Exploration enables science and science enables exploration;* leveraging scientific expertise for human exploration of the solar system;

TECHNOLOGY PULL AND PUSH: Application of high Technology Readiness Level (TRL) technologies for near term missions, while focusing sustained investments on *technologies and capabilities* to address the challenges of future missions;

GRADUAL BUILD UP OF CAPABILITY: *Near-term mission opportunities* with a defined cadence of compelling and integrated human and robotic missions, providing for an incremental buildup of capabilities for more complex missions over time;

ECONOMIC OPPORTUNITY: Opportunities for *U.S. commercial business* to further enhance their experience and business base;

ARCHITECTURE OPENNESS AND RESILIENCE: Resilient architecture featuring multi-use, evolvable space infrastructure, minimizing unique developments, with each mission leaving something behind to support subsequent missions;

GLOBAL COLLABORATION AND LEADERSHIP: Substantial *new international and commercial partnerships*, leveraging current ISS partnerships and building new cooperative ventures for exploration; and

CONTINUITY OF HUMAN SPACEFLIGHT: *Uninterrupted expansion of human presence into the solar system* by establishing a regular cadence of crewed missions to cislunar space during ISS lifetime.

Mr. Gerstenmaier reviewed a chart showing that human space exploration would transition from the ISS to the surface of Mars in several phases. Phase 0 is for exploration systems testing on ISS. Phase 1 would be cislunar flight-testing of exploration systems. Phase 2 would be cislunar validation of exploration capability. Phase 3 would be crewed missions beyond the Earth-Moon system. Phase 4a would be development and robotic preparatory missions. Phase 4b would be Mars human landing missions. Mr. Gerstenmaier discussed ISS "end-of-life" considerations. Rather than declaring a definite end date for ISS, NASA will focus on other considerations, including ISS usefulness as a test bed for exploration research and development activities. Safe sustainment of the ISS will remain paramount. He reviewed a chart showing greater detail on the first three phases of the transition.

Mr. Gerstenmaier discussed science accomplishments and lessons learned from the IYM of Astronaut Scott Kelly and the Twin Study involving Astronaut Kelly and his twin brother, former Astronaut Mark Kelly. In response to a question from Dr. Hubbard, Mr. Gerstenmaier reported that Astronaut Scott Kelly was able to walk as soon as he landed. However, clothing felt heavy on his skin, and he no longer had calluses on the bottom of his feet.

Mr. Gerstenmaier reviewed a chart showing technologies and capabilities for the Journey to Mars that can be effectively investigated on the ISS. He described the BEAM that is to be launched to the ISS on SpaceX CRS-8 to

demonstrate technologies for deep space habitation. He noted that the module requires life support systems to be attached along a central spine, which would be a different location than NASA is accustomed to.

Mr. Gerstenmaier reviewed a chart on CCP major partner milestones. Both commercial crew partners are on track to complete certification by the end of 2017. He discussed NASA's strategic planning for low-Earth orbit (LEO) commercialization. He explained that the vision is for sustained economic activity in LEO enabled by human space flight, driven by private and public investments creating value and benefiting Earth through commercial supply and public and private demand. He noted that if NASA would be required to continue doing research in LEO, it would take money away from the Mars program. Dr. Squyres recalled that at the last NAC meeting, Mr. Bowersox had advised that it would be better to learn in LEO that some astronauts may not be suited for space exploration, rather than wait to learn about it in cislunar space. Mr. Hale asserted that for NASA to engage in deep space exploration, it is critical to free up resources. In response to a question from Dr. Squyres, Mr. Gersterunaier explained that the capability to purchase commercial cargo access for cislunar space is a concept under development.

Mr. Gerstenmaier discussed Exploration Systems Development (ESD). He explained that beginning human exploration beyond LEO as soon as practicable would help secure the U.S. future in space. There are three components: the SLS, the Orion spacecraft, and ground systems development and operations (GSDO). He reviewed recent accomplishments in each component. He presented a chart showing Proving Ground phase 1 flight-test objectives. He described the Exploration Mission (EM)-1 vehicle configuration. EM-1 will be an uncrewed distant retrograde orbit (DRO) with a targeted launch date no later than November 2018. Thirteen CubeSats will be flown on EM-1 as secondary payloads.

Mr. Gerstenmaier described progress on the Asteroid Redirect Mission (ARM). He reviewed how the ARM objectives support human exploration. He discussed an ARM draft finding recently released by the Small Bodies Assessment Group (SBAG). He noted that the ARM Formulation Assessment and Support Team (FAST) and the ARM Investigation Team (IT) have been providing support to the Asteroid Robotic Redirect Mission (ARRM). Mr. Gerstenmaier explained that the acquisition strategy for the ARRM spacecraft leverages existing commercially available U.S. industry capabilities for a high-power, solar-electric-propulsion (SEP)-based spacecraft. Mr. Gerstenmaier presented a chart showing a pre-formulation mission summary for the Asteroid Redirect Crewed Mission (ARCM). The total mission duration would be 243 days. Using SLS and the Exploration Upper Stage (EUS), a two-person crew would be launched aboard an Orion spacecraft augmented with the ARCM mission kits. The crew would return to Earth with samples from the asteroid.

Mr. Gerstenmaier discussed specific habitation system objectives and the habitation systems testing on the ISS. He presented a chart on NextSTEP Broad Agency Announcement (BAA) for habitation awards.

Mr. Gerstenmaier presented a graphic showing the components of the Mars 2020 Rover. He described study activity on the Evolvable Mars Campaign (EMC). He explained that the EMC goal is to define a pioneering strategy and operational capabilities that can extend and sustain human presence in the solar system, including a human journey to explore the Mars system starting in the mid-2030s. He reviewed a chart on EMC focus questions. He described the role and capabilities of System Maturation Teams. These are subject matter experts from across the Agency who have been involved in maturing systems and advancing technology readiness for NASA. He presented a chart on capabilities that need to be developed for the Journey to Mars and a chart showing the risk reduction for the development of those capabilities. Mr. Gerstenmaier described the Mars Exploration Zones Workshop that had been conducted in October 2015, at the Lunar and Planetary Institute in Houston, Texas.

Mr. Gerstenmaier concluded his presentation by explaining that the human exploration of Mars is achievable by taking the long view. NASA is putting the right pieces in place and is building a long-term, sustainable program of human exploration. Mr. Hubbard stated that there is a lot to like in this program, especially the long-view emphasis. Mr. Hale commented that many people think that the Moon should be the primary focus. He added that over the last two years, the plan for the Journey to Mars has become more credible. Mr. Gerstenmaier responded that the Proving Ground concept does not preclude lunar surface activity if some other nation wants to do that.

Dr. Squyres thanked Mr. Gerstenmaier for his presentation.

NASA Technology Prioritization Plans for the Journey to Mars

Dr. Squyres introduced Mr. James Reuter, Deputy AA for Programs, Space Technology Mission Directorate (STMD), NASA Headquarters.

Mr. Reuter discussed the eight guiding principles for Space Technology Programs. Those principles are:

- Adhere to a stakeholder-based investment strategy.
- Invest in a comprehensive portfolio.
- Advance transformative and crosscutting technologies.
- Develop partnerships to leverage resources.
- Select using merit based competition.
- Execute with lean structured projects.
- Infuse rapidly or terminate promptly.
- Place NASA at technology's forefront- refresh the Agency's workforce.

Mr. Reuter discussed the process that STMD uses for investment planning. He described the ways in which STMD collaborates with HEOMD and the Science Mission Directorate (SMD) at NASA. He reviewed the phases for human space exploration from the ISS to the surface of Mars. Mr. Reuter presented a chart on risk reduction for capabilities that need to be developed for transportation, health, and working in space and on Mars for the Earth Reliant, Proving Ground, and Earth Independent phases. He reviewed a chart assessing capabilities needed for Mars exploration. He discussed critical time frames in which decisions on new technologies must be made. He presented a chart showing Proving Ground phase 1 flight-test objectives.

Mr. Reuter described space technology contributions to the ARM, space transportation systems, Mars robotic precursor missions, and deep-space habitation. He described the Mars Human Exploration Entry Descent and Landing (EDL) Architecture Study. He noted that a conclusion had been reached to use retro-propulsion, rather than parachutes, for descent onto Mars. Mr. Reuter presented charts describing the major projects in the STMD technology demonstrator portfolio: the GPIM, the Deep Space Atomic Clock, the Laser Communications Relay Demonstration, Restore-L Satellite Servicing, the Mars Oxygen In Situ Resource Utilization (ISRU) Experiment, terrain relative navigation, evolvable cryogenics, Solar Electric Propulsion (SEP), and deep space optical communications. Dr. Squyres remarked that the Council has commented in the past very favorably on SEP and asked whether potential benefits for science missions had been taken into consideration when developing SEP requirements. Mr. Reuter responded affirmatively and added that SEP is a cross-cutting technology. Mr. Hale commented that, "Green Propellant sounds too good to be true."

Mr. Reuter discussed STMD public-private partnerships. He described the Game Changing Development Program and reviewed a chart on SBIR and Small Business Technology Transfer (STTR). He discussed Space Technology Research Grants (STRG). He described how space technology drives exploration. Mr. Hale asked how effective NASA had been in getting funding for the technology that needs to be developed. Mr. Reuter responded that STMD has not been the most popular NASA Mission Directorate on Capitol Hill. Some projects were either deferred or cancelled because \$140M had been cut from the budget. Dr. Austin advised that caution should be exercised to avoid building systems the way they would be used on Earth, rather than from a zero-gravity perspective. Dr. Austin took the opportunity to commend GSFC on its efforts in Science, Technology, Engineering, and Math (STEM). However, she expressed concern that NASA's percentages in reaching out to women and minorities is "disappointing and has gotten worse."

Dr. Squyres thanked Mr. Reuter for his presentation.

NASA FY 2016 Budget and the President's FY 2017 Budget Request for NASA

Dr. Squyres introduced Mr. David Radzanowski, Chief Financial Officer (CFO), NASA Headquarters.

Mr. Radzanowski explained that his presentation would use the same charts that he used when presenting the President's FY 2017 Budget Request for NASA to Congress. He noted that the majority of the 2017 Budget Request had been developed before the FY 2016 budget had been approved by Congress. He explained that NASA always uses a five-year budget plan, with the out-years being notional and predicated on a two percent annual increase. He noted that under Space Operations, there was a new line item for Space Transportation.

Mr. Radzanowski reviewed highlights of the budget request. The budget:

- Provides continuity and stability for the Nation's plan to extend humanity's reach further into space, ultimately sending humans to Mars;
- Builds on U.S. preeminence in science and technology, improves life on Earth, and protects the home planet, while creating jobs and strengthening the American economy;
- Provides \$19B to advance the Nation's space exploration plan and ensure that the U.S. remains the world's leader in space exploration, aeronautics research, and scientific discovery for years to come;
- Supports the growth of a vibrant American commercial space industry and partners with industry to send astronauts to the ISS cost-effectively and safely from American soil by the end of 2017;
- Continues development of the Orion crew vehicle, SLS, and Exploration Ground Systems (EGS) that will send astronauts on deep space exploration missions in the 2020's and beyond;
- Invests in space technologies that enhance U.S. space capabilities, reduce the cost of space exploration, and lower barriers to new commercial space capabilities;
- Supports operation of ISS to at least 2024;
- Enhances technology investments aimed at sending humans to Mars, including space-to-ground laser communications, satellite servicing, habitation concepts, and advanced propulsion;
- Aligns robotic technology with a crewed mission to rendezvous with a redirected asteroid in cislunar space to allow NASA to expand crewed operations beyond LEO as a proving ground for Mars class missions; Funds achievement of multiple milestones in the development, integration, and testing of the next Great Observatory, the JWST, planned for launch in 2018;
- Funds formulation of a mission to Jupiter's moon Europa, missions to Mars and other destinations throughout the solar system, and supports the Discovery and New Frontiers programs;
- Funds crucial satellite and research efforts to help understand the Earth's systems and climate, continues the 43-year Landsat record of global land-imaging measurements, and supports the National Space Weather Strategy and Action Plan;
- Establishes a major new experimental flight initiative to demonstrate and validate new technologies in aeronautics that dramatically reduce fuel consumption, emissions, and noise, and open new markets for U.S. industry;
- Continues to address integration of Unmanned Aircraft Systems into the National Airspace System and accelerates the development of hybrid electric propulsion and other emerging technologies;
- Funds a University Innovation and Challenge project to establish university leadership in developing transformative concepts and addressing key technical challenges facing the aviation industry; and
- Contributes to the government-wide effort to improve the delivery and effectiveness of STEM education programs.

Mr. Radzanowski explained that there had been a \$1.1B reduction for planetary science and that a significant portion of the funds for planetary science are needed to support the Mars 2020 mission. Mr. Young noted that the Decadal Survey had identified a Mars sample return mission as a priority. Dr. David Spergel advised that NASA tries to follow the Decadal Survey as best it can under the funding that is available. Mr. Hubbard explained that a Mars orbiter is not the "deathblow" to a Mars sample return mission. Dr. Squyres commented that the planetary community would be watching this closely. In response to a question from Gen. Lyles, Dr. Spergel explained that line items for SMD's Research and Analysis (R&A) Program mostly cover scientists' proposals for using science data. Dr. Squyres advised that the R&A grants are important for developing the next generation of space scientists.

Dr. Bradley Peterson commented that the R&A Program line items are the part of the budget that is most poorly understood by the public. Mr. Young asked whether NASA could support the EM-I and EM-2 launch dates with the planned funds. Mr. Gerstenmaier responded that funds would be sufficient to support the 2018 launch, but not the 2021 launch. In response to a question from Dr. Peterson, Mr. Radzanowski explained that NASA would be purchasing six seats on the Russian Soyuz spacecraft in FY 2017 for astronaut transportation to the ISS. In response to a question from Ms. Blakey, Mr. Radzanowski stated that the price per seat on the Soyuz varies and entails more cost than what NASA is paying for each commercial seat.

Mr. Radzanowski noted that the budget assumes a 66-person reduction in NASA's civil servant headcount. That is to be achieved through attrition and assumes that for every three people who leave NASA, two replacements would be hired.

Mr. Radzanowski presented a chart showing NASA's planned mission launches for fiscal years 2016 through 2021.

Dr. Squyres thanked Mr. Radzanowski for his presentation.

Center for the Advancement of Science in Space (CASIS) and the Demand for Access to LEO

Dr. Squyres introduced Dr. Gale Allen, Deputy Chief Scientist, NASA Headquarters; Mr. Gregory Johnson, President and Executive Director, CASIS; and Dr. Michael Roberts, Deputy Chief Scientist, CASIS.

Dr. Allen described the role of the NASA Chief Scientist as an advocate to the Executive Office of the President, advisor to the Agency, and representative of the science community. She presented a chart showing how the ISS National Laboratory management fits into the organizational structure of HEOMD. She reviewed a chronological bibliography of prior studies showing that the discussion on how to use the ISS has been ongoing since 1993 and is not a new issue. Dr. Allen noted that the NASA Authorization Act of 2005 designated the U.S. segment of the ISS as a National Laboratory to be operated by a nongovernmental entity. The NASA Authorization Act of 2010 directed NASA to use a cooperative agreement with a not-for-profit entity to manage the National Laboratory. The Act calls for NASA to designate a Liaison to the management entity, and the current Liaison is Mr. Sam Scimemi, ISS Director, HEOMD, NASA Headquarters. Dr. Allen explained that a NASA cooperative agreement (rather than contract or grant) is used when the principal purpose is to provide assistance to accomplish a public objective. In contrast, if the principal purpose is to acquire goods or services, then a procurement contract must be used. Early in 2011, NASA released a Cooperative Agreement Notice (CAN) to solicit proposals for managing the National Laboratory on the ISS, and CASIS was selected. She then introduced Mr. Johnson of CASIS.

Mr. Johnson provided the statement of CASIS's mission as set forth in paragraph 1.2.1 of the cooperative agreement with NASA:

CASIS will be responsible for maximizing the value of the ISS to the Nation by developing and managing a diversified R & D portfolio based on US national needs for basic and applied research and by using the ISS as a venue for STEM educational activities.

He reviewed CASIS's goals and responsibilities as provided for in the cooperative agreement. Under the agreement, NASA provides transportation through commercial resupply services; on-orbit logistics; a minimum 50 percent resource allocation of U.S. orbital segment facilities, hardware, and crew time; and \$15M in annual funding.

Mr. Johnson presented a chart showing geographic ecosystems that were developed by CASIS. He reviewed a chart on how CASIS initiatives were mapped to Earth benefits. He discussed CASIS's customer-focused approach and described how the ISS National Laboratory has evolved.

Mr. Roberts discussed LEO commercialization. He presented "NASCAR slides" showing the logos of private companies that have or soon will have investigations or payloads on the ISS. He described how CASIS is enabling "demand-side" interest in the ISS National Laboratory. The focus areas are protein crystallization, organ and tissue bioengineering, and on-orbit production.

Mr. O'Brien asked whether CASIS had received funds from non-NASA sources. Mr. Johnson explained that other than the \$15M received annually from NASA, "philanthropy has not been fruitful." Dr. Squyres explained that this is an important issue. Mr. Young commented that the Council "is after a number." Mr. Johnson responded that CASIS is not permitted to generate revenue and that it was difficult to estimate the value of in-kind contributions from outside entities. Mr. Young asked whether there was an auditable financial report. Mr. Johnson responded that \$800,000 had been contributed to CASIS in the last fiscal year. Dr. William Ballhaus noted that the aspiration was for the National Laboratory to become self-supporting. Mr. Gerstenmaier explained that the intent was to see if private companies would pay for their own research and, hopefully, in the future pay for their own facility. Dr. Ballhaus noted that the intent was to eliminate the expense for NASA by 2024. Dr. Squyres stated that the Council is interested in the probable demand for research from the private sector in the future. Mr. Johnson noted that CASIS has evaluated more than 200 proposals for commercial research since its inception. Mr. Hale observed that since NASA is giving free transport to the ISS and free crew time, one would think that other users would "beat the door down." Mr. Johnson responded, "It has not been happening." Mr. Scimemi explained that CASIS is not in business to make a profit. Mr. Johnson added that the in-kind contributions are not auditable. Dr. Squyres advised that it is crucial for the 50 percent allocation of crew time to be fully subscribed and that the Council wants to understand what the down-stream demand for research is likely to be. Mr. Johnson responded that he estimates \$4B by 2024.

Dr. Hubbard noted that the dream of using microgravity for protein crystallization was at least 35 years old. Mr. Roberts responded that it had been "oversold a little." In response to a question from Dr. Squyres, Mr. Roberts explained that the process for determining who would receive funding was on the CASIS website. Dr. Squyres added that the hope is that the process will generate sufficient commercial demand for access to LEO and that commercial entities would begin to contribute to the cost for ISS transportation and infrastructure. Mr. Hale stated that NASA wants to "get out of the Space Station business" by 2024 or 2028. He asserted that private enterprise has not determined the business case for building a commercial space station in the future. He added that NASA is providing "seed money" to get industry to examine how to make money in space and to encourage industry to build its own space station in the future. At some point, the intent would be for CASIS to become unnecessary and disappear. The time for that, however, is running short. Dr. Hubbard explained that there is between 10 to 20 years for all that to happen. Dr. Sanders opined that the ISS would not be needed in the future and that the BEAM could serve as a mini-space station. Dr. Hubbard suggested that the problem is that there have been 30 years of "commercial hype and over-selling."

Dr. Squyres thanked Dr. Allen, Mr. Johnson, and Dr. Roberts for their presentation.

Human Exploration and Operations (HEO) Committee Report

Dr. Squyres introduced Mr. Ken Bowersox, HEO Committee Chair. Mr. Bowersox described the Committee membership and presented HEOMD's organization chart. He reviewed a chart on the phases for human space exploration from the ISS to the surface of Mars. Mr. Bowersox briefed the Council on the status of the ISS. He discussed ISS port utilization, Increment 47 crew members, the ISS research plan, and the ISS consumables status. He reviewed a HEOMD Human Research Program (HRP) chart on the human risks disposition for all Design Reference Missions (DRMs). Mr. Young commented that the chart coding was based on consequences and that consequences are different than risk. Mr. Bowersox reviewed a chart on the HRP integrated path to risk reduction. He described an anomaly on extra vehicular activity (EVA) 35. Astronaut Tim Kopra reported that water was accumulating in his helmet during the EVA, and the EVA was terminated. The cause for the water accumulation is under investigation.

Mr. Bowersox discussed the status of the CRS-2 contract. Those contracts have been awarded to three companies: Orbital-ATK, SpaceX, and Sierra Nevada Corporation. A minimum of six missions will be ordered from each provider. To bridge a launch gap, the current CRS contracts have been extended. Mr. Bowersox reviewed CCP highlights and presented a chart showing milestones on the Commercial Crew Transportation Capability contract (CCtCAP). He explained that CCP has robust and efficient processes for certification, including addressing waivers

and deviations. He noted that Boeing and SpaceX are advancing their design concepts and engaging in meaningful insight with NASA.

Mr. Bowersox presented a graphic showing the EM-1 vehicle stack and reviewed a milestone chart on the EM-I mission. He explained that ESD's top concerns include integrated avionics and software verification and validation (V&V), funding uncertainty, schedule threats related to the critical path, production and operations sustainability at the rate of one flight per year after EM-2, and on-orbit micrometeoroid and orbital debris (MMOD).

Mr. Bowersox discussed the Asteroid Redirect Mission (ARM). He presented a graphic illustrating how the ARM would serve as an early mission in the cislunar space Proving Ground. He reviewed a chart on the alignment between the ARM asteroid identification segment, the ARRJv1, and the ARCM. The target for the robotic mission launch date is December 2021. The target for the crewed mission launch date is December 2026. Mr. Bowersox explained that the cost cap for the ARRM is \$1.25B, not including the launch vehicle and mission operations. Mr. Young reported that a recent Government Accounting Office (GAO) report showed that the ARRM would cost much more than the cost cap. Dr. Squyres stated he would be interested in hearing back from the Committee on that issue. Mr. Bowersox described the ARM FAST and IT efforts. He reviewed charts on candidate parent asteroids for the ARRM and the ARRM capture phase. He described the ARCM. The mission duration would be 24.3 days. A two-person crew would be launched aboard an Orion augmented with the ARCM mission kits. The Orion would rendezvous and dock with the robotic spacecraft in a 71,000 kilometer (km) lunar DRO. After rendezvous, the crew would return to Earth with samples.

Mr. Bowersox discussed NASA Procedural Requirement (NPR) 7120.5E, which establishes NASA space flight program and project management requirements. He described recently added charter functions for the Program and Project Management Board (PPMB). The PPMB is intended to serve as a one-stop forum to adjudicate all 7120.5E issues, waivers, deviations, and tailoring. Requirement owners would retain authority to approve tailoring, waivers, and deviations. Dr. Ballhaus commented that it is good for there to be controls and for the requirements owner to be kept in the loop. Mr. Bowersox explained that the Committee had surveyed program managers on how to improve the process. The Committee found that the program managers find the PPMB to be another bureaucracy that they would prefer not to deal with. Dr. Sanders commented that it has become harder for program managers to get relief from the requirements. Mr. Hale noted that that comment is fairly typical from program managers around the Agency. He added that as much as 30 percent of program costs go into reporting.

Mr. Bowersox presented several HEO Committee observations.

- Progress continues on Commercial Crew capability with full funding in 2016.
- Progress continues on SLS and Orion with no major schedule adjustments due to technical issues.
- HEOMD has added detail to plans for human exploration missions in the 2020s using a buildup approach to develop capabilities beyond LEO.
- HEOMD's approach for human exploration planning is reasonable considering the current political and economic environment, but the Committee is eager to see additional detail in exploration plans beyond 2030.
- ARM planning and development is continuing with completion of the Formulation and Assessment Team's report.

Mr. Bowersox identified the HEO Committee's top concerns:

- Lack of U.S. launched crew transportation to LEO;
- Current level of definition for Mars exploration architecture, which impedes efforts to generate support;
- Bureaucratic processes that NASA imposes on itself that do not always add value to balance the load imposed on the organization and are a threat to accomplishment of NASA's exploration mission;
- Low SLS and Orion launch rate that poses future risks for proficiency of the operations team and reduces program resilience in the event of mission failure; and
- Budget uncertainty and reduced flexibility in funding accounts that make it more difficult than ever for program managers to meet technical and schedule objectives.

Dr. Squyres stated that he appreciated the process of maintaining at the Committee level a top concerns list. He asked Mr. Gerstenmaier whether the Council's committees have been giving him the feedback that he needs. Mr. Gersrenmaier responded that he has not received any feedback. Dr. Spergel suggested splitting space radiation risk into two risks: high-energy radiation risk and low energy radiation risk. Dr. Squyres thanked Mr. Bowersox for his presentation.

Council Discussion

Dr. Squyres reviewed the presentations that had been given. He opened the floor for Council members' thoughts and comments. Mr. Hale stated that the best news he had heard during the day was the increased budget for aeronautics research. Mr. Hubbard complimented Mr. Gerstenmaier for a terrific job in moving along the thought process for the Journey to Mars. He stated that two things were missing, however: the sequence of missions and criteria for ending the ISS. He added that the ISS could detract from and should be disconnected from the Journey to Mars.

Mr. O'Brien commented that NASA would be remiss if it was allowing the allocation of crew time to CASIS to slow down the march to Mars. Ms. Kathryn Schmolli stated that the Agency did a disservice to commercialization in space in the 1980s by over-hyping it. Dr. Spergel cautioned against relying on CASIS to develop a commercial market for LEO, because it would interfere with getting to Mars. Dr. Squyres agreed that it would be unfortunate if the crew time or up-mass dedicated to CASIS slowed down progress in getting to Mars. He cautioned that it does not appear that CASIS is impeding progress. Dr. Ballhaus suggested looking into reports he has heard that there are backlogs of experiments involving crew time. Mr. Young stated he was disappointed by the CASIS presentation because it was a generalities briefing and not a substantive briefing. Mr. Hale asserted that a commercial LEO is critical to getting to Mars and that NASA has insufficient funds to do both LEO and deep-space exploration. He added that the government has to incentivize commercial LEO. Mr. Young noted that if private enterprise thought that there was a real commercial opportunity in LEO, they would go for it. He suggested that "CASIS should get out of the way." Ms. Blakey commented that she had not heard anything to suggest that CASIS is holding back the Journey to Mars. She noted that many people in the country were interested in what NASA is doing for humanity on Earth. Gen. Lyles expressed appreciation for Mr. Gerstenmaier's presentation and his "go as you can afford to pay" approach. Dr. Squyres explained that the Council members all see value in trying to generate commercial interest in LEO, but all share a degree of skepticism. Mr. Gerstenmaier explained that NASA is required by law to provide 50 percent of the U.S. research capabilities on the ISS to CASIS. Dr. Peterson asked how it would be known if commercialization fails. Dr. Squyres stated that that was an interesting point. Dr. Ballhaus suggested asking NASA's Chief Technologist whether NASA's effort to commercialize LEO posed an interference to getting to Mars. Mr. O'Brien asked whether another organization could have done a better job than CASIS. Mr. Hubbard advised the Council to avoid conflating basic research science with the commercialization effort. He asserted that basic research for science disappeared when NASA cut the budget for research. He added that over the next few years, the best use for the ISS would be support for the Journey to Mars.

Dr. Squyres requested Council Members Ballhaus, Hubbard, and Blakey to draft a recommendation asking NASA to inform the Council whether the 50 percent ISS crew time allocation to CASIS is slowing down the Journey to Mars. He requested Council Members Young, Hale, and Lyles to draft a recommendation to have an independent party review CASIS's efforts and advise on how CASIS could improve its performance.

Adjourn

The Council meeting adjourned for the day at 5:30pm.

Friday, April, 2016

Call to Order. Announcements

Ms. Rausch called the NAC meeting to order and welcomed everyone to the second day of the Council meeting. She reminded Council members that the meeting was a public meeting under FACA and that all presentations and comments are considered "on the record." She stated that the NAC meeting minutes and presentations will be posted to the NASA website, www.nasa.gov, soon after the meeting.

Remarks by Council Chair

Ms. Rausch introduced Dr. Squyres, who described the day's agenda.

Ad Hoc Task Force on STEM Education Report

Dr. Squyres introduced Dr. Anita Krishnamurthi, Chair (*attending via telecon*), and noted that she is the new Chair for the STEM Committee. Dr. Krishnamurthi provided an update on the Committee's status. She reviewed the observations that the Committee presented at the NAC's December 2015 meeting. She noted that NASA Office of Education has responded to those observations with preliminary actions and clarifications.

Dr. Krishnamurthi described three key questions that would drive the Committee's future conversations:

1. What is the role of NASA's Business Services Assessments (BSA) vis-a-vis NASA education? How does their work intersect with the Task Force and the Task Force's observations and forthcoming recommendations?
2. How should NASA articulate crisp and prioritized goals for education that are commensurate with the allocated budget? Should the next iteration of the NASA Education Implementation Plan (NEIP) define these?
3. Given NEIP goals, how can NASA organize education programs offered across the Agency so it is a joint effort?

Dr. Krishnamurthi reviewed the Committee's next steps:

- Understand the funding profiles of programs (including mandatory programs, statutory requirements, and grant cycles);
Explore the implications of "going deep" vs. "spreading wide" on education investments;
Hold joint meeting with the NAC Science Committee per request of the Chair, Dr. Peterson;
Discuss the goal of efforts targeted at broadening participation in STEM fields; and
Translate observations into concrete recommendations.

Dr. Squyres asked whether the Task Force would be available for the NAC's upcoming "annual all hands meeting" in July 2016. Dr. Krishnamurthi responded affirmatively. Dr. Peterson noted that his committee would be available to meet at that time with the Task Force. Dr. Squyres thanked Dr. Krishnamurthi for her presentation.

Technology, Innovation and Engineering (TI&E) Committee Report

Dr. Squyres introduced Dr. William Ballhaus, TI&E Committee Chair. Dr. Ballhaus described the Committee membership. He reminded everyone that the Committee's charter covers technology across the enterprise. He reviewed the briefings given to the Committee at its last meeting.

Dr. Ballhaus discussed STMD public-private partnerships .He explained that the objective of those partnerships is to deliver critical space technologies needed for future missions by leveraging previous investment by U.S. industry and providing new opportunities for collaboration that accelerate development and utilization.

Dr. Ballhaus described two new key activities in STMD. Restore-L will continue formulation of technology demonstration for a satellite servicing mission with a scheduled launch in 2019. It is a groundbreaking mission that uses robotic technology to rendezvous with and refuel a government-owned satellite in LEO autonomously and via remote control. The other new key activity is the Deep Space Optical Communications (DSOC) mission. Other key activities in STMD are the Laser Communications Relay Demonstration, SEP, the GPIM, and the Deep Space Atomic Clock. Dr. Ballhaus reviewed the President's FY 2017 Budget Request for STMD. He presented charts on STMD recent accomplishments and key milestones. He described FY 2016 activities in Advanced Exploration Systems (AES). He noted that AES has 65 milestones scheduled for FY 2016, a \$182M budget, 460 civil servants, and 154 contractor employees.

Dr. Ballhaus described the BEAM. It is a public-private partnership to demonstrate a commercial inflatable module on the ISS during a two-year mission. Sensors inside the BEAM will verify structural integrity and characterize the radiation environment. Dr. Ballhaus discussed how HEOMD and STMD engage with each other on technology needs. He described the crosscutting new technology needs for the EMC that have been identified by HEOMD. Dr. Ballhaus presented a chart showing the Technology Demonstration Mission (TDM) portfolio. He described TDM infusion successes and the infusion of new technologies into science missions. He reviewed a chart on planetary science technology trends.

Dr. Ballhaus presented a proposed NAC finding, for the Administrator, that it would be useful to explore technology demonstration incentives for new science program mission areas. Dr. Squyres explained that the proposed finding was appropriate for the Administrator because it affected more than one NASA Directorate. The Council approved the finding with the understanding that it would be converted into the NAC's standard format for findings and recommendations. The revised finding states:

In July 2014, the Council recommended that the Science Mission Directorate and Space Technology Mission Directorate Associate Administrators review the policy that disincentivizes infusion of new technology into small and medium-class science missions. The flagship missions utilize new technologies, but smaller missions have not. The Council is pleased to see incentives were added to the last Discovery round for inclusion of new technologies that could benefit future science missions. For example, four out of the selected Phase A Discovery study teams took advantage of these incentives to include new technologies (i.e., Deep Space Optical Communications). The Council finds that it would be useful to explore similar technology demonstration incentives for other science program mission areas.

Dr. Ballhaus presented a proposed finding to applaud STMD for embracing Restore-L as a nationally important capability demonstration mission, but questioning whether NASA has collaborated with the Defense Advanced Research Projects Agency (DARPA) to the maximum extent possible. The Council approved the finding with the understanding that it would be converted into the NAC's standard format for findings and recommendations. The revised finding states:

The transfer of the Restore-L mission from HEOMD to STMD resulted in a net reduction of \$37 million in budget to the STMD portfolio. The majority of the reductions were taken from the Technology Demonstration Missions, which eliminates the Low Density Supersonic Decelerator and Composite Exploration Upper Stage. It appears that Restore-L has much in common with the Defense Advanced Research Projects Agency (DARPA) Phoenix program, with the differentiator being Low Earth Orbit vs. Geosynchronous Earth Orbit demonstration. Has NASA collaborated with the DARPA to the maximum extent possible? The cumulative U.S. Government investment is -\$800 million using a common set of contractors and hardware.

Dr. Ballhaus presented a proposed Committee finding, for the STMD AA, on risk reduction technology matrixes for the ISS. After discussion and subject to minor modifications by Dr. Ballhaus, the Council approved the finding with

the understanding that it would be converted into the NAC's standard format for findings and recommendations. The revised finding states:

A set of Exploration Proving Ground missions is currently being defined. The Council looks forward to reviewing the risk reduction matrices and technology investment plans associated with the Proving Ground missions. Specifically, the Council is interested in understanding what technology risk reduction efforts require use of the International Space Station and why, and what is the plan to retire these technology risks by the time the ISS retires in 2024.

Dr. Ballhaus presented a proposed NAC finding, for the Administrator, on the need to mitigate the potential debris problem associated with the operational deployment of thousands of small satellites. After discussion, Dr. Ballhaus agreed to make changes to the recommendation and present the revised recommendation to the Council later in the meeting.

Dr. Ballhaus presented a proposed Committee recommendation, for the STMDAA, to conduct an independent study of current small satellite technology developments to determine the appropriate focus for NASA's small spacecraft technology investments. The Council approved the recommendation with the understanding that it would be converted into the NAC's standard format for findings and recommendations. The revised recommendation states:

The Council finds that the mission utility of small satellites is increasing rapidly and promulgated across industry, academia and government. The end-of-life issue associated with the operational deployment of thousands of small satellites creates a continually increasing architectural debris problem. There is a need for mitigating this potential debris problem. Should NASA play a role in helping the U.S. Government deal with this problem? The NASA Administrator could get this topic on the agenda for the Partnership Council meeting and engage the Federal Aviation Administration.

Dr. Squyres thanked Dr. Ballhaus for his presentation.

Aeronautics Committee Report

Dr. Squyres introduced Ms. Marion Blakey, Aeronautics Committee Chair.

Ms. Blakey reviewed the Aeronautics Committee membership. She described areas of interest explored at the last Committee meeting. Ms. Blakey discussed the anticipated growth in global aviation. Over 36,000 new aircraft will be required in the next 20 years, representing a \$4 trillion (T) to \$5T value. Ms. Blakey explained that U.S. technological dominance is being challenged by China. She presented a chart on the Aeronautics Research Mission Directorate (ARMD) 10-Year Investment Strategy. It covers subsonic and supersonic concept technology studies, the ERA Project, X-plane integration and demonstration, and FAA NextGen Research Transition Teams (RTTs). She reviewed the FY 2017 Budget Request for aeronautics and noted that it accelerates key components of NASA's Aeronautics Plan.

Ms. Blakey presented a proposed Committee finding, for the ARMDAA, that endorses the ARMD 10-year investment strategy, encourages setting a goal to make aviation safe for the environment, and expresses excitement about the X-planes. The Council approved the finding with the understanding that it would be converted into the NAC's standard format for findings and recommendations. The revised finding states:

The Aeronautics Committee endorsed the 10-year strategy that ARMD has established. The Committee finds that ARMD needs to be sure to focus on a goal setting strategy that makes aviation safe for the environment.

Ms. Blakey reviewed a chart on the ARMD strategic portfolio model. She described the portfolio elements and the ARMD roadmaps. There are six strategic thrusts covered by the roadmaps:

- Strategic Thrust 1: Safe, Efficient Growth in Global Operations
- Strategic Thrust 2: Innovation in Commercial Supersonic Aircraft

- Strategic Thrust 3: Ultra-Efficient Commercial Vehicles
- Strategic Thrust 4: Transition to Low-Carbon Propulsion
- Strategic Thrust 5: Real-Time System-Wide Safety Assurance
- Strategic Thrust 6: Assured Autonomy for Aviation Transformation

Ms. Blakey reviewed the ARMD planning priorities for each strategic thrust.

Ms. Blakey presented a proposed Committee finding, for the ARMD AA, that Unmanned Aircraft System (UAS) Traffic Management (UTM) is a potential testbed for capability prototyping and has potential to be a contributing factor to NextGen. The Council approved the finding with the understanding that it would be converted into the NAC's standard format for findings and recommendations. The revised finding states:

The Aeronautics Committee believes that Unmanned Aircraft Systems Traffic Management is a potential test bed for capability prototyping to be an integrating force and potentially revolutionize the Air Traffic Management for the benefit of the aviation industry. The Committee found that it has the potential to be a contributing factor to NextGen.

Ms. Blakey described a recent NASA/Air Force Executive Research Committee (ERC) meeting held at NASA Headquarters. The purpose of the meeting was to explore collaboration opportunities between NASA and the Air Force. One of the main topics was hypersonics and NASA's increased budget in that research area. To ensure that future meetings can inform development of budget and strategic investment decisions, both parties agreed to develop an ERC meeting schedule that takes into account each other's budget preparation timeline. Ms. Blakey reviewed strategic assumptions in the hypersonic research strategy. She explained that it is critical to see TRL advancement through to flight-test demonstrations. She described the Hypersonic Technologies Project in the FY 2017 Budget Request. The project objective is to advance analytical tools, test techniques and capabilities, and critical technologies to ensure U.S. supremacy in hypersonics for future national needs. The project will work with the DOD to develop a National Hypersonic Strategy. NASA's investment will be informed by and aligned to that strategy.

Ms. Blakey concluded her presentation with a chart showing the Committee's 2016 work plan.

Dr. Squyres thanked Ms. Blakey for her presentation.

Science Committee Report

Dr. Squyres introduced Dr. Bradley Peterson, Science Committee Chair. Dr. Peterson described the Committee membership and its subcommittees. He discussed recent science results. In heliophysics, satellite data shows that air on the edge of space is getting colder. The Sun's axial dipole component indicates that Solar Cycle 25 should have an amplitude similar to that of the current Solar Cycle 24. In Earth science, satellite measurements show that Chinese emissions offset a large portion of the reduction in mid-tropospheric ozone that should have occurred over the Western U.S. due to emission reduction policies. The actual impact of Chinese emissions has been small, but its future magnitude is highly uncertain. In planetary science, the New Horizons team has discovered a chain of mountains covered by methane that has condensed as ice from Pluto's atmosphere. The Dawn spacecraft has completed one year in orbit around Ceres. In astrophysics, a black hole jet related to glow from the Big Bang has been found without a corresponding radio emission for the first time.

Dr. Peterson presented the SMD organization chart. He reviewed SMD FY2017 program highlights. He explained that NASA science is contributing to program stability by providing reliable cost estimates for its missions. Dr. Peterson reviewed the Heliophysics 2017 Budget Request and presented a graphic showing the missions for the Heliophysics Program through 2024. He presented a graphic showing the Earth science satellite constellation and noted that it is in good shape. He reviewed the Earth Science Division Program. He noted that the FY 2017-2021 Budget Request is informed by and consistent with the Decadal Survey and that the FY 2016 appropriation, at \$270M over the \$1.63B request, supports a robust Planetary Science Program.

Dr. Peterson discussed the Planetary Defense Coordination Office (POCO). It provides warnings of potential impact effects from potentially hazardous objects (PHOs) if not deflected or mitigated. The POCO leads research into asteroid deflection and impact mitigation technologies and provides the lead coordination role in U.S. Government planning for response to an actual impact threat by providing planetary science and deep space missions expertise for the Federal Emergency Response Team. Dr. Peterson explained that the biggest threats are collisions with large objects and large-scale coronal emissions that could bring down the Earth's entire electric grid. He noted that there have been efforts to harden the grid with large capacitors. He cautioned, however, that "it would only take 15 minutes to blast us back to the Stone Age."

Dr. Peterson reviewed the FY 2017 Budget Request for Astrophysics and JWST. It compares well with the FY16 Appropriation and significantly exceeds the FY 17 notional run-out in the President's FY 2016 Budget Request for NASA Astrophysics, including JWST. The FY 2017 Budget Request and notional runout allows the WFIRST to be executed without additional funding. WFIRST is a NASA observatory designed to perform wide-field imaging and surveys of the near infrared (NIR) sky and was the highest ranked large space mission in the 2010 Decadal Survey. It will enable Hubble-quality imaging over 100 times more sky than the Hubble. WFIRST will utilize two 2.4 meter telescopes given to NASA by the NRO. Dr. Peterson noted that Senior Review funding may be inadequate to continue all currently operating missions. He discussed Japan Aerospace Exploration Agency's (JAXA's) Hitomi (formerly ASTRO-H). It successfully launched on February 17, 2016; however, contact was lost on March 26, 2016. He noted that "the loss was a huge blow to x-ray astronomy internationally."

Dr. Peterson reviewed JWST hardware progress. JWST remains on track for an October 2018 launch. He described the Research Coordination Network (RCN). He discussed NASA's Space Communications and Navigation (SCAN) networks spanning the globe. Dr. Peterson briefed the Council on the status of the Big Data Task Force (BDTF), which is expected to advise NASA on how to improve the science return from NASA's extensive data stores. He expressed concern over the fact that the BDTF's initial meeting has been delayed due to delays in getting committee members appointed. Dr. Squyres agreed to work on resolving that problem with the Agency. Dr. Peterson discussed a chart on the role of the terrestrial biosphere in global climate and carbon cycles.

Dr. Peterson presented a proposed Committee recommendation, for the SMD AA, that NASA (i) provide support to enable instrument developers to qualify and employ construction methods that would be compatible with the use of system-level, dry-heat microbial reduction (DHMR); and (ii) provide for a study to identify successful approaches by which modern instruments can be subjected to the current suite of commercially available microbial-reduction methods, including DHMR. Dr. Squyres requested that the Council be briefed at its next meeting on the status of Mars 2020 and planetary protection. After further discussion, the Council approved the recommendation with the understanding that it would be modified by Dr. Peterson to include developing methods other than dry-heat. The revised recommendation states:

In order to ensure that future scientific instruments can meet the challenges of planetary protection implementations for missions to worlds that could support Earth life, the Science Committee, on behalf of the Planetary Protection Subcommittee, recommends that NASA provide support to enable instrument developers to qualify and employ construction methods that will be compatible with the use of system-level microbial techniques, including the use of dry heat microbial reduction (DHMR).

Concomitantly, the Committee recommends that NASA benchmark or consider engaging the Space Studies Board (SSB) to conduct a study to identify successful approaches by which modern instruments can be subjected to the current suite of commercially available microbial-reduction methods, including the use of DHMR. Approaches from other fields (including medical, military and food-industry practitioners) would be particularly important to evaluate. Methods identified for use should be compatible with implementation strategies capable of complying with the regulatory framework for planetary protection currently in use by NASA and the Committee on Space Research (COSPAR).

Dr. Peterson presented a proposed Planetary Science Subcommittee (PSS) finding, for the SMD AA, that (i) the PSS is alarmed by reports of increasing data losses by active planetary missions, and (ii) current NASA science missions using the Deep Space Network (DSN) should be asked to inform NASA about recent DSN performance changes

they have experienced. Dr. Squyres commented that "the DSN is a marvel, it is a national treasure; it should be fixed." The Council approved the finding with the understanding that it would be converted into the NAC's standard format for findings and recommendations. The revised finding states:

The Science Committee finds that the Planetary Science Subcommittee (PSS) is alarmed by reports of increasing data losses by active planetary missions (e.g., Cassini, with details provided by the Outer Planets Assessment Group in their February 2016 finding on the Deep Space Network), especially following a 10% funding cut to the Deep Space Network at the end of 2015. The PSS supports aggressive efforts to address this issue and would like to hear updates as soon as possible. In particular, current NASA science missions using the Deep Space Network should be asked to inform NASA about recent Deep Space Network performance changes they have experienced

Dr. Squyres thanked Dr. Peterson for his presentation.

Institutional Committee Report

Dr. Squyres introduced Ms. Kathryn Schmoll, Institutional Committee Chair.

Ms. Schmoll reviewed the Committee's membership and the Committee Work Plan. She described the November 5, 2015, NASA Office of Inspector General (OIG) Report entitled "NASA's Top Management and Performance Challenges." She noted that four of the eight challenges identified in the OIG's report are institutional challenges:

- Overhauling NASA's IT governance
- Securing NASA's Information Technology systems and data
- Managing NASA's infrastructure and facilities
- Ensuring the integrity of the Agency's contracting and grants processes

Ms. Schmoll reviewed a chart on mission support budget trends from FY 2012 to FY 2017. She explained that mission support covers (i) construction and environmental compliance and restoration, and (ii) safety, security, and mission services. She discussed a graph showing the age of NASA facilities. She explained that the aging facility base drives operations, maintenance, and investment requirements. She noted that "a building over 50 years old is not a useful building."

Ms. Schmoll discussed the key drivers for BSA: a rapidly evolving environment, a severely constrained budget, and ongoing institutional challenges. She explained that most of mission support capabilities are below baseline service levels and that over 83 percent of NASA's facilities are beyond useful life. The estimated cost for deferred maintenance is over \$2.5B. Ms. Schmoll discussed the status of BSA "deep dives." She described BSA's roles and the BSA deep-dive team process.

Ms. Schmoll presented the Committee's observations on BSA:

Overall BSA efforts are to be commended.

There is greater transparency in the BSA process. The recent deep-dive teams took advantage of lessons learned from the early assessment teams.

When determining what BSAs to perform and implement, NASA should consider the OIG Report on Top Management Challenges.

Follow-thru is important. It is important to track that these decisions actually get implemented and actions are accomplished.

It is essential to have senior management backing and engagement where possible. The commitment at all levels and across all Centers is vital. Leadership should be mindful of BSA "process overload."

The Institutional Committee endorses the Mission Support Council (MSC)-approved Human Capital Deep Dive recommendations.

At Dr. Squyres request, Ms. Schmoll agreed to revise the Committee's observations as a NAC finding for the Administrator.

Ms. Schmoll presented the Committee's observations on the BSA IT Implementation Plan:

The IT Implementation Plan has been developed with extensive involvement from all stakeholders.

It seems well-defined but potentially resource intensive.

There has been noteworthy progress in establishing a coherent plan with common nomenclature and framework.

Structure will evolve with implementation.

At Dr. Squyres request, Ms. Schmoll agreed to revise the observations as NAC findings for the Administrator.

Ms. Schmoll discussed NASA's cybersecurity program and primary compliance drivers. She presented a chart on the various sources of Federal mandates and compliance metrics for cybersecurity. Ms. Schmoll discussed the Cross Agency Priority (CAP) goals for cybersecurity and presented a chart on Agency progress towards those goals. She noted that NASA CAP goal performance over the past year has improved significantly. She reviewed the key near-term initiatives and plans for NASA's cybersecurity program.

Ms. Schmoll presented a proposed Committee recommendation that the Agency should continue to focus on cybersecurity and accelerate the development of an IT security risk management structure. At Dr. Squyres request, Ms. Schmoll agreed to revise the recommendation as a NAC recommendation for the Administrator.

Dr. Squyres thanked Ms. Schmoll for her presentation.

Council Discussion

The Council discussed the "homework" that had been assigned the previous day to prepare recommendations on CASIS and the ISS. Dr. Squyres agreed to prepare final language for those recommendations and present them to the council for its approval later in the day.

Ms. Schmoll remarked that the chart presented by Mr. Gerstenmaier on why it is hard to go to Mars was excellent and that the budget presentation was spectacular. Mr. Hubbard stated that he is "going to miss everyone" and that he has enjoyed the opportunity to work with the Council members during his term on the Council. Dr. Squyres added that the Council greatly appreciates Mr. Hubbard's service to the NAC, the Agency, and the Nation.

Public Input

Dr. Squyres invited comments from the public.

Mr. Jeff Bingham discussed the allocation of resources on the ISS to CASIS and expressed concern that the Council was getting into a national policy area beyond the scope of NASA. He asserted that Congress had rejected exclusive use of the ISS for exploration. He also asserted that commercial utilization of space, including an independent entity to manage it, is required by law.

Dr. Squyres noted that as NAC Chair, he has always stressed that the Council's advice should be actionable. He added that the Council is aware that there are statutes that NASA must comply with, and he assured Mr. Bingham that those constraints would be taken into consideration by the Council during its deliberations.

Council Discussion and Final Wrap-Up

Ms. Schmoll presented a revised NAC recommendation, for the Administrator, that the Agency should focus on cybersecurity and accelerate the development of an IT security risk management structure. The Council approved the recommendation with the understanding that it would be converted into the NAC's standard format for findings and recommendations. The revised recommendation states:

The Council recommends that NASA accelerate the schedule to develop an IT Security Risk Management structure from its current schedule completion date of December 31, 2017, to an earlier date.

Ms. Schmoll presented a revised NAC finding, for the Administrator, that the OIG Report on Top Management Challenges should be considered when determining what BSAs to perform and implement. The Council approved the finding with the understanding that it would be converted into the NAC's standard format for findings and recommendations. The revised finding states:

The Council commends the overall BSA efforts to date. There is excellent transparency in the BSA process. The Council reinforces the importance of having senior management backing and engagement where possible. The commitment at all levels and across all Centers is vital. The Council suggests when determining what BSAs to perform and implement in the future, NASA should consider the Office of Inspector General Report on NASA's Top Management Challenges. The recent deep dive teams took advantage of lessons learned from the early assessment teams. Leadership should be mindful of BSA "process overload." The Council endorses the Mission Support Council approved Human Capital Deep Dive recommendations. The Council stresses the importance of tracking that these BSA decisions actually get implemented and the actions are accomplished.

Dr. Ballhaus presented a revised NAC finding, for the Administrator, on the need to mitigate the potential debris problem associated with small satellites. The Council approved the finding with the understanding that it would be converted into the NAC's standard format for findings and recommendations. The revised finding states:

The Council finds that the mission utility of small satellites is increasing rapidly and promulgated across industry, academia and government. The end-of-life issue associated with the operational deployment of thousands of small satellites creates a continually increasing architectural debris problem. There is a need for mitigating this potential debris problem. Should NASA play a role in helping the US Government deal with this problem? The NASA Administrator could get this topic on the agenda for the Partnership Council meeting and engage the Federal Aviation Administration.

Dr. Squyres presented a revised NAC recommendation, for the Administrator, that the Agency determine whether the allocation of ISS resources to CASIS impedes the Journey to Mars. The Council approved the recommendation, which states:

The Council recommends that NASA conduct an internal evaluation of the top priority ISS research directly related to the Journey to Mars and determine whether some portion of the resources (including crew time, up-mass, and dollars) applied to the ISS National Laboratory could be used to more rapidly advance the Journey to Mars.

The Council deliberated whether to recommend an independent study to inform CASIS about best practices in development of new industries. Dr. Squyres stated that there was a strong sense among the Council members that the presentation from CASIS did not include information that the Council wanted. He explained that the fault for that is shared by the Council for not giving better guidance and that there should be a subsequent presentation. Mr. O'Brien asserted that much time had been wasted, that there was not much time remaining, and that the asset is

diminishing every day at a huge cost to taxpayers. He added "time is of the essence." Mr. Hale observed that at least eight years remained. Mr. Bowersox suggested having the HEO Committee's Research Subcommittee meet with CASJS first to conduct fact-finding. Dr. Squyres advised that a study would delay matters and that "a year is a big deal." He suggested having CASIS return to the Council to talk again with very specific guidance. Mr. Young commented that the Council was "dissatisfied not with the presentation, but with what they are doing. It doesn't seem to have a high probability of success." Dr. Squyres agreed with Mr. Bowersox's suggestion to engage in fact-finding if it could be accomplished prior to the NAC's next meeting.

The Council discussed the upcoming transition in Presidential Administrations. Dr. Peterson advised that it would be important to be prepared to be proactive and present the transition teams with a plan for Mars. Mr. Hale reported that he had worked with the last transition team and learned that space policy is made at the White House. He asserted, "It is setting the expectation too high to suggest that NASA can affect the formulation of space policy." Ms. Blakey advised that it is important to know who is listened to on the transition teams.

In closing, Dr. Squyres thanked Ms. Rausch, Ms. Marla King, Ms. Mary Floyd, and Mr. David Frankel for the outstanding support given to the Council. Mr. Young thanked Dr. Squyres. He noted that Dr. Squyres "does a great job leading the activity." Mr. Young also acknowledged Mr. Gerstenmaier for "a great job in holding the Agency together."

Adjournment

The Council meeting adjourned at 2:40 pm.

NASA ADVISORY COUNCIL

NASA Headquarters
Program Review Center, Room 9H40
300 E Street, SW
Washington, DC 20546

PUBLIC MEETING

March 31-April 1, 2016

Thursday, March 31, 2016

9:00 -9:03 am	Call to Order, Announcements	Ms. Diane Rausch Executive Director NASA Advisory Council NASA Headquarters
9:03 -9:10 am	Opening Remarks by Council Chair	Dr. Steven W. Squyres Chair, NASA Advisory Council
9:10-10:00 am	Remarks by NASA Administrator	Mr. Charles F. Bolden, Jr. NASA Administrator
10:00- 11:00 am	NASA Human Exploration Update	Mr. William Gerstenmaier Associate Administrator (AA) for Human Exploration and Operations Mission Directorate NASA Headquarters
11:00am-12:00noon	NASA Technology Prioritization Plans for the Journey to Mars	Mr. James Reuter Deputy AA, Programs Space Technology Mission Directorate NASA Headquarters
12:00 noon - 12:30 pm	Council Discussion	All
12:30-1:30 pm	Lunch	
1:30-2:30 pm	NASA FY 2016 Budget and the President's FY 2017 Budget Request for NASA	Mr. David Radzanowski Chief Financial Officer NASA Headquarters
2:30 -3:30 pm	Center for the Advancement of Science in Space (CASIS) and the Demand for Access to LEO	Dr. Gale Allen Deputy Chief Scientist NASA Headquarters Mr. Gregory Johnson President and Executive Director, CASIS Dr. Michael Roberts Deputy Chief Scientist, CASIS

3:30-4:30 pm	Human Exploration and Operations Committee Report	Mr. Kenneth Bowersox, Chair
4:30-5:30 pm	Council Discussion	All
5:30pm	Adjourn	

Friday, April 1, 2016

9:00 -9:01 am	Call to Order, Announcements	Ms. Diane Rausch Executive Director NASA Advisory Council NASA Headquarters
9:01-9:05 am	Remarks by Council Chair	Dr. Steven W. Squyres Chair, NASA Advisory Council
9:05 -9:30 am	Ad Hoc Task Force on STEM Education Report	Dr. Anita Krishnamurthi, Chair <i>(via telecon)</i>
9:30- 10:15 am	Technology, Innovation and Engineering Committee Report	Dr. William Ballhaus, Chair
10:15- 11:00 am	Aeronautics Committee Report	Ms. Marion Blakey, Chair
11:00- 12:00 noon	Science Committee Report	Dr. Bradley Peterson, Chair
12:00 noon – 12:30 pm	Institutional Committee Report	Ms. Kathryn Schmoll, Chair
12:30- 1:30 pm	Lunch	
1:30- 1:45pm	Public Input	
1:45- 3:00pm	Council Discussion and Final Wrap-Up	All
3:00pm	Adjourn	

NASA ADVISORY COUNCIL

Membership- March 2016

Role	Council Members
Chair-NASA Advisory Council	Dr. Steven Squyres, <i>James A Weeks' Professor of Physical Sciences, Cornell University</i>
Member at Large	Dr. Wanda M. Austin, <i>President and CEO, The Aerospace Corporation</i>
Chair-Technology, Innovation and Engineering Committee	Dr. William F. Ballhaus Jr., <i>President and Chief Executive Officer (Ret.), The Aerospace Corporation</i>
Chair-Aeronautics Committee	The Honorable Marion C. Blakey, <i>President and CEO, Rolls Royce North America</i>
Chair-Human Exploration and Operations Committee	Mr. Kenneth Bowersox, <i>US. Naval Aviator (Ret); Former NASA astronaut</i>
Member at Large	Mr. N. Wayne Hale, <i>Consultant, Special Aerospace Services of Boulder, Colorado; NASA (Ret.)</i>
Member at Large	Prof. G. Scott Hubbard, <i>Department of Aeronautics and Astronautics, Stanford University</i>
Member at Large, Ex-Officio	Gen. Lester L. Lyles, <i>Chair, Aeronautics and Space Engineering Board, National Academy of Engineering; USAF (Ret)</i>
Member at Large	Mr. Miles O'Brien, <i>Independent Journalist</i>
Chair, Science Committee	Dr. Bradley Peterson, <i>Professor Emeritus, Ohio State University</i>
Chair, Institutional Committee	Ms. Kathryn Schmoll, <i>Vice President, Finance and Administration (Ret.), University Corporation for Atmospheric Research</i>
Member at Large	Dr. David Spergel, <i>Chair, Space Studies Board, National Academy of Sciences, Princeton University</i>
Member at Large	Mr. A. Thomas Young, <i>Executive Vice President, Lockheed Martin (Ret.); former Director, NASA Goddard Space Flight Center</i>

NASA ADVISORY COUNCIL
 NASA Headquarters
 Washington, DC
 March 31 -April 1, 2016

MEETING ATTENDEES

NASA Advisory Council Members:

Dr. Steven W. Squyres, <i>Chair</i>	Cornell University
Dr. Wanda M. Austin (<i>via telecon</i>)	The Aerospace Corporation
Dr. William Ballhaus	The Aerospace Corporation (Ret.)
Ms. Marion C. Blakey	Rolls Royce North America
Mr. Ken Bowersox	U.S. Navy (Ret.)
Mr. N. Wayne Hale	Special Aerospace Services of Boulder, CO (Ret.)
Prof. G. Scott Hubbard	Stanford University
Mr. Miles O'Brien	Independent Journalist
Dr. Bradley Peterson	Ohio State University
Ms. Kathryn Schmoll	University Corp. for Atmospheric Research (Ret.)
Mr. A. Thomas Young	Lockheed Martin (Ret.)
Ms. P. Diane Rausch, <i>Executive Director</i>	NASA Headquarters

NASA Attendees:

Allen, Gale	NASA Headquarters
Denning, Elaine	NASA Headquarters
Desori, Prasun	NASA Headquarters
Gatens, Robyn	NASA Headquarters
Gates, Michele	NASA Headquarters
Gerstenmaier, William	NASA Headquarters
King, Marla	NASA Headquarters
McKay, Meredith	NASA Headquarters
Mitchell, Jonathan	NASA Headquarters
Mullins, Todd	NASA Headquarters
Radzanowski, David	NASA Headquarters
Reuter, Jim	NASA Headquarters
Rodriguez, Irma	NASA Headquarters
Scimemi, Sam	NASA Headquarters
Siegel, Bette	NASA Headquarters

Other Attendees:

Antonelli, Tony	Lockheed Martin
Beckman, Bill	Boeing
Black, San	Office of Management and Budget
Bordi, Francisco	The Aerospace Corporation
Dittmar, Mary Lynne	Coalition for Deep Space Exploration
Brennan, Cindy Martin	CASIS
Dillon, Joe	Stair Co.
Frankel, David	P B Frankel, LLC

Johnson, Gregory	CASIS
Li, Allen	Committee on Science, Space and Technology, U.S. House of Representatives
Logsdon, John	George Washington University
Obennarm, Richard	Committee on Science, Space and Technology, U.S. House of Representatives
Roberts, Michael	CASIS
Sanders, Patricia	NASA Aerospace Safety Advisory Panel
Talbot, Brian	CASIS
Terrell, Kim	Katz International Management LLC

Telecon (Dial-In) Attendees :

Aaron Oestrle	Poli Space
Allen Deluna	ATDL INC
Ana Wilson	Ingenicomm
Andrea Riley	NASA
Anne Vulkosky	Lockheed Martin
Betsy Pugel	NASA Headquarters
Beverly Girten	NASA Headquarters/Education
Bill Jordan	NASA JSC
Bill Putter	OLIA NASA
Brad Johnson	NASA Goddard
Brian Whitley	NASA JSC
Carlos	NASA JSC
Carolyn Telenco	Public
Chris	Bigelow Aerospace
Chris Flaherty	NASA
Chris Gilbert	VE Consult
Cindy Martin-Brennan	CASIS
Craig Kundrot	NASA HQ
Curt Wiederhoef	JSC Support Contract
Cynthia Dinwiddie	SW Research Institute
Damara Arrowood	SciDVA
Daniel Schroy	Office of Management and Budget
Daniel Woodard	IMSA
Darrell Branscome	NASA Consultant
Dave Huntsman	NASA
Eric Berger	ARS Technica
Erin Neal	Absterge Twitch
Erin Preston	Government Accountability Office
Frank Moring	Aviation Week
Gene Mikulka	Talking Space Podcast
Gerry Haas	Citizen
Gib Kirkham	NASA

Grace Hu	Office of Management and Budget
Greg B	Press
James Dean	Florida Today
James Free	NASA
James Muncy	Poli Space
James Zimmennan	Retired
Jeff Bingham	Retired
Jeff Foust	Space News
Jennifer Grove	NASA HQ
Jens Foley	NASA Headquarters
John Dyste	Orbital ATK
John Rwnmel	SETI Institute
Kathryn Hamilton	NASA
Kathy Nado	NASA HQ
Keith Ewing	nasawatch.com
Kelly	The Watch
Ken Shields	CASIS
Kristin Vanwychen	Government Accountability Office
Loren Grush	The Verge
Lyn Wigbels	American Astronomical Society
Marcia Smith	Space Policy online.com
Marguerite Broadwell	NASA
Mary Floyd	Ingenicomm
MaryKenvin	NASAOLIA
Michael Moloney	Space Studies Board, National Academies
Mike Hathaway	No Affiliation
Patrick O'Neil	CASIS
Rasheda Holmes	Government Accountability Office
Richard Mckinney	Consultant
Richard Rogers	Stellar Solutions
Robert Zimmennan	Symbiotek
Roger Nolter	PSEG Nuclear
Scott Powers	Florida Politics.com
Stephanie Sharehold	NASA
Stephen Jurczyk	NASA Space Technology Mission Directorate
Steve Collins	The Watch
Steve Hanna	Civilian
Steven Clark	Space Flight Now
Tabitha Thompson	NASA
Theodore Kronmiller	Law Office
Tony Reichhardt	Aerospace Magazine
Warren Bates	CASIS
William Pratt	Lockheed Martin

Xaidia E. Raymond NASA

NASA ADVISORY COUNCIL
NASA Headquarters
Washington, DC
March 31 -April, 2016

LIST OF PRESENTATION MATERIAL

- 1) Human Exploration and Operations Progress and Plans on the Journey to Mars [Gerstenmaier]
- 2) NASA Technology Prioritization Plans for the Journey to Mars [Reuter]
- 3) Fiscal Year 2017 Budget Estimates [Radzanowski]
- 4) Human Exploration and Operations Committee Report [Bowersox]
- 5) Ad Hoc Task Force on STEM Education Report [Krishnamurthi]
- 6) Technology, Innovation and Engineering Committee Report [Ballhaus]
- 7) Aeronautics Committee Report [Blakey]
- 8) Science Committee Report [Peterson]
- 9) Institutional Committee Report [Schmoll]