

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

NASA ADVISORY COUNCIL


December 1-3, 2015

**NASA Johnson Space Center
Houston, Texas**

MEETING MINUTES



P. Diane Raasch
Executive Director



Steven W. Spayres
Chair

**NASA ADVISORY COUNCIL
NASA Johnson Space Center
Houston, Texas
December 1-3, 2015**

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*Meeting Report prepared by
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NASA ADVISORY COUNCIL**NASA Johnson Space Center
Houston, Texas****PUBLIC MEETING****December 1-3, 2015****Tuesday, December 1, 2015**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 the NASA Johnson Space Center (JSC) in Houston, Texas. 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. Meeting minutes will be taken and would 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 should 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 thanked Mr. Mark Geyer, Deputy Center Director, JSC, and everyone at JSC for hosting the meeting. Dr. Squyres noted that Mr. Michael O'Brien, Associate Administrator for the Office of International and Interagency Relations (OIIR), NASA Headquarters, had recently retired. Dr. Squyres explained that Mr. O'Brien had been NASA's official interface for NASA's advisory bodies and commended him for bringing great clarity and value to the advisory process. He requested Ms. Rausch to bring the commendation to Mr. O'Brien's attention. Dr. Squyres noted that Mr. John Borghese, Aeronautics Committee Vice-Chair, would be standing in for Ms. Marion Blakey, Aeronautics Committee Chair. He reminded the Council members to use their microphones because people online want to follow the deliberations. He reviewed the planned agenda for the meeting.

Welcome to the NASA Johnson Space Center

Dr. Squyres introduced Mr. Mark Geyer, JSC Deputy Director. Mr. Geyer welcomed everyone to JSC. He provided an overview on the work being performed at JSC. The International Space Station (ISS or Station) is the Center's largest flight program. He also described the Bigelow Expandable Activity Module (BEAM). It is an inflatable habitat that will be flown to the ISS on a SpaceX flight in January 2016 for a two-year test. In response to a question from Mr. Tom Young, Mr. Geyer explained that NASA is interested in inflatable technology due to the savings in mass. Mr. William Gerstenmaier, Associate Administrator for the Human Exploration and Operations Mission Directorate (HEOMD), NASA Headquarters, added that an expandable habitation module provides greater volume, better thermal properties, is quieter, and allows radiation particles to pass straight through, rather than ricochet. Mr. Gerstenmaier noted that there is a need to understand how the module would react to micro-meteorites and orbital debris (MMOD). He commented that it would be a great opportunity to use the ISS as a testbed. In response to a question from Mr. Young, Mr. Gerstenmaier explained that the failure rates on ISS were less than had been predicted. Mr. Geyer described the process for constructing new facilities at JSC. He explained that when a new

facility is constructed, it cannot exceed 90 percent of what is demolished. They are combining small, older buildings into large, new buildings that are more energy efficient.

Dr. Squyres thanked Mr. Geyer for his remarks.

Remarks by NASA Administrator

Dr. Squyres introduced Mr. Charles F. Bolden, Jr., NASA Administrator. Mr. Bolden introduced Dr. Dava Newman, NASA Deputy Administrator. He explained that Dr. Newman had been in that position for eight months and had previously been a Professor in the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology (MIT). He added that Dr. Newman was an outstanding addition to the leadership team at NASA. Mr. Bolden emphasized that NASA takes very seriously the Council's recommendations and findings. As examples, he observed that the previous Council meeting had produced recommendations on NASA Procedural Requirement (NPR) 7120 on governance, the role of NASA Center Directors, and the National Research Council (NRC) *Pathways to Exploration* report.

Mr. Bolden expressed pleasure that for the fifth year in a row, NASA had received a clean audit opinion. He explained that when he became the NASA Administrator, getting a clean audit for NASA was one of the first challenges that he took on, because the NASA audit issue had been raised at his Senate confirmation hearing. He stated he had not known about the NASA audit problem, and "it was the first thing that the Chairman of the Senate Commerce Committee hit me on."

Mr. Bolden stated he was "incredibly pleased" that for the fourth consecutive year, NASA had been judged to be the best place to work in government for a large government agency. He attributed that success to the mid-level leadership at NASA and to the individual employees who make up the NASA family. He described recent retirements. Mr. Patrick Scheuerman retired as the Director of NASA's Marshall Space Flight Center. Mr. Larry Sweet retired as NASA's Chief Information Officer (CIO). Mr. Sweet was replaced by his Deputy, Ms. Renee Wynn, who had previously served as the CIO for the Environmental Protection Agency (EPA). Mr. Michael O'Brien, NASA's Associate Administrator for International and Interagency Relations, has announced his retirement and will be replaced by Mr. Al Condes, who has been Mr. O'Brien's deputy for the last 12 years.

Mr. Bolden noted that on December 14, 2015, NASA would open the period for the recruitment of new astronauts. It would remain open until mid-February 2016. He noted that there was some concern that the astronaut selection office might not be adequately equipped to respond to the hordes of applicants expected on the heels of the Hollywood blockbuster movie, "The Martian." He expressed confidence that the NASA team would be more than ready to handle the situation. With respect to Mars, Mr. Bolden explained that it had been "a huge quarter" for NASA, beginning with the discovery of very high-salinity, flowing water by the high resolution cameras on the Mars Reconnaissance Orbiter (MRO), which has been on orbit for a little more than a year. He described recent findings from the Mars Atmosphere and Volatile Evolution (MAVEN) mission and its study of the impact of solar winds on Martian atmosphere. He commented that MAVEN is a very proud partner to the Indian Space Research Organization (ISRO) Mars Orbiting Mission (MOM), which is a part of the Journey to Mars and an important part of the Mars orbiting infrastructure. NASA is very proud to assist India in having a highly successful first-time attempt at sending a mission into orbit around Mars.

Mr. Bolden described NASA's new report, entitled *NASA's Journey to Mars – Pioneering Next Steps in Space Exploration*. It can be downloaded from the NASA website. He requested that Council members read it and give NASA a critical review. He explained that the report describes how NASA is closer to sending humans to Mars than at any point in NASA's history. The NASA Journey to Mars begins with the first of three phases, Earth-Reliant, where humans have now been for more than 40 years, using the ISS as a "toe-hold" on the rest of the solar system. In the next decade, the decade of 2020s, NASA plans to move to the second phase, the Proving Ground. "Saying that NASA is returning to the Moon would be an accurate description of what it means to be working in the Proving Ground," Mr. Bolden stated. NASA would be returning to cis-lunar orbit, which is an orbit around the Moon. NASA's intention is to be effective in "implementing and making it possible for its international partners to put humans back on the surface of the Moon, whether they be commercial, international, academic, or otherwise." That, he explained, is one of the intended outcomes of the 10 years that NASA would spend in the Proving Ground.

Mr. Bolden stated that the third phase, Earth Independent, is the horizon goal for the Journey to Mars, and that means putting humans in the Martian environment where they would be eight months away from Earth and operating on their own. NASA is looking forward to that day and all the challenges that go with it. A big part of the journey is the Orion crew spacecraft. Mr. Bolden complimented Mr. Geyer for his work on Orion's successful first flight, which took place last December 2014. It was the first time in over 40 years that NASA had flown a new spacecraft intended to carry humans beyond low-Earth orbit (LEO). Mr. Bolden noted that the U.S. Navy had been a major partner in conducting the mission. He found it incredible and inspirational to watch 17 and 18 year-old "kids" in Navy uniforms driving high speed boats with divers in the water to rescue the Orion spacecraft with Mr. Geyer and others yelling, "Don't hurt my spacecraft." Mr. Bolden observed that, as a former Navy midshipman and Marine Corps officer, he could not help but envy a number of them for being out there at sea off the coast of San Diego, participating in history. He predicted, "One of these days they'll be talking to their grandkids about what they did."

Mr. Bolden described NASA's role in making the movie "The Martian," which he believed has been a "resounding success." Under a non-reimbursable Space Act Agreement (SAA) with 20th Century Fox Entertainment, NASA provided technical assistance and guidance on everything from scripts to costumes and set design. The screenwriter, Mr. Drew Goddard, described the movie as "a love letter to NASA." Two members of the NASA Astronaut Office were personal advisors to Mr. Matt Damon and Ms. Jessica Chastain, the male and female lead actors, and helped to make sure that they understood what it was like to be a NASA astronaut. NASA and the filmmakers participated in joint education efforts on the Journey to Mars and the importance of "STEAM" (Science, Technology, Engineering, Arts, and Mathematics) education, which now goes beyond "STEM" education to include the arts as a critical part of what NASA does. This included Historically Black Colleges and Universities (HBCUs), a social media campaign, public service announcements with Ridley Scott and Matt Damon, and appearances on every major U.S. network and many cable outlets over the time period leading up to and immediately following the movie release. NASA has launched a "Real Martians" website that can be visited as well. It is part of the NASA website and highlights the work that is ongoing in NASA's real life Journey to Mars. It answers questions for people who want to know, "How realistic was the movie?" The Real Martians website gives people an opportunity to see things like the Mars Rover that is actually being tested at JSC, some of the life support systems, and vegetation that NASA is trying to grow in collaboration with the U.S. Department of Agriculture. Mr. Bolden explained how technology drives exploration. NASA is working with industry partners on advancing the technologies that drive the Journey to Mars and NASA's robotic exploration of the universe. In October 2015, NASA unveiled a new initiative that makes more than 1,200 NASA patents available to startup companies without requiring upfront payments.

Mr. Bolden discussed the ISS and described the current one-year mission of U.S. Astronaut Scott Kelly. Astronaut Kelly is more than halfway through his year in space on the ISS, conducting the mission with his counterpart, Russian Cosmonaut Mikhail Kornienko. Astronaut Kelly is also participating with his twin brother, former Astronaut Mark Kelly, in a twin study that is an unprecedented study in genomics. It involves genomicists around the world who helped to design the various tests that are being conducted over the year of the study. November 2015 marked 15 years of continuous human habitation on the ISS. President Obama called Scott Kelly to congratulate him and the entire crew for being a part of that mission, and also to congratulate Mr. Kelly on setting an American record for the most time in space by a U.S. astronaut. Mr. Bolden noted that more than 220 people from 17 countries have visited the ISS. Researchers from 83 countries have conducted over 1,760 research investigations on board. ISS educational activities have reached more than 42 million students around the world.

Mr. Bolden reported on developments in commercial crew and commercial cargo. NASA recently signed the first mission order with commercial company, SpaceX, to transport astronauts aboard their Crew Dragon spacecraft in 2017. It means they now have a mission in hand, and NASA has given its commitment that it is going to fly with them. The same order was awarded to Boeing back in May 2015 for its CST-100 Starliner spacecraft. The commercial crew page on the NASA website has pictures of the first four NASA astronauts selected to train and prepare for commercial spaceflights: Doug Hurley, Sunita "Sunny" Williams, Eric Boe, and Bob Behnken. The first flight should take place in 2017 or 2018. Funding for Commercial Crew Program is still an open issue. In August 2015, NASA notified the Congress that due to continued reductions in funding for the Commercial Crew Program over the past several years, NASA had to execute a \$490 million (M) contract modification with Russia for the purchase of additional seats on the Soyuz spacecraft. It is hoped that NASA will not have to do that again. Mr. Bolden asserted that the United States, the greatest country in the world, should be able to get its own astronauts into space, and noted that it should be remembered that there is a significant economic benefit to doing that. A majority of the states in the U.S. have workers who are part of the effort to return human space launches to American soil.

Mr. Bolden reviewed various NASA accomplishments. The New Horizons mission continues to dazzle everyone with imagery from Pluto. The New Horizons team began an extensive downlink of images from the spacecraft in October 2015. It revealed that Pluto had blue skies and water ice as well as some sort of an atmosphere. It also returned the highest resolution images to date of Charon, Pluto's largest moon. He noted that scientists continue to learn from the Cassini spacecraft orbiting Saturn. During a recent flyby, it detected a massive ice storm on Triton, one of Saturn's moons, which means at least five more years of winter for Triton.

NASA's aeronautics team continues to advance toward the goals of making flights safer, cleaner, quieter, and more efficient. In October 2015, NASA Ames Research Center (Ames or ARC) hosted representatives of 21 aviation organizations from across the world to discuss those goals. In September 2015, NASA announced that Virgin Atlantic and Alaska Airlines had been selected to test NASA's Traffic Aware Planner (TAP) application, which will potentially help air carriers reduce fuel consumption and carbon emissions.

In the area of Earth science, NASA continued over the past quarter to make significant contributions to the science community's understanding of Earth's climate and how it changes. NASA recently started a five-year study of the connection between plankton in the ocean and climate change. NASA is now publishing online daily breathtaking color images of Earth from NASA's Earth Polychromatic Imaging Camera (EPIC) camera that is flying on the Deep Space Climate Observatory (DSCOVR) spacecraft, located a million miles away from Earth.

In the field of education, Deputy Administrator Newman joined Administrator Bolden in October 2015 at an amazing White House Astronomy Night. It was the second time that has been done at the White House. NASA placed a number of telescopes on the South Lawn, and they were joined by more than 100 students and 12 NASA astronauts. Americans around the country were able to virtually participate in the event from more than 80 national parks, observatories, schools, museums, and astronomy clubs simultaneously. NASA continues to focus on STEAM and has made awards to nine universities to create and operate a STEAM academy, which is a Congressionally mandated program that provides funding for minority research. Mr. Bolden noted that he had co-written an op-ed article for NBC News with Elisa Beard, Chief Executive Officer (CEO) of Teach for America, on the importance of STEAM and outreach to the minority communities. The op-ed article was very well received.

Mr. Bolden invited Dr. Newman to provide comments to the Council. Dr. Newman thanked the Council members for their work. She explained that the Council's advice is taken seriously by NASA and that the Council is expected to produce helpful criticism. She explained that NASA is focused on the Journey to Mars. NASA is looking for participation from industry and international partners so that everyone "has skin in the game." Dr. Newman remarked that the Space Launch System (SLS), at 8.1 meters in diameter and 61 meters in height, "is incredible to look at." She noted that the robotic exploration of Mars is important. She explained that there is a need to thank all the NASA employees and the employees of NASA's contractors for their outstanding work and dedication.

Mr. Bolden offered to take questions from the Council members.

Mr. John Borghese asked Mr. Bolden to comment on a recently enacted law authorizing U.S. citizens to extract resources from celestial bodies for a profit. Mr. Bolden responded that he has asked lawyers for help in understanding the statute. He explained that he is not sure that Congress can pass a law authorizing American citizens to do that in light of existing treaties and that the question is pending at the United Nations.

Dr. William Ballhaus asked whether NASA was concerned about space debris originating from the proliferation of small satellites in LEO. Mr. Bolden responded that NASA, like every other space-faring nation, is concerned about orbital debris and the likelihood that small satellites, including CubeSats, would add to that debris. The Space Technology Mission Directorate (STMD) is working to develop a miniature, propellant capability for small satellites and CubeSats, as well as other methods to enable them to be controlled and de-orbited or sent into a parking orbit, rather than being at the whim of Mother Nature for how long they remain in orbit. Mr. Young commented that a challenge is presented when there is a national security payload involved, because they do not want propulsion capabilities on small satellites. Mr. Bolden explained that it is a major problem that needs to be solved, but that no agency has sufficient funds in its budget to be able to tackle it. He conceded that the government is "failing miserably in answering one of the biggest challenges for low Earth orbit-- sustainability and safety."

In response to a question from Dr. Squyres, Mr. Bolden responded that it would be helpful for Council members who know Presidential transition team members from either political party to share that information with him and to help facilitate meetings between NASA and the transition teams. He stated that he would continue to serve as the NASA Administrator until the end of the President's term in January 2017. It is his intention to approach both transition teams with an offer to brief them on the NASA portfolio and on what he believes is important for continuation of U.S. leadership in space and aeronautics. Mr. Bolden added that it is important to let the nominees know that they bear a certain amount of responsibility for maintaining that leadership. If that responsibility is ignored when they get into office, it would be noted. Mr. Bolden explained that the law now provides for both political parties to put in place active transition teams immediately after their respective conventions, rather than having to wait until after the election in November 2016.

In response to another question from Dr. Squyres, Mr. Bolden noted that the Aerospace Safety Advisory Panel (ASAP) is mandated to send a report to Congress at the end of each year. In each ASAP report for the last three or four years, one finding has been the critical importance of fully funding the President's Budget Request for the Commercial Crew Program as a matter of safety. Mr. Bolden stated that the NASA Advisory Council cannot lobby Congress, but that it can help people to understand the issue. Mr. Bolden added that NASA is reaching out to other Federal agencies to form new partnerships to promote a LEO infrastructure that would be sustained through commercial means and not the U.S. Government. That would be important for the transition from 2024 through 2028, when the ISS program comes to an end.

Dr. Squyres informed Mr. Bolden that the NASA Advisory Council had begun to have a closer interaction with the ASAP and would continue to follow through on a partnering with the ASAP. Mr. Bolden responded that that is critical. Mr. Bolden explained that one area where the Council disagrees with the ASAP is the area of governance and responsibilities for NASA Center Directors. He noted that there were no former NASA Center Directors on the ASAP, but there are several former NASA Center Directors on the Council. The presence of former Center Directors on the Council helps to fill some gaps. Mr. Bolden stated that safety is within the Council's purview. He explained that if NASA was not running a safe, efficient operation and not looking at reasonable mission assurance, then there would not be anything for the Council to advise NASA on. Accordingly, he believes that there is a synergy between the ASAP and the NAC that he welcomes.

Mr. Wayne Hale asked Mr. Bolden to describe what he would like to have people recognize as his legacy as NASA's Administrator. Mr. Bolden responded that he was not interested in having a legacy. He would like people to remember that during his term, NASA began to receive clean audits and that it was a good steward of the taxpayers' dollars.

In response to a question from Mr. Scott Hubbard, Mr. Bolden explained that it is his responsibility as the NASA Administrator to make sure that the NASA Associate Administrators understand that they do not manage the people who work at the NASA Centers. There should be a healthy tension between the NASA Associate Administrators and the NASA Center Directors. The Center Director is responsible for the execution of an Associate Administrator's program, along with the Program Manager.

Dr. Ballhaus described a time when the U.S. Air Force moved Program Executive Office responsibilities to the Pentagon. It turned out to be a complete disaster and cost the U.S. Government billions of dollars because authority had been separated from resources. He questioned the advisability of changing the NASA Center Director's role from being an intellectual leader to worrying about "roads and commodes." Mr. Bolden responded that he would have to take issue with the statement that the Center Director is not accountable for programs and project execution. Mr. Young recalled a conversation in which a NASA Center Director had stated that he was not responsible for the James Webb Space Telescope (JWST). Mr. Young expressed concern that while things had improved, the lines of responsibility still are not crystal clear. Mr. Bolden described NASA's Executive Council. It is the senior governing council in the Agency. His philosophy is that the only matters that should come to the Executive Council are issues that would put NASA on the front page of the *Washington Post* or the *New York Times* or that would get him called to the White House or Capitol Hill. Dr. Newman remarked that NASA Centers are working together more seamlessly than ever and that people are getting that there is "One NASA." Dr. Ballhaus cautioned that there is a problem when Centers do not have distinct roles and have to compete for missions. He suggested conducting a roles and missions exercise to ascertain whether it is good to have Centers compete for missions. Mr. Bolden responded

that NASA is trying to get to the point where a Center recognizes that it does not have to think about competing and that NASA would make decisions by designating Centers, rather than requiring competition.

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

NASA Human Exploration Update

Dr. Squyres introduced Mr. William Gerstenmaier, HEOMD Associate Administrator, NASA Headquarters. Mr. Gerstenmaier briefed the Council on the status of human exploration. He described NASA's long-term human spaceflight program. The objective, as stated in the 2014 NASA Strategic Plan, is to "extend human presence into the solar system and to the surface of Mars." Sustainability is the central idea in NASA's approach and the reason for implementing the Journey to Mars with a pioneering approach. A sustained program requires:

- Resilient architectures
- Robust and evolvable access to space
- Safe and productive long-duration human spaceflight
- In-space transportation for cargo and crew missions
- Knowledge of Mars and access to Mars surface
- Standards that allow hardware from a variety of sources

Mr. Gerstenmaier explained that those requirements are features of NASA's current programs and investment strategy. NASA's strategy is to make progress in those programs and investments at the rate that funding, technologies, and partnerships allow. He noted that standards are necessary especially for life support systems and that developing those standards is an opportunity to demonstrate global leadership.

Mr. Gerstenmaier described recent progress. The ISS one-year mission with Astronaut Scott Kelly has completed its first six months. Mr. Gerstenmaier observed that the one-year mission compelled NASA and Russia to work closer than ever before on a joint investigation. He described recent contracts awarded by NASA for Venture-Class Launch Services (VCLS). He reviewed a funding chart for the ISS Technology Demonstration Plan. In response to a question from Dr. Ballhaus, he explained that the chart is used to inform the budget process. Mr. Young commented that the chart indicates that the program is "in deep, serious trouble." Mr. Gerstenmaier presented a chart on the Human Resource Program (HRP) integrated path to risk reduction. He discussed the status of the Orbital and SpaceX Commercial Resupply Service (CRS) missions. Orbital has contracted with United Launch Alliance (ULA) for an Atlas V launch of the Cygnus spacecraft. SpaceX's Dragon capsule will transport the BEAM to the ISS for a two-year test. He presented graphics showing recent accomplishments in the programs for Orion, SLS, and Ground Systems Development and Operations (GSDO). He noted that there is more hardware development activity than at any time since the Apollo program.

Mr. Gerstenmaier reviewed progress in the Asteroid Redirect Mission (ARM). He described the acquisition strategy for the Asteroid Redirect Robotic Mission (ARRM). NASA will leverage current, commercially available, spacecraft bus capabilities to decrease the cost risk. NASA chartered an ARM Formulation Assessment and Support Team (FAST) to provide timely inputs for mission requirements formulation in support of an ARRM Requirements Closure Technical Interchange Meeting (TIM) planned for mid-December 2015. Asteroid 2008EV5 remains the reference target asteroid. He presented a chart showing major ARM risk reduction activities completed by the NASA Glenn Research Center (GRC) for NASA's Space Technology Mission Directorate (STMD). Mr. Gerstenmaier described the ARM Capture System testing at the NASA Goddard Space Flight Center (GSFC), the ARM Relative Navigation System (RNS), the ARM Contact and Restraint Subsystem (ACRS), and the ARM Robot Subsystem (ARS). He described the ARS microspine gripper. It uses almost 2000 independent hooks to grip an asteroid surface.

Mr. Gerstenmaier described *NASA's Journey to Mars* report. He discussed the distinction between Design Reference Missions (DRMs) for going to Mars and the Evolvable Mars Campaign (EMC), which is NASA's current design philosophy for going to Mars. He explained that there are many DRMs that NASA is using to inform the EMC. The EMC is an ongoing series of architectural trade analyses that NASA is executing to define the capabilities and

elements needed for a sustainable human presence on Mars. It builds from previous studies and ongoing assessments. Mr. Gerstenmaier reviewed several charts showing EMC questions that are under study by work groups. He noted that NASA wants to put rovers on the Moon to help evaluate in situ resource utilization (ISRU), which would be accomplished with international partners. He presented a chart on the Proving Ground capability evolution. Mr. Gerstenmaier explained that the Journey to Mars requires a resilient architecture that can embrace new technologies and partners and that can identify Agency investment choices to be made in the near-, mid-, and long-term timeframes. The EMC informs NASA's choices by providing technical information from a cross-Agency, end-to-end integrated analysis. The EMC needs to continue to develop linkages to the Agency decision-making and capability-investment processes. Mr. Gerstenmaier concluded his presentation with the observation that no matter what path is ultimately selected, there are common capabilities required to be developed by NASA and its partners over the next 10 years. Cis-lunar space around the Moon is important because it will provide an opportunity to experiment with risk-tolerance strategies.

Mr. Hubbard complimented Mr. Gerstenmaier for a "terrific" presentation. He asked whether the near-term architecture is understood well enough to enable NASA to make proper investments. Mr. Gerstenmaier responded affirmatively. At Dr. Squyres' request, Mr. Gerstenmaier described the habitation modules that are being studied. He noted that an expandable habitation module will be tested on the ISS next year. It will permit racks to be stored in the core of the module, allowing the exterior to be used for radiation protection and water storage.

Dr. Squyres thanked Mr. Gerstenmaier for his presentation.

NASA Human Spaceflight Transition and Low Earth Orbit Commercialization

Dr. Squyres introduced Mr. Samuel Scimemi, Director, ISS, HEOMD, NASA Headquarters. He described seven strategic principles for sustainable exploration:

- Implementable in the near-term with the buying power of current budgets and in the longer term with budgets commensurate with economic growth;
- Exploration enables science and science enables exploration, leveraging robotic expertise for human exploration of the solar system;
- Application of high Technology Readiness Level (TRL) technologies for near term missions, while focusing sustained investments on technologies and capabilities to address challenges of future missions;
- 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;
- Opportunities for U.S. commercial business to further enhance the experience and business base;
- Multi-use, evolvable space infrastructure, minimizing unique major developments, with each mission leaving something behind to support subsequent missions; and
- Substantial new international and commercial partnerships, leveraging the current ISS relationships while building new cooperative ventures.

Mr. Scimemi explained that the seven principles provide the context and guidance for the next-level considerations on what happens to Low Earth Orbit (LEO) after ISS and what happens to the ISS platform after NASA's mission is complete in LEO. He described the strategic framework for the human spaceflight transition from ISS to cis-lunar space. NASA will focus on transition indicators and meeting ISS-specific requirements for human spaceflight and LEO commercial efforts, rather than declaring a definite end date for the ISS. NASA would not transition from ISS until it is executing human deep-space missions. In response to a question from Dr. Ballhaus, Mr. Scimemi explained that the framework is being used to focus on developing budget requests. Mr. Gerstenmaier added that he does not regard humans in cis-lunar space as a permanent presence. Dr. Squyres commented that the perceived 2024 end date for ISS now seemed "squishy," which he asserted was not necessarily a bad thing. Mr. Scimemi explained that it is guaranteed that the ISS would have an end date, possibly around 2028. However, from a budgetary and policy standpoint, it is currently 2024. NASA would need to make an intelligent decision on how to leave the facility and how to transition the partnership. NASA is exploring possible outcomes for the ISS platform at its end-of-life, including deep-orbiting, transferring responsibility, and disassembly. In response to a question from Dr. Bradley Peterson, Mr. Scimemi explained that the ISS core would not last as long as the newer modules. He added that extending the ISS life would require a greater investment than NASA wants to make, although some parts could be

reused. NASA's policy is to transition to a commercial space station. Mr. Gerstenmaier added that it would be best to have commercial interests take over LEO. He noted that there are sufficient funds for Orion, SLS Exploration Mission (EM)-3 and EM-4, and operating ISS through 2024. Dr. Squyres advised that articulating that well for NASA's stakeholders and international partners would be very important. Mr. Gerstenmaier emphasized that it would be important to transition the ISS to commercial industry. Mr. Hale asserted that that would put the Center for the Advancement of Science in Space (CASIS) on the critical path. Dr. Squyres requested a presentation on CASIS for the next Council meeting. Mr. Scimemi explained that NASA is preparing to transition LEO post-ISS human spaceflight activities to the private sector. He described what is needed. NASA has to develop a proven, reliable transportation system and has to build a commercial demand. There has to be a market. NASA will continue current LEO commercial development efforts. In addition, NASA is actively engaging other U.S. Government agencies. He asserted that there is time to develop what is needed because ISS would be around for another 10 years.

Mr. Scimemi explained that the primary human spaceflight goal is to prepare and develop all crew-related capabilities needed for long-duration transit missions to Mars. NASA is planning for one or more one-year, crewed expeditions by the end of the 2020s. Those expeditions would directly measure preparedness in the relative safety of the lunar vicinity and are referred to as "shakedown cruises." Mr. Young asked whether the plans should include a three-year shakedown cruise. Mr. Scimemi responded that a three-year shakedown cruise is not needed to prove that a three-year Mars mission would be feasible. Mr. Hale added that a three-year shakedown cruise could be added if it is determined to be necessary. Mr. Scimemi described how the shakedown cruises would provide an anchor for other human spaceflight activities. He reviewed a chart showing opportunities for public-private and international partnerships and for government-direct development within the framework. He noted that NASA has extensive expertise and capabilities to be leveraged. He discussed the knowledge and capabilities that needed to be developed in the Proving Ground to learn how to be Earth Independent. He reviewed a chart on cis-lunar habitation system objectives for life-support, environmental monitoring, crew health, extravehicular activity (EVA), and fire and radiation protection. He presented a chart showing human health and performance research that would be needed for the transition from ISS to cis-lunar space. He explained that the ARM would be accomplished along the way with humans in cis-lunar space.

Mr. Scimemi presented a chart on the vision for the transition to commercial LEO. The vision calls for "sustained economic activity in LEO enabled by human spaceflight, driven by private and public investments creating value and benefitting Earth through commercial supply and predominantly private demand." He explained that commercial demand for LEO must be developed in sectors of the economy other than research, including tourism, manufacturing, and marketing. Dr. Squyres asked whether private demand currently existed. Mr. Scimemi answered affirmatively and cited fiber production and protein crystal growth as examples. Dr. Ballhaus asked what the return was on that investment. Mr. Scimemi responded that he did not have that information. Mr. Gerstenmaier noted that NASA is subsidizing commercial space by providing transportation and operating the ISS. He added that consideration should be given to tax incentives. Dr. Squyres explained that commercializing LEO is a critically important issue and that "the vision is exactly the right one." Mr. Gerstenmaier commented that it is not up to NASA to prove the business case that private demand exists. It is up to NASA to expose the benefits of space to industry and then allow private industry to make the case. Mr. Hale stated that it remains to be seen whether there could be a reasonable return on investment. Dr. Squyres asked whether the transition plan for the ISS would change if NASA concluded that there was not a demand for commercial LEO. Mr. Gerstenmaier responded that there would never again be a large space station. Commercial LEO would not be the same scale. Dr. Squyres suggested that the ISS transition plan may need to be independent from LEO commercialization. Mr. Scimemi explained that the transition plan for LEO commercialization would need to come from industry. Mr. Gerstenmaier noted that the research focus for NASA was no longer in LEO; it is in cis-lunar space. Mr. Kenneth Bowersox cautioned that Astronauts would still have to spend time in LEO for operational and training needs. He explained that you would want them to have some experience in microgravity before sending them on an extended space mission. Dr. Hubbard asserted that the Journey to Mars and cis-lunar space is not dependent upon commercial development in LEO. The LEO business models that are likely to succeed would not require humans in LEO. Mr. Hale suggested that there are many entrepreneurs who would be interested in commercial LEO if the transportation element could be surmounted. Mr. Scimemi noted that it was highly probable that NASA would continue crew activities and materials research in LEO. Mr. Young indicated that it would be prudent for NASA to base its ISS transition plans on LEO commercialization not happening. Mr. Gerstenmaier responded that LEO commercialization is not required in NASA's plans for the ISS transition. He explained that NASA cannot operate a LEO infrastructure and continue to do extensive exploration. It would be necessary, he explained, to "step away" from LEO if, as directed by law,

NASA works to expand human presence throughout the solar system. Mr. Gerstenmaier encouraged the private sector to learn what can be done in microgravity. He asserted that private companies can use microgravity research in LEO to gain a competitive advantage over other companies.

Dr. Squyres thanked Mr. Scimemi for his presentation.

Adjournment

The Council meeting was adjourned for the day at 5:00 pm.

Wednesday, December 2, 2015

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 the FACA Federal statute, 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. He described the day’s agenda. He noted that Mr. James Stofan, Chair, NAC Ad Hoc Task Force on STEM Education, would be attending the meeting that day, and would be briefing the Council members for the first time.

Human Exploration and Operations Committee Report

Dr. Squyres introduced Mr. Kenneth Bowersox, Human Exploration and Operations (HEO) Committee Chair. Mr. Bowersox described the Committee membership. He presented NASA HEOMD’s organization chart. He discussed NASA’s Journey to Mars report and requested that Council members read the report and submit comments.

Mr. Bowersox briefed the Council on the status of the ISS. He presented charts describing ISS port utilization, Increment 45 crew members, and the ISS consumables status. He briefed the Council on the Japanese H-II Transfer Vehicle (HTV)-5 resupply spacecraft mission, the Orbital (Orb)-4 mission, and the SpaceX-8 mission. He described the 62P Progress-MS mission. It would be the first Progress flight on the Soyuz 2.1A booster since the 59P Progress accident. He noted that Mr. Scimemi had briefed the HEO Committee on the human spaceflight transition from ISS to cis-lunar space. Mr. Bowersox reviewed the Exploration Mission (EM)-1 Integrated Mission Milestone Summary chart. He noted that NASA is planning a 2021 launch date for EM-1 and that there is a Congressional commitment for a launch date no later than 2023. He presented graphics showing recent accomplishments on Orion, SLS, and GSDO.

Mr. Bowersox presented charts on Earth Reliant near-term objectives and on Proving Ground objectives. He described recent accomplishments in the Advanced Exploration Systems (AES) program. Those accomplishments include the BEAM, the Resource Prospector, logistics reduction, life support systems, spacecraft fire safety, and nuclear thermal propulsion. He noted that scientists do not understand what happens to fire in microgravity and have not been able to conduct tests on the subject due to the danger.

Mr. Bowersox discussed a briefing given to the HEO Committee by Ms. Kathryn Lueders, NASA CCP Program Manager, on the status of the CCP. He described the Crew Transportation System (CTS) Certification and CTS Certification of Flight Readiness (CoFR). The CTS Certification is the approval of the commercial provider’s evidence that all test, analyses, verification, and validation proves that the baseline design meets the applicable requirements. The CTS CoFR refers to the NASA endorsement that compares and validates the hardware built to the certified configuration. CTS Certification and CTS CoFR are incrementally approved through oversight and risk-based insight in parallel to Commercial Crew Transportation Capability (CCtCap) certification-related milestones. The process strives to achieve a balance of insight and oversight appropriate for shared government and industry

accountability in establishing a safe, reliable, and cost-effective CTS. The industry partner is responsible for design, development, test, and evaluation, which would culminate in its certification assertion that its CTS is able to transport crew to and from the ISS. The NASA CCP is accountable for ensuring compliance to CCP's human spaceflight requirements through evaluation and approval of the contractor's compliance evidence and execution of NASA's insight into the contractor's solution in accordance with a risk-based insight approach implemented under a shared assurance model.

Mr. Bowersox reviewed a chart on the CCP requirement development. He explained that the Agency, HEOMD, and the CCP retain key accountability for NASA human spaceflight safety and mission success requirements allocated from NASA Procedural Requirements (NPR) 8705.2B. The Human Rating Certification Package in NPR 8705.2B Appendix D represents a subset of the data required in the Commercial CTS (CCTS) Certification Data Package. The CCT-REQ-1130 requirements are the requirement set for the entire CTS from launch through landing while independent of the ISS. SSP 50808 is an over-arching interface document that contains the requirements that are necessary for docking or berthing to the ISS. The standards for both documents have been reviewed and are the same or complementary. Variances may be submitted and are approved through the appropriate Program Board structure. Mr. Bowersox presented a chart on the purpose and mapping of CCT-REQ-1130. He noted that Ms. Lueders reported that both commercial providers are meeting contractual milestones, maturing their detailed designs, providing increased insight opportunities, and are building and testing hardware.

Mr. Young asked about the requirements for flight demonstrations before the vehicles are approved. Mr. Gerstenmaier responded that there would be an uncrewed flight and a crewed flight. The contractor has the option to choose whether or not the crewed flight goes to the ISS. One contractor has chosen to go to the ISS, and the other has not. Dr. Ballhaus asked whether NASA would participate in the contractor's Flight Readiness Review (FRR). Mr. Bowersox responded that the process is being developed. He added that it is NASA's decision whether or not to put crew on the vehicle and that the contractor does not get paid if crew is not put on the vehicle. Mr. Gerstenmaier added that putting crew on board is his decision, but the contractor can appeal that decision to the NASA Administrator. Dr. Squyres advised that good communications between the contractor and NASA leading up to the FRR are important for minimizing the possibility that NASA might decline to put a crew on the vehicle. Mr. Gerstenmaier stated that the communications process between the contractors and NASA was very clear and is exactly the same as the standard process followed for Space Shuttle flights, Soyuz, and for ISS critical events.

Mr. Bowersox commented that the HEO Committee would remain interested in the topic, and would want to look at the actual CoFR statement to see who is responsible for signing it. Dr. Squyres explained that this was a specific issue that the Administrator Bolden had asked the Council to focus on. Mr. Bowersox added that NASA's Aerospace Safety Advisory Panel (ASAP) is also working on that issue for the Administrator Bolden and is working on it at a much greater level of detail than the HEO Committee. He advised against having the Committee increase its focus. Dr. Squyres concurred and explained that it is not the intention of the Council to duplicate the function that the ASAP provides on that issue. He reported that he has had conversations on the subject with Vice Admiral Joseph Dyer, the ASAP Chair. They have agreed that it is important to strengthen communications between the Council and the ASAP so that each group knows what the other is doing. For that reason, it has been agreed that a NAC (Council) member representative will attend ASAP meetings and an ASAP member representative will attend NAC (Council) meetings. Mr. Bowersox had already attended an ASAP meeting representing the NAC (Council), and this practice will be continued in the future. Mr. Bowersox explained that it is important for both groups to avoid asking the Agency for answers to the same questions. It would help NASA work more efficiently if the NAC and ASAP coordinated their efforts. The ASAP is doing a great deal of work on the subject and he advised that the NAC should monitor the subject on a lower frequency. Mr. Gerstenmaier asked that there be as much coordination as possible because NASA is getting very similar questions from both groups. Dr. Squyres concurred.

Mr. Bowersox presented several HEO Committee observations:

- *Plan for Commercial Crew vehicle certification and flight readiness seems reasonable – critical work and process definition ahead*
- *Capability requirements for future exploration being used to guide ISS transition. Progress on the ISS transition plans – work still underway*
- *SLS, Orion, and ground systems programs – building momentum*

- *Current capability based approach for human exploration is reasonable considering current political and economic environment*

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

- Lack of U.S. launched crew transportation to Low Earth Orbit
- Interruption in U.S. launched cargo capability
- Current level of definition for Mars exploration architecture impedes effort to generate support
- Cost impact of NASA processes 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 reduce program resilience in the event of mission failure

Dr. Squyres stated that it was an excellent list that mirrors concerns that have been expressed by the Council. Mr. Bowersox concluded his presentation with a chart showing future special topics to be considered by the Committee and items for the Committee's continued review.

Dr. Squyres thanked Mr. Bowersox for his presentation.

Technology, Innovation and Engineering Committee Report

Dr. Squyres introduced Dr. William Ballhaus, Technology, Innovation and Engineering (TI&E) Committee Chair. Dr. Ballhaus described the TI&E Committee membership. He presented a chart showing the elements of the Journey to Mars. Mr. Young asserted that a NASA technology program could not be planned against the chart. Dr. Ballhaus noted that his Committee did not get the plan from NASA that it was expecting. He reviewed a chart on resilient architectures for Mars exploration. According to NASA's Chief Technologist, Mr. David Miller, resiliency is being robust, or adaptable, to change, and proactively planning for change is always better than simply reacting to change as it occurs. Dr. Ballhaus presented charts showing a conceptual integrated campaign for Mars in the 2020s and an integrated vision for a Mars robotic precursor initiative. He noted that the 2020s will be a "transition decade" that leads humans to Mars in the 2030s.

Dr. Ballhaus discussed a chart showing the history of beyond-LEO spaceflight architecture development. He discussed the difference between DRMs and the design philosophy for the EMC. He reviewed a chart on the NASA Space Technology Mission Directorate (STMD) strategic planning. He noted that adequate funding for the program has not materialized, and there is only a small amount of money for discretionary activities. Dr. Ballhaus described how HEOMD and STMD work together on technology needs. He presented charts on the capabilities needed for pioneering space in the Journey to Mars.

Dr. Ballhaus discussed in-situ resource utilization (ISRU) and surface power. The objective is to reduce logistical support from Earth by utilizing local resources to produce water, oxygen, propellants, and other consumables. He described the Resource Prospector, the Mars Oxygen ISRU Experiment (MOXIE), and a ground demonstration of fission surface power. Dr. Ballhaus reviewed a chart on current activities in developing technologies for entry, descent, and landing (EDL). The objective is to develop the capability to land heavy payloads over 18 metric tons on Mars for human missions. He reviewed a chart on current activities in developing technologies for environmental control and life support systems (ECLSS). The objective is to develop highly-reliable support systems that recycle air, water, and waste to reduce consumables. He presented a chart showing the status of funding for capability-development risk reduction. He reviewed current capability risks.

Dr. Ballhaus presented a chart showing an April 15, 2010, quotation from President Barack Obama's space policy speech at the NASA Kennedy Space Center. President Obama stated:

"By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth. And a landing on Mars will follow."

Dr. Ballhaus presented a Committee observation on HEOMD and STMD joint efforts:

HEOMD and STMD working together have identified a range of critical technologies and further capabilities required to support human missions to Mars. NASA has a broad range of architectural landscape options and is working to narrow them. NASA is defining a common set of technology investment requirements across these architectures. They have identified gaps in the areas of: power and in-space propulsion, ECLSS, habitation, ISRU, communications and navigation.

Dr. Ballhaus explained that the TI&E Committee had been asked to assess NASA's risk assessment on technology investment. He presented a proposed Committee finding for the STMD Associate Administrator on the Committee's ability to assess the technology investment matrix:

In order to assess the technology investment matrix, the TI&E Committee would need the following:

- *A mission definition*
- *A plan that includes technology risk burn down lead times and tech demo completion dates*
- *Budget commitments and authority to proceed dates*
- *An assessment of technologies that could be effectively evaluated on extant ISS environment*

In the absence of these items, the Committee offers the following:

- *The Committee has been told that NASA budget limitations and uncertainties are a significant impediment to a human exploration mission to Mars in the 2030s with SLS, Orion, and other system developments as the current near term pacing items in human exploration.*
- *NASA has defined what budget it needs in STMD, but the discretionary portion has diminished over time, and has forced many of the planned technology investments and demo risk reduction missions to be significantly delayed, descoped, or eliminated.*

To effectively advocate to correct the situation, in the absence of a defined mission plan to go to Mars, this Committee believes the preferred approach is to develop the technology pull from the Proving Ground missions:

- *The Committee believes the current HEOMD efforts must demonstrate measurable progress in most of the essential areas enabling future human exploration missions*
- *At a cadence that maintains U.S. human space leadership and U.S. public support*
- *Must address major technology gaps (power and in-space propulsion, ECLSS, habitation, ISRU, communications and navigation) with timeline for need dates and appropriate investment*

Dr. Squyres asked whether a mission definition would have to show the architecture all the way to "boots on the ground" at Mars. Dr. Ballhaus responded in the affirmative, and added that the mission would be a pull on the technology. Mr. Young commented that the problem is not the detail as much as it is the absence of a complete plan to put boots on the ground. Dr. Ballhaus concurred. Dr. Squyres observed that the HEO Committee had concluded that, in the current political and budgetary environment, the lack of specificity in the Mars architecture is appropriate. He explained that there appeared to be a difference of opinion between the two Council committees on how specific the Agency's plan needed to be. He asked whether developing the common technologies that NASA knows would be needed, independent of the specifics of the architecture, would be sufficient. Dr. Ballhaus explained that there is no urgency to fund those technologies because there is no plan that says NASA is going to Mars by a particular date. The technologies will not be funded until there is an urgency argument. Mr. Young concurred and offered EDL as an example; it is clearly needed, but there is no time period for when it should be funded. For that reason, many decision makers see no urgency in funding that technology. Mr. Hale commented that some technologies might not work out, requiring a change in the plan. Therefore, a detailed plan today could end up being the wrong plan. He suggested identifying and funding as early as possible those technologies that would radically affect the plan if they did not work. Dr. Ballhaus agreed and added that when someone invests in technology, they are buying options, many of which would never be exercised, particularly with respect to the early TRLs.

Dr. Ballhaus stated that the Committee's conclusion was that, "it probably does not make sense to talk about going to go to Mars now." He added that NASA should be following the Augustine Committee's "flexible path" approach

to take steps in spreading human presence throughout the Solar System that demonstrate U.S. leadership where other nations want to follow. Dr. Ballhaus reiterated that NASA is not ready to have a specific plan to go to Mars now because there is no urgency argument, and it does not look like it is going to be funded. He explained that the pacing items now are not the technology; the pacing items are in the Proving Ground: SLS, Orion, and GSDO. It would make sense, therefore, to identify the Proving Ground missions and ascertain the mission pull on technology from those missions. He asserted that that would generate an urgency argument. Mr. Hale concurred. Mr. Hubbard advised that a mission in 2033 would be a good forcing function from a celestial mechanics perspective, and end-to-end boots on the ground can be notional until then. As that date approaches, the degree of detail can go up, and that is where one would find the forcing function for technology investment. Dr. Squyres concurred.

Dr. Squyres suggested that the essence of the TI&E Committee's finding is that the focus now for technology investment should be the Proving Ground missions up to the "shake-down" cruises in the late 2020s. Dr. Ballhaus concurred, with the caveat that there should also be some funding of technology "push" to enable disruption. Mr. Young commented that there is not adequate information to plan a technology program for going to Mars with a sufficient sense of urgency to get the program funded. Dr. Ballhaus concurred. Mr. Young stated that to him, the default position to plan a technology program around cis-lunar space is disappointing and discouraging. It feeds into the probability of a lower level of support for humans going to Mars. He asserted that limiting the U.S. exploration policy to exploring cis-lunar space just to carry out technology development activities would be the "death knell" for the human exploration program. Mr. John Borghese agreed with Mr. Young and added that there would be reduced funding and a loss of public support if the Proving Ground missions are not tied directly to going to Mars. Mr. Young concurred. Dr. Ballhaus stated that the Committee was looking for a plan that would generate urgency for technology development and could not find one.

Dr. Squyres explained that the proposed Committee finding was a Council-level issue, and that the Council would return to it later in the meeting for further discussion.

Dr. Squyres thanked Dr. Ballhaus for his presentation.

Institutional Committee Report

Dr. Squyres introduced Ms. Kathryn Schmoll, Institutional Committee Chair. Ms. Schmoll reviewed the Institutional Committee's membership and the Committee Work Plan. She described the November 14, 2014, NASA Office of Inspector General (OIG) Report entitled "NASA's Top Management and Performance Challenges." She noted that four of the seven challenges identified in the OIG's report are institutional challenges:

- Overhauling NASA's Information Technology (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 noted that the OIG had dropped from its list the proper use of Space Act Agreements (SAAs). She intends to have her Committee look into what caused that to happen.

Ms. Schmoll presented a chart on the Business Services Assessment (BSA) Deep Dives. She discussed improving IT security at NASA. In response to a question from Mr. Borghese, Ms. Schmoll confirmed that insider threats are included in cyber security. Ms. Schmoll reviewed a chart on BSA Procurement Deep Dive recommendation themes. She described the BSA Procurement Deep Dive. Ms. Schmoll noted that 90 percent of NASA's funds are spent on procurements. The lead times are very long, from 200 to 600 days, when a procurement involves a Source Evaluation Board (SEB). One reason for the delay is that SEB chairs often have no SEB experience. NASA is looking at establishing a professional corps of people with SEB experience. Ms. Schmoll explained that the Committee supports the eight Mission Support Council - approved Procurement Deep Dive recommendations. She noted that her Committee has proposed to the NASA Mission Support Directorate (MSD) Associate Administrator that grants and cooperative agreement functions be included in a BSA when resources are available.

Ms. Schmoll reviewed a chart delineating NASA Cooperative Education (Co-Op) hires by fiscal year. She described the NASA Pathways Program. She concluded her presentation by discussing a chart on facilities maintenance funding. She noted that NASA's facilities maintenance program is underfunded.

Dr. Squyres thanked Ms. Schmoll for her presentation.

Council Discussion

At Dr. Squyres request, the Council returned to a discussion on the proposed TI&E finding. He reminded the Council members that any finding should be actionable by the Agency, that is, at the Agency-level.

Mr. Hubbard suggested using the recent Jet Propulsion Laboratory (JPL) Mars study as a test article for making technology investment decisions. Mr. Bowersox offered to review the study to see whether it provides the necessary detail. Dr. Ballhaus suggested eliminating the first bullet from the proposed finding because the technologies needed are known and it is only the time when they would be needed that is unknown. Mr. Young opposed eliminating the language because it served as the basis for the remainder of the finding. He stated, "it is a shock" that there is no human exploration plan for the Moon and none for Mars. He asserted that the Council needed to have a reaction to that for the rest of the world. Mr. Gerstenmaier explained that while NASA does not have a cis-lunar plan, it does have a plan to buy down the risks for going to Mars. Mr. Hale noted that the Council had already made a recommendation for more specificity. Mr. Miles O'Brien advised that cadence is a big concern about telling the story. Dr. Peterson noted that the Apollo program had been sold in a step-by-step process.

Dr. Squyres explained that it would be helpful to distinguish two purposes that the plan should serve. One purpose, primarily for the public, is to demonstrate a plan that is sufficiently inspiring and compelling to keep the program going. The other purpose is to provide sufficient detail to enable NASA to make wise decisions on its technology portfolio. Mr. Bowersox noted that useful language might be found in NASA's Journey to Mars report. Ms. Rausch distributed a copy of this report to each of the Council members in real-time.

Mr. Young expressed concern that, "NASA is ill-prepared for the budget debate in the next Administration." Dr. Squyres agreed, and explained that it would be critically important to the fate of the Agency for NASA to have an investment plan ready when the next Administration puts together its first budget request to Congress. At Dr. Squyres' request, further discussion on the proposed finding was deferred until later in the meeting.

Dr. Squyres requested comments from the Council members on NASA's planning to transition from a focus on Earth Reliant (LEO and the ISS) to the Proving Ground (cis-lunar space). Mr. Borghese commented that there was too much attention on commercialization of the ISS. Mr. Young asserted that there was no way that NASA could have an Earth-orbiting program and a deep space exploration program at the same time. Mr. Gerstenmaier responded that NASA could have EM-1, EM-2, and the ISS at the same time, provided the current budget levels are maintained. Dr. Squyres explained that it would be very difficult for the Agency to carry out the ISS program indefinitely in parallel with a deep space exploration program. Mr. Young advised that NASA should encourage commercial opportunity, but not spend much time on it; it should move on to the deep space exploration program as soon as possible. He added that he did not think that the commercial opportunities were strong. Mr. Hale expressed concern that the funding allocated to the ISS would not be recaptured after the program is ended and that NASA may be walking away from its outpost in space. Mr. Hubbard noted that it was established policy that NASA would transition from the ISS as soon as possible.

Further discussion on the subject was deferred, at Dr. Squyres request, until later in the meeting.

NASA Johnson Space Center Early Career Presentations

Dr. Squyres announced that in keeping with tradition, the Council would hear presentations from NASA early career scientists and engineers. He introduced Dr. Ellen Ochoa, JSC Center Director, who then introduced the four JPL early career presenters to the Council.

Mr. Jared Daum and Mr. Wahab Alshahin, Engineers, JSC Aerospace and Flight Mechanics Division, gave a presentation entitled, "Parachute Canopy Instrumentation Platform." Mr. Daum commented that he chaired an

emergent employee resource group that had an opportunity to work on actual flight projects and full life-cycle testing. Mr. Borghese noted that the early career group is a different approach from the traditional approach of partnering a young engineer with a senior engineer. Mr. Daum concurred and explained that the group members had mentors and access to world leaders in parachute development.

Dr. Andrea Hanson, Manager, JSC Exercise, Physiology and Countermeasures Laboratory, Biomedical Sciences Branch, and Dr. Megan Downs, Exercise Physiologist, JSC Biomedical Research and Environmental Sciences Division, gave a presentation entitled, “Miniature Biometric Sensor.” Dr. Squyres asked whether they had any trouble finding human test subjects for their research. Dr. Hanson responded that their team had a consistent subject pool lined up – each other.

Mr. Rubik Sheth, Project Manager, Phase Change Material Heat Exchanger, and Technical Assistant, Thermal Systems Branch, gave a presentation entitled, “Phase Change Material Heat Exchanger Technology.” Mr. Sheth noted that the JSC early career program fostered innovation and enabled him to master the art of project management. Mr. Borghese asked whether Mr. Sheth had taken any specific training in project management. Mr. Sheth responded that he had not, but that he had a very good mentor.

Dr. Squyres thanked Mr. Daum, Mr. Alshahin, Dr. Hanson, Dr. Downs, and Mr. Sheth for their excellent presentations. The Council applauded the presenters.

Aeronautics Committee Report

Dr. Squyres introduced Mr. John Borghese, Aeronautics Committee Vice-Chair (subbing for Ms. Marion Blakey, Chair). Mr. Borghese reviewed the Aeronautics Committee membership. He described NASA’s Revolutionary Vertical Lift Technology (RVLT) project. The project’s vision is to enable the next generation of vertical lift vehicles with aggressive goals for efficiency, noise, and omissions to expand current capabilities and develop new commercial markets. Mr. Borghese stated that “vertical lift” formerly had been referred to as “rotary wing” and that there is a large commercial market for vertical lift. He reviewed a chart on RVLT research themes and technology challenges. He presented a Committee finding on the RVLT project for the Aeronautics Research Mission Directorate (ARMD) Associate Administrator. The Council approved the finding, which reads as follows:

The Aeronautics Committee emphasizes that with a limited budget, the Revolutionary Vertical Lift Technology Project is taking the right path and it is a well thought-out plan. The Committee commended the project in doing a very good job in balancing the portfolio with limited resources.

Mr. Borghese discussed the Convergent Aeronautical Solutions (CAS) project. CAS will support, inform, and challenge ARMD strategic decisions by converging emerging and non-aeronautics technology advancements and by rapidly completing concept feasibility assessments to identify boundaries of concept effectiveness, reveal value, and reduce risk. He reviewed charts showing CAS project progress and research activities. Mr. Borghese described Scalable Convergent Electric Propulsion Technology Operations Research (SCEPTOR). SCEPTOR focuses on how distributed electric propulsion (DEP) technologies can enable airplanes to cruise more efficiently at higher speeds. He described a project to design and fabricate a DEP wing system and test it by attaching it to a truck and flying the truck at five miles per hour. The project is significant because it would promote a fully electric General Aviation technology demonstrator with zero in-flight carbon emissions. Mr. Borghese presented a Committee finding on SCEPTOR for the ARMD Associate Administrator. The Council approved the finding, which states:

The Aeronautics Committee recognized that the Convergent Aeronautical Solutions project is a very innovative approach that provides an incubation cycle to answer big problems. The Committee was impressed with the innovation and number of ideas that are being pursued in a short amount of time. The Committee endorses the approach laid out by the project and feels that it provides tremendous benefit to the Aeronautics Research Mission Directorate mission.

Mr. Borghese described ARMD’s University-led Strategic Aviation Research initiative. The initiative is designed to leverage the capability of universities to help solve the most complex challenges associated with ARMD’s strategic thrusts. ARMD released a Request for Information (RFI) soliciting proposals and received 29 responses from 18

universities. Mr. Borghese presented a Committee finding for the ARMD Associate Administrator on this initiative. The Council approved the finding, which states:

The Aeronautics Committee applauds Aeronautics Research Mission Directorate for developing a strategy to encourage universities to move into a position of leadership to tackle core technical challenges. The Committee found that this strategy showed leadership in this area. Asking universities to take a leadership role in addressing large ideas is a positive development to utilize their full potential to help shape the future.

Mr. Borghese presented a Committee recommendation for the ARMD Associate Administrator on the University Leadership initiative. The Council approved the recommendation, which states:

The Aeronautics Committee recommends that the communication with the university community be improved by reaching out early and through multiple channels to insure receiving the broadest possible response. Examples include early indications of intent to release a Broad Agency Announcement (BAA) and early notification to the research division of institutions to allow appropriate time to generate ideas for proposals.

Mr. Borghese described the ARMD research data access strategy. He explained that the White House Office of Science and Technology Policy (OSTP) has directed Federal agencies with over \$100M in research and development expenditures to develop a plan to support increased public access to the results of the funded research. A draft NASA Policy Directive (NPD) 2230, "Research Data and Publication Access," is almost finalized. The NPD states that "effective data management has the potential to increase the pace of scientific discovery and promote more efficient and effective use of government funding and resources." NASA's Chief Information Officer (CIO) is developing a data website that has a front-end for all NASA data. Peer-reviewed publications generated with NASA funds will be housed in the National Institutes of Health (NIH) PubMed Central (PMC) database. ARMD has developed a data access strategy and guidance that conforms with with the NASA plan. It covers data management, archiving, and publications. Mr. Borghese described a pilot project that archives data from several research programs. The data can be found at <https://aero-fp.larc.nasa.gov/>. A lesson learned from the pilot project is that it would be beneficial to have a common data archive capability that ARMD either needs to develop on its own or in conjunction with the NASA Science Mission Directorate (SMD). Dr. Squyres noted that the NAC had a new Ad Hoc Task Force on Big Data that reports to the NAC Science Committee. He suggested that the NAC Aeronautics Committee and NAC Science Committee work together on the NASA's data access strategy.

Mr. Borghese described the vision and strategy for Real-time System-wide Safety Assurance (RSSA). He presented a chart on RSSA outcomes and benefits. He discussed Unmanned Aerial System (UAS) Traffic Management (UTM). He explained that UTM is a research software application prototype that: (1) allows UAS operators to submit flight plans to execute a specific mission in low-altitude airspace, and (2) determines how to safely enable single or multiple UAS operations either within visual line-of-sight or beyond visual line-of-sight. The UTM near-term goal is to safely enable initial low-altitude UAS as early as possible. UTM balances national and regional security, safe airspace integration, and scalable operations for economic growth. He described the recent UTM conference held at the NASA Ames Research Center. There were 1,190 registered attendees. The previous conference had only 120 attendees. He explained that NASA is collaborating with the Federal Aviation Administration (FAA) and the UAS community to identify research, policy, and regulations, and to consider integration with existing systems. There will be a joint NASA and FAA endeavor to gather input from the UAS community and build a common research agenda to move more quickly toward UAS integration. He explained that the FAA is cautious and concerned about flight safety. Mr. Young commented that, "the amateurs are overwhelming the situation." Mr. Borghese reviewed a chart on four UTM system software builds. He noted that Amazon intends to provide UAS package delivery by 2018. He presented a Committee finding on the UTM briefing for the ARMD Associate Administrator. The Council approved the finding, which states:

The Aeronautics Committee found that the briefing on Unmanned Aerial System Traffic Management was well prepared and clearly stated the goals of the project. The Committee was impressed by the effort led by NASA and how the concept is being endorsed by the community both by the Federal Aviation Administration and industry.

Mr. Hubbard acknowledged Dr. Jaiwon Shin for a “terrific job” during his current tenure as the ARMD Associate Administrator. Dr. Squyres thanked Mr. Borghese for his presentation.

Ad Hoc Task Force on STEM Education Report

Dr. Squyres introduced Mr. James Stofan, Chair, Ad Hoc Task Force on STEM Education. Mr. Stofan described the Committee’s membership. He reviewed a chart on NASA’s education structure. He explained that the NASA Office of Education (OE) reaches across all NASA Centers and Mission Directorates. The OE Associate Administrator has responsibility for education, but does not have authority over the education assets. Mr. Stofan described NASA education highlights. STEM Education and Accountability Projects (SEAP) is a competition developed in response to an Office of Management and Budget (OMB) requirement that NASA’s internal projects and activities compete with one another for education funding. He observed that many NASA education efforts “have gone underground” due to a U.S. Government-wide effort to sweep up all STEM dollars and consolidate those funds in the education budgets of three Federal agencies – the National Science Foundation, the Smithsonian Institution, and the Department of Education. He presented a brief video about three students working on a NASA Space Grant project. Mr. Stofan explained that NASA’s Higher Education Program will continue to focus on the Minority University Research and Education Program (MUREP). MUREP provides competitive awards to Minority Serving Institutions (MSIs) and eligible community colleges as required by the five MSI-focused Executive Orders. Those institutions recruit and retain underrepresented and underserved students, including women and girls, and persons with disabilities, into STEM fields. MUREP strives to ensure that faculty and students are informed about NASA’s competitive research and education opportunities. Mr. Stofan presented charts showing MUREP statistics.

Mr. Stofan discussed the NASA OIG report and recommendations on NASA’s Education Program. He presented a chart on STEM education funding for each Federal agency. He reviewed several slides addressing statistics on NASA’s budgets for education. Out of the \$18 billion (B) NASA budget, NASA education receives \$161M or approximately one percent. Out of that amount, only \$11M is available for discretionary activities.

Mr. Stofan presented a STEM Task Force observation on the need for revisions to the NASA Education Implementation Plan (NEIP):

The NEIP should be revised so that it:

- *Explains the unique role that NASA plays in the Federal STEM education efforts, and identifies how NASA education activities and investments work with other entities (including State Education Administrations and Local Education Administrations) to improve Science, Technology, Engineering and Mathematics (STEM) education.*
- *Explicitly states the STEM education goals and outcomes that NASA intends to achieve, the specific contributions of each Mission Directorate, Office and Center to the Agency’s education goals, and the metrics NASA will use to measure performance.*
- *Details how each Mission Directorate, Office and Center will contribute to these goals and how they are accountable for contributing to the Agency goals. Budgets and key grant competitions should be highlighted.*
- *Is clear to key audiences (including students, parents, teachers, K-12 administrators, university faculty, and scientists) what NASA is doing (and not doing) to help their efforts.*

Create an additional streamlined Agency document that communicates the top-level goals and specific assets that NASA will make available to key audiences.

Clearly articulate the difference in goals between education and outreach.

Mr. Stofan presented a STEM Task Force observation on the need to strengthen the structure of NASA’s education efforts and its ability to execute and communicate on them:

In order to ensure that NASA STEM education work has support across the engineering, scientific, and education communities, NASA should explore ways to further leverage external advisors in both formal and informal roles to ensure that both the strategic guidance and content expertise is available to accomplish the ambitions NASA aspires to.

NASA should revisit the organizational structure and governance to clarify the decision-making processes about STEM education:

- *Mission Directorates and Centers should invest and make transparent their contributions to NASA's education efforts.*
- *To ensure Agency coordination, the Associate Administrator for Education should have explicit authority and accountability for ensuring Mission Directorate and Center involvement and participation in the overall Education Strategy.*
- *Budget and spending decisions should be coordinated across all funding sources to achieve the overall NASA Education goals.*

The NASA Education website should be updated to allow participants simple unified access to information from all Mission Directorates, Centers and Offices.

Mr. Stofan presented a STEM Task Force observation on competitive allocation of funds to elicit projects that meet the objectives of the NEIP:

- *The budget for NASA's education efforts should be commensurate with achievement of the goals articulated in the NEIP.*
- *All solicitations released by NASA for STEM education activities (Mission Directorates, Centers, Offices) should have explicit ties to the NEIP, and include questions about how responders will address the stated goals. It is okay that NASA does not invest in all levels of the education system. With the limited funding that NASA has, solicitations should be targeted to make the most impact on specific sectors (depth vs. breadth) of the education community.*
- *NASA should actively cultivate the network of Earth and space science educators and researchers, and connect those individuals to the broader STEM education community, learning scientists, and school and district administrators.*
- *NASA should continue to expand the publication of abstracts from funded projects and the evaluation data gathered.*

Mr. O'Brien commented that NASA's education goals appear to be more like outreach than curriculum development. Mr. Stofan responded that NASA does not develop curriculum. Mr. Young advised that NASA should not become a mini-Department of Education. He asserted that NASA takes college "fresh-outs" who come to work at NASA, and turns them into scientists and engineers by giving them hands-on experience. Mr. Borghese advised that NASA should investigate the best practices in private industry for promoting STEM education.

Dr. Squyres thanked Mr. Stofan for his presentation.

Council Discussion

Dr. Squyres asked the Council to consider two essential topics for potential Council-level findings or recommendations. The first would be the need for a Mars architecture with a technology program to support it. The second would be the strategic framework for transitioning from the LEO-based Earth Reliant human exploration program towards one focused on the cis-lunar Proving Ground. He expressed encouragement over hearing for the first time from NASA its plans for a one-year, shakedown cruise in cis-lunar space by the end of the 2020s and the upcoming emphasis on habitation capabilities that would be needed for the one-year mission. He advised that NASA should ensure that the capabilities of the ISS are fully exploited before completing the transition to move away from the ISS. He added that NASA should not depend on a commercial demand for human access to LEO as part of the transition.

Mr. Hubbard observed that the Council had been unsuccessful in three prior attempts to get NASA to provide an architecture for sending humans to Mars. Mr. Hale concurred, and added that the Council has made it clear that NASA needs to make a detailed plan. Dr. Squyres noted that the Council had been requesting a detailed plan for a year and a half. Mr. Hubbard concluded that the Council is “unlikely to get anywhere in requesting an architecture that gets us all the way to Mars.”

Dr. Ballhaus advised that investments in ISRU could generate technology push that would alter the future. He added that the Proving Ground missions would provide technology pull. Mr. Hale commented that an issue always remains on the timeframe for phasing the funding for technology development.

Mr. Borghese advised that it would be important to have a plan in place for engagement with the next Presidential Administration. Mr. Hubbard stated, “If we push the reset button again on SLS and Orion, we are toast.” Dr. Squyres explained that NASA would always need a way to get its astronauts into LEO in order to ascertain whether they can endure being in space before being sent on a long-duration mission. Mr. Young asserted that the commercial world would not provide LEO crew transportation after NASA transitions from the ISS. The transportation activity would have to be fully funded by NASA and would be a significant budget expense. Dr. Squyres commented that it would be valuable to learn more about what is being accomplished by the nonprofit Center for the Advancement of Science in Space (CASIS). Mr. Borghese advised that the commercialization of space should be divorced from going to Mars. Mr. Hubbard advised that the only business cases for space commercialization do not require humans in space. Dr. Ballhaus asserted that the Augustine Committee was correct when it determined that human health research and microgravity materials research were the primary reasons for the ISS.

Dr. Squyres tasked Dr. Ballhaus, Mr. Hubbard, and Mr. Young with developing a possible finding or recommendation on a Mars architecture and technology development. He tasked Mr. Hale and Mr. Bowersox with developing a possible finding or recommendation on the transition from LEO to cis-lunar space. Dr. Squyres noted that many Council members were very passionate about STEM education. Ms. Schmoll commented that the extent to which the NASA education budget had been depleted is “appalling.” Mr. O’Brien asserted that NASA appeared to be planning “a champagne trip to Mars on a beer budget.” Mr. Hale asserted that, “education is organic in the makeup of the people in the NASA organization.” Dr. Squyres agreed, adding that “education is in the DNA of the Agency.” Mr. Borghese advised that due to the limited budget, NASA’s education focus should be on outreach.

Mr. Borghese expressed concern over the cyber-vulnerability of embedded systems at NASA and explained that encryption was not sufficient protection. He noted that Defense Advanced Research Projects Agency (DARPA) research groups had successfully “hacked” into data links and taken control over UAVs. He asked whether NASA: (1) had a comprehensive plan relative to inside threats; and (2) was utilizing independent vulnerability testing. Mr. Bowersox advised that those are sensitive topics that should not be examined by an advisory group subject to the requirements of the Federal Advisory Committee Act (FACA). Mr. Hale added that the Agency is very concerned about those topics.

Adjournment

The Council meeting was adjourned for the day at 5:00 pm.

Thursday, December 3, 2015

Ms. Rausch called the Council meeting to order and welcomed everyone to the third 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. He described the day’s agenda.

Public Input

Dr. Squyres invited comments from the public. Dr. Alan Angleman, Study Director, National Academies of Sciences, Engineering, and Medicine, recommended that an additional criterion for Council-level recommendations be “first, do no harm.” In other words, consider the possible unintended consequences. He also posited several questions with respect to a possible recommendation on the human Mars program. What might be the consequences if a detailed Mars plan showed that NASA was unlikely to meet the Administration’s stated goals, or if that detailed plan led to cost estimates that were unaffordable under likely budget scenarios? Do we think that NASA is misdirecting its human Mars research and technology efforts? Does HEOMD really need more “help” in that regard?

Mr. Don Nelson, a retired NASA engineer, read and submitted a written statement asserting that there is a likely potential that SLS and Orion will fail. Dr. Ballhaus commented that there is a remarkable difference between mission assurance for commercially developed vehicles and U.S. Government developed vehicles. The U.S. Government failure rates are significantly lower. He asked whether those statistics had been considered. Mr. Nelson responded that they had not been considered.

Science Committee Report

Dr. Squyres introduced Dr. Bradley Peterson, Science Committee Chair. Dr. Peterson described the Science Committee membership and its subcommittees. He then discussed recent science results.

In Heliophysics, the Magnetospheric Multi-Scale (MMS) mission has four satellites flying in the tightest multi-spacecraft formation ever flown in orbit, only six miles apart from each other. NASA’s Solar and Heliospheric Observatory (SOHO) has discovered its 3000th comet. The mission success as a comet finder is dependent on the people who sift through its data, a task open to the world as the data is publicly available online in near real time. He presented a brief lunar transit movie made with images from the DSCOVR satellite.

In Earth Science, Mr. Peterson observed that the 2015 Antarctic ozone hole reached its annual maximum on October 2, 2015, and was the fourth largest ozone hole since 1991. The 2015 Arctic sea ice summer time minimum was the fourth lowest on record. Sea ice decline has accelerated since 1996. The Arctic sea ice cover experienced relatively slow rates of melt in June 2015, which is the month the Arctic receives the most solar energy. However, the rate of ice loss picked up during July 2015. In response to a question from Mr. Young, Dr. Peterson stated that there is evidence that the size of the Antarctic ice pack is increasing.

In Planetary Science, Dr. Peterson presented images from NASA’s New Horizon spacecraft showing Pluto’s mountains, frozen plains, and foggy atmospheric hazes. He discussed a global ocean believed to have been discovered within Enceladus. The Dawn spacecraft has enabled scientists to make detailed observations of the surface of the dwarf planet Ceres. The mystery bright spots on that planet’s surface are associated with impact craters and are believed to contain hydrated magnesium sulphates.

In Astrophysics, Dr. Peterson reported that observations obtained from NASA’s Hubble Space Telescope (HST) show that the nearest quasar is powered by a double black hole. High spectral resolution observations from NASA’s Stratospheric Observatory for Infrared Astronomy (SOFIA) indicate the presence of water absorption in the protostar AFGL 2591. Using NASA’s Spitzer Space Telescope, astronomers have confirmed the discovery of the nearest rocky planet outside the solar system.

Dr. Peterson described briefings that the NAC Science Committee received from its five science subcommittees: the Earth Science Subcommittee, the Heliophysics Subcommittee, the Astrophysics Subcommittee, the Planetary Science Subcommittee, and the Planetary Protection Subcommittee. He presented the NASA Science Mission Directorate (SMD) organization chart and reviewed the status of SMD programs. He presented a chart showing the results of the most recent SMD Senior Review. The Senior Review panel members recommended continued operations for all SMD current missions. Mr. Peterson described a successful sounding rocket launch demonstrating the new Orbital ATK Black Brant Mk4 rocket motor. He discussed the National Space Weather Strategy (NSWS), which had been officially released on October 29, 2015. The White House OSTP led a multi-agency effort to

develop NSWS, which articulates strategic goals for improving forecasting and enhancing national preparedness for severe space weather events. A Space Weather Action Plan (SWAP) has been developed to incorporate severe space weather events in Federal emergency preparedness. Dr. Peterson explained that coronal mass ejections from the Sun pose a threat to the world's electric power grid and if disrupted, "could return the world to the Stone Age within six months." He added that giant capacitors are now available from the U.S. that could be used to protect the grid.

Dr. Peterson reviewed a chart on Venture Class Launch Services (VCLS). He described the Arctic-Boreal Vulnerability Experiment (ABOVE). Its purpose is to determine how vulnerable ecosystems and society are to environmental change in the Arctic and boreal region of North America. He reviewed the status of the Discovery Program and the New Frontiers Program. He described the first Human Landing Site Workshop recently conducted at JPL. Dr. Peterson discussed the distribution of perchlorates that have been discovered on Mars. He explained that perchlorates are briny, wet sand where the water is embedded in the grains. He explained that the water would be expensive to extract, but cheaper than hauling water to Mars.

Dr. Peterson presented a chart on the President's FY 2016 Budget Request for NASA Astrophysics. Total funding for Astrophysics, including JWST, is flat at approximately \$1.3B through FY 2020. JWST remains on schedule for an October 2018 launch. All JWST manufacturing is almost completed. Many activities are deep into integration and testing. He presented a slide showing the telescope's structure and flight cryocooler. Dr. Peterson described progress on the Wide-Field Infrared Survey Telescope (WFIRST) mission. He described results from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboard the Mars Reconnaissance Orbiter (MRO). The results point to a more habitable condition on the near surface of Mars than previously thought.

Dr. Peterson discussed the interim report on proposal pressures from the National Science Foundation's Astronomy and Astrophysics Advisory Committee (AAAC) Proposal Pressures Study Group. There is concern over falling success rates for competed research proposals in the astronomical sciences. The cause does not lie in changing demographics, proposal quality, or grant size. A tendency to recycle proposals exacerbates the problem. The lower success rates stress agencies, reviewers, the community, and the Nation. Anecdotally, people are leaving the field, review panels are more risk averse, and new researchers are not entering the field.

Dr. Peterson briefed the Council on the status of formation of the NAC Ad Hoc Task Force on Big Data. This Ad Hoc Task Force will report to the Science Committee. Its first meeting will be held within the next few months of 2016. He reviewed a chart on SMD science education awards. Twenty-seven of 73 compliant proposals have been selected for negotiations leading to cooperative agreement awards.

Mr. Young complimented Dr. Peterson for a "terrific, fascinating" presentation.

Council Discussion and Final Wrap-Up

The Council reviewed a proposed finding drafted by Mr. Hale and Mr. Bowersox on the transition from a LEO-focused Earth Reliant human exploration program toward one focused on the cis-lunar Proving Ground.

Mr. Hubbard expressed concern over the absence of any dates. Dr. Squyres advised that avoiding prescriptive transition dates would be appropriate "in the spirit of do no harm" since it was the Council's first comment on the issue. After further discussion, the Council approved the following finding:

The Council was encouraged to hear that NASA is moving expeditiously on plans to transition from a Low Earth Orbit (LEO) -focused human exploration program toward one focused on the cis-lunar proving ground, as part of a deep space program leading to Mars. An effectively-managed transition will be important because future funding is unlikely to be sufficient for robust deep space exploration and long-term maintenance of a large LEO infrastructure simultaneously.

Even after a shift of focus to cis-lunar space and beyond has occurred, NASA may need to maintain some capability to get astronauts to low Earth orbit. If the Agency concludes that such a capability is necessary, it would be best not to rely on a presumed commercial demand for human access to LEO that may or may not materialize. Taking steps to encourage commercial activity in LEO may not be adequate to guarantee NASA long-term future access to LEO.

The Council reviewed a proposed recommendation drafted by Dr. Ballhaus, Mr. Hubbard, and Mr. Young for NASA to define a baseline Mars architecture that allows decisions to be made on technology investments to be used to brief the 2017 Presidential Administration transition teams and inform the first budget of the new Administration. Mr. Young opined that the issue could be the key to whether or not there would be a Journey to Mars exploration program. After further discussion, the Council approved the following recommendation:

The Council was very pleased to see the new information that was provided by NASA at this meeting about the Human Exploration architecture. Especially noteworthy were a one-year crewed “shake-down cruise” in cis-lunar space before the end of the 2020s, and the development of a deep space habitat capable of supporting that activity.

In preparation for the 2017 transition of Administrations, the Council recommends that NASA further develop their plan for future Human Exploration, such that it:

- (1) Provides a consistent vision across all elements of the program;*
- (2) Allows selection of technology investments on a timely basis;*
- (3) Enhances advocacy and continuity of support that transcends Administrations; and*
- (4) Provides the ability to respond to changes in the external environment (e.g., funding changes or technology breakthroughs).*

The level of detail in the plan need only be sufficient to accomplish the four items listed above.

Mr. Hubbard requested a presentation at the next NAC meeting on what is meant by commercial space and on how well CASIS was performing. He also requested that the next meeting consider the entire planetary protection issue. Dr. Peterson noted that there is a complicated, structural problem with planetary protection because there is a single entity within NASA responsible for both making and implementing policy. He agreed, at Dr. Squyres request, to have the Science Committee consider the issue first.

The Council discussed potential dates and locations for its next three meetings. It was agreed that the Council’s schedule for CY 2016 would be as follows, subject to the availability of NASA Administrator Bolden:

- March 2016: NASA Headquarters (dates TBD; Council members will be polled in near future for their specific availability)
- Week of July 25, 2016: NASA Glenn Research Center (annual all-hands meeting)
- November 29 - December 1, 2016: NASA Armstrong Flight Research Center

Ms. Schmoll recommended that the Council dedicate one half-day from its next meeting in March 2016 at NASA Headquarters to visit NASA Goddard Space Flight Center to see the completed JWST mirror assembly.

Dr. Squyres went around the table and solicited final comments from Council members. Dr. Ballhaus noted that he had appreciated the time that Mr. Gerstenmaier had spent with the Council. Mr. O’Brien explained that when engaging the public, being timid and circumspect about a big plan would not win the day. Mr. Hale thanked Ms. Diane Rausch, Ms. Marla King, and Ms. Mary Floyd for their support of the meeting. The Council members responded with applause. Mr. Bowersox reminded Council members that he welcomed their comments on NASA’s Journey to Mars report. Mr. Hubbard thanked Dr. Squyres “for being a terrific cat-wrangler.” Dr. Squyres thanked the staff at JSC for hosting the meeting. The Council members responded with applause. Dr. Squyres complimented Mr. David Frankel on the Council’s minutes. Mr. Hale noted that the NASA Oral History program had been defunded. Dr. Squyres stated that it is very important to document the Agency’s oral history. He invited Mr. Hale to submit a Council-level finding on the matter in the future.

Adjournment

The Council meeting was adjourned at 11:00 am.

NASA ADVISORY COUNCIL

**NASA Johnson Space Center
Gilruth Conference Center – Lone Star Room
Houston, Texas**

PUBLIC MEETING

December 1-3, 2015

Tuesday, December 1, 2015

1:00 – 1:03 pm	Call to Order, Announcements	Ms. Diane Rausch Executive Director NASA Advisory Council NASA Headquarters
1:03 – 1:10 pm	Opening Remarks by Council Chair	Dr. Steven W. Squyres Chair, NASA Advisory Council
1:10 – 1:30 pm	Welcome to the NASA Johnson Space Center	Mr. Mark Geyer JSC Deputy Director
1:30 – 2:30 pm	Remarks by NASA Administrator	Mr. Charles F. Bolden, Jr. NASA Administrator
2:30 – 3:30 pm	NASA Human Exploration Update	Mr. William Gerstenmaier Associate Administrator for Human Exploration and Operations Mission Directorate NASA Headquarters
3:30 – 4:15 pm	NASA Human Spaceflight Transition and Low Earth Orbit Commercialization	Mr. Samuel Scimemi Director, International Space Station, Human Exploration and Operations Missions Directorate NASA Headquarters
4:15 – 5:00 pm	Council Discussion	All
5:00 p.m.	Adjourn	

Wednesday, December 2, 2015

9:00 – 9:01 am	Call or 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 – 9:45 am	Human Exploration and Operations Committee Report	Mr. Kenneth Bowersox, Chair
9:45 – 10:30 am	Technology, Innovation and Engineering Committee Report	Dr. William Ballhaus, Chair
10:30 – 10:45 am	Break	
10:45 – 11:15 am	Institutional Committee Report	Ms. Kathryn Schmolli, Chair
11:15 – 12:00 noon	Council Discussion	
12:00 noon – 1:00 pm	Lunch	
1:00 – 2:00 pm	NASA Johnson Space Center Early Career Presentations:	Dr. Ellen Ochoa JSC Center Director
	Parachute Canopy Instrumentation Platform	Mr. Jared Daum, Engineer Aeroscience and Flight Mechanics Division JSC
	Miniature Biometric Sensor	Dr. Andrea Hanson, Manager Exercise, Physiology and Countermeasures Laboratory, Biomedical Sciences Branch JSC
		Dr. Megan Downs, Exercise Physiologist, Biomedical Research and Environmental Sciences Division JSC
	Phase Change Material Heat Exchanger	Mr. Rubik Sheth, Project Manager Phase Change Material; Technical Assistant, Thermal Systems Branch JSC
2:00 – 2:45 pm	Aeronautics Committee Report	Mr. John Borghese, Vice Chair <i>(for Ms. Marion Blakey)</i>
3:30 – 3:45 pm	Break	
3:45 – 5:00 pm	Council Discussion	All
5:00 p.m.	Adjourn	

Thursday, December 3, 2015

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 – 9:15 am	Public Input	
9:15 – 10:00 am	Science Committee Report	Dr. Bradley Peterson, Chair
10:00 – 11:00 am	Council Discussion and Final Wrap-Up	All
11:00 am	Adjourn	

NASA ADVISORY COUNCIL

Membership – December 2015

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; Former Director, NASA Ames Research Center</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>U.S. Naval Aviator (Ret); Former NASA Astronaut</i>
Member at Large	Mr. N. Wayne Hale , <i>Consultant, Special Aerospace Services; NASA (Ret.)</i>
Member at Large	Prof. G. Scott Hubbard , <i>Department of Aeronautics and Astronautics, Stanford University; Former Director, NASA Ames Research Center</i>
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>
Ex Officio	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 Johnson Space Center
Houston, Texas
December 1-3, 2015**

MEETING ATTENDEES

NASA Advisory Council Members:

Dr. Steven W. Squyres, <i>Chair</i>	Cornell University
Dr. William Ballhaus	The Aerospace Corporation (<i>Ret.</i>)
Mr. John Borghese (<i>for Ms. Marion Blakey</i>)	Rockwell Collins
Mr. Ken Bowersox	U.S. Navy (<i>Ret.</i>)
Mr. N. Wayne Hale	Special Aerospace Services
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
Mr. A. Thomas Young	Lockheed Martin (<i>Ret.</i>)
Ms. P. Diane Rausch, <i>Executive Director</i>	NASA Headquarters

NASA Attendees:

Alshahin, Wahab	NASA Johnson Space Center
Bolden, Charles	NASA Headquarters
Corbin, Barbara	NASA Headquarters
Daum, Jared	NASA Johnson Space Center
Edsen, Marybeth	NASA Johnson Space Center
Gerstenmaier, William	NASA Headquarters
Hanson, Andrea	NASA Johnson Space Center
Downs, Megan	NASA Johnson Space Center
King, Marla	NASA Headquarters
Ochoa, Ellen	NASA Johnson Space Center
Rodriguez, Irma	NASA Headquarters
Schimemi, Sam	NASA Johnson Space Center
Sheth, Rubik	NASA Johnson Space Center
Wynne, Vanessa	NASA Johnson Space Center

Other Attendees:

Akkerman, Jim	Advent Launch Services
Berger, Eric	ARS Technica
Carreau, Mark	<i>Aviation Week & Space Technology</i>
Engelauf, Philip	[not affiliated]
Frankel, David	P B Frankel, LLC
Kranz, Jean M.	Office of Congressman Brian Babin, TX-36
McDonald, Vernon	Wyle
Nelson, Don	[not affiliated – NASA retiree]
Stofan, James	NAC Ad Hoc Task Force on STEM Education

Telecon Attendees:

Adkins, Bill	Adkins Strategies
Allen, Gale	NASA Headquarters
Allen, Lenell	NASA Headquarters
Angleman, Alan	National Research Council
Applin, Zachary	NASA Langley Research Center
Ardila, David	NASA Johnson Space Center
Barber, Sara	U.S. House of Representatives
Bloomfield, Michael	NASA Johnson Space Center
Brandt, Peter	[not affiliated]
Branscome, Darrell	NASA Langley Research Center
Burdick, Garry	Jet Propulsion Laboratory
Canright, Shelly	NASA Headquarters
Carreau, Mark	<i>Aviation Week</i>
Cates, Grant	NASA Johnson Space Center
Chang, Kenneth	<i>New York Times</i>
Clark-Williams, Angela	Ingenicomm
Cowing, Keith	<i>NASA Watch</i>
Culligan, Tom	Aerospace Consultant
Cummings, Nicholas	U.S. Senate
Davis, Jason	The Planetary Society
Day, Wayne	National Research Council
Dean, James	<i>Florida Today</i>
Denning, Elaine	NASA Headquarters
Dreier, Casey	The Planetary Society
Feeley, Jens	NASA Headquarters
Floyd, Mary	Ingenicomm
French, Michael	NASA Headquarters
Gilbert, Chris	Ve Consult
Gingras, Iris	[not affiliated]
Girten, Beverly	NASA Headquarters
Graham, Sandra	National Academies
Green, Mike	NASA Headquarters
Grush, Loren	The Virge
Hambleton, Kathryn	NASA Headquarters
Harwood, Bill	CBS News
Hu, Grace	Office of Management and Budget
Hunt, Cortney	University of Houston
James, Donald	NASA Headquarters
Kitmacher, Gary	NASA Johnson Space Center
Kreutzberg, Keith	NASA Johnson Space Center
Kring, David	Lunar and Planetary Institute
Kronmiller, Kate	Orbital ATK
Lillie, Charles	[not affiliated]
Lochner, James	Universities Space Research Association
Mack, Eric	BNET/CBS
Manning, Joshua	U.S. Senate
Mason, Tom	University of Colorado
McDonald, Vernon	Wyle
Messier, Douglas	Parabolic Arc
Millman, David	[not affiliated]
Moloney, Michael	National Academy of Sciences
Morring, Frank	<i>Aviation Week</i>
Omeara, John	St. Michaels College
Ottinger, Maryanne	University of Houston

Peters, Daniel
Pratt, William
Reichhardt, Tony
Rummel, John
Scimemi, Sam
Siders, Jeff
Siegel, Bette
Simmons, Nigel
Sladek, Mary
Smith, David
Smith, Diane
Smith, Marcia
Smith, Nick
South, Jeff
Stout, Jared
Tantardini, Marco
Terrell, Kim
Tomek, William
Warner, Cheryl
Wimmer, Catherine
Woodard, Daniel
Worley, Lauren
Zamka, George
Zimmerman, James
Zulkosky, Ann

NY Skies
Lockheed Martin
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NASA Headquarters
Orbital ATK
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[not affiliated]
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Italian Space Agency
KIMS Washington DC
NASA Langley Research Center
NASA Headquarters
NASA Headquarters
Contractor, NASA Kennedy Space Center
NASA Headquarters
Bigelow Aerospace
NASA (Ret.)
Lockheed Martin

NASA ADVISORY COUNCIL
NASA Johnson Space Center
Houston, TX
December 1-3, 2015

LIST OF PRESENTATION MATERIAL

- 1) Human Exploration Update to the NAC Human Exploration and Operations Committee [Gerstenmaier]
- 2) Human Space Flight Transition from ISS to Cis-Lunar Space and Low Earth Orbit Commercialization [Scimemi]
- 3) Technology, Innovation and Engineering Committee Report [Ballhaus]
- 4) Human Exploration and Operations Committee Report [Bowersox]
- 5) Institutional Committee Report [Schmoll]
- 6) Parachute Canopy Instrumentation Platform [Alshahin, Daum]
- 7) Miniature Biometric Sensor with Health Risk Assessment Feedback [Hanson, Downs]
- 8) Phase Change Material Heat Exchanger Development and Demonstration Project [Sheth]
- 9) Aeronautics Committee Report [Borghese]
- 10) Ad Hoc Task Force on STEM Education Report [Stofan]
- 11) Science Committee Report [Peterson]
- 12) NASA Johnson Space Center [Geyer]

Other material distributed at the meeting:

NASA's Journey to Mars – Pioneering Next Steps in Space Exploration

Public Input: Document submitted by Don A. Nelson, Retired NASA Engineer – Coordinator Commercial Space Shuttle Freighter