

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

NASA ADVISORY COUNCIL

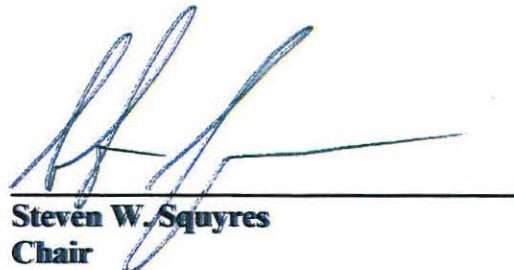
January 14-15, 2015

**NASA Stennis Space Center
Mississippi**

MEETING MINUTES



**P. Diane Rausch
Executive Director**



**Steven W. Squyres
Chair**

NASA ADVISORY COUNCIL

**NASA Stennis Space Center
Mississippi
January 14-15, 2015**

**Public Meeting Minutes
Table of Contents**

Call to Order, Announcements.....2

Opening Remarks by Council Chair.....2

Welcome to NASA Stennis Space Center.....2

Remarks by NASA Administrator.....3

NASA Human Exploration Strategy.....9

Radiation and Human Exploration of Mars.....11

Council Discussion.....12

Human Exploration and Operations Committee Report.....13

Council Discussion.....14

Science Committee Report.....15

Institutional Committee Report.....16

Ad Hoc Task Force on STEM Education.....17

Public Input.....18

Aeronautics Committee Report.....18

Technology, Innovation, and Engineering Committee Report.....20

Council Discussion.....21

NASA Stennis Space Center Early Career Employee Presentations.....21

Council Discussion.....22

Wrap-up and Final Acknowledgments.....23

Appendix A Agenda

Appendix B Council Membership

Appendix C Meeting Attendees

Appendix D List of Presentation Material

*Meeting Report prepared by
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NASA ADVISORY COUNCIL

**NASA Stennis Space Center
Mississippi**

**Roy S. Estess Building
Building 1100, Room 321**

PUBLIC MEETING

January 14-15, 2015

Wednesday, January 14, 2015

Call to Order, Announcements

Ms. Diane Rausch, Executive Director, NASA Advisory Council (NAC or Council), called the meeting to order and welcomed the NAC members and attendees to the NASA Stennis Space Center (SSC or Stennis) in Mississippi. She stated 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 will be posted to the NASA website, www.nasa.gov, soon after the meeting. Each NAC member has been appointed by the NASA Administrator, Mr. Charles F. Bolden, Jr., based on the member's individual subject matter expertise. All members are Special Government Employees (SGE), subject to ethics regulations, and must recuse themselves from discussions on any topic in which there could be a potential conflict of interest. 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. He welcomed everyone to the Council's public meeting. He noted that the Council's original meeting date in December 2014 had to be postponed to January 2015 due to a schedule conflict with NASA's Orion Exploration Flight Test-1 and thanked everyone for adjusting schedules. He congratulated NASA for the successful test. Dr. Squyres thanked Dr. Richard Gilbrech, SSC Director, for giving the Council members a remarkable tour earlier in the day. He noted that more people should have an opportunity to see the outstanding work going on at Stennis. He stated that seeing the rocket engine test stands at Stennis dispels any notion that the work at Stennis is easy.

Welcome to NASA Stennis Space Center

Dr. Squyres introduced Dr. Richard Gilbrech. Dr. Gilbrech welcomed the NAC members, NASA Administrator Bolden, and Mr. William Gerstenmaier, Associate Administrator for the Human Exploration and Operations Mission Directorate, NASA Headquarters. Dr. Gilbrech gave an overview on NASA Stennis Space Center and its history. Dr. Werner Von Braun had been looking for a place where the Saturn rockets could be launched and selected the current location. Dr. Von Braun understood that testing rockets would make a lot of noise, and he established a large buffer zone to protect neighboring communities. A slide was presented showing that Stennis's buffer zone is larger than the District of Columbia. Dr. Gilbrech noted that Stennis has 7.5 miles of canals that are used to bring large rockets onto the site.

Dr. Gilbrech described the SSC rocket propulsion test heritage, the SSC Test Complex, and SSC Test Facilities and support services. He reviewed recent rocket propulsion testing at Stennis and discussed the work being done at Stennis on the Space Launch System (SLS) and Orion. The main involvement is on the core stage. The previous week at SSC, the RS-25 rocket engine (former Space Shuttle Main Engine) was successfully tested for 500 seconds.

A video on engine testing was shown to the Council. Dr. Gilbrech described working with commercial companies and explained that it compels one to become innovative. He noted that lessons are learned on both sides. Applied sciences at Stennis were described. Dr. Gilbrech described plans for a Federal Air Administration (FAA) restricted airspace expansion. He noted that there are over 40 resident Federal agencies on the site.

A chart on economic impact from the Center was presented. Dr. Gilbrech reported that for four years in a row, SSC has been designated the best place to work in NASA.

Dr. Squyres thanked Dr. Gilbrech for his comments.

Remarks by NASA Administrator

Dr. Squyres introduced NASA Administrator Bolden, who shared some opening remarks with the Council.

Mr. Bolden indicated that his remarks would be relatively brief compared to some in the past. He noted that SSC is home to the NASA Shared Services Center (NSSC), which helps him considerably in his day to day work.

Mr. Bolden thanked Dr. Squyres and all of the Council members for their willingness to serve, recognizing that it is hard work and not always convenient. However, their contributions help NASA address the challenges it has, and he expressed his appreciation and emphasized that he takes their recommendations very seriously. He acknowledged that he and the Council members may not always agree, and sometimes NASA is not very responsive, but they are always working on improving it. As he mentioned to the Council before coming into the meeting, NASA will review the recommendation responses that have been provided to the members, and the members can come in and sit and talk with him about NASA's responses to make sure that the responses are well understood.

Mr. Bolden provided a brief overview of what has been happening since the last Council meeting in July 2014 at NASA Langley Research Center (LaRC). It has been an incredibly busy year and a very rewarding year, which was somewhat interrupted over one brief period of time by the two accidents that occurred, one involving NASA's contractor, Orbital Sciences (Orbital), when it lost the Antares launch vehicle and the Cygnus cargo module, and then another involving Virgin Galactic when it lost SpaceShipTwo and a crew member. Those were "downtimes," but it was good to see in both cases that a pledge was made to find out what went wrong, get it fixed, and get back to flying. Both companies are hoping to return to flight some time in 2015. Mr. Bolden observed that it would be hard for NASA to do something like that so quickly because of its status as a Federal agency. Hopefully, Orbital and Virgin Galactic will find that they have the flexibility and the ability to recover and get back to flying.

It has been a busy year for NASA at the same time because of the many different things that have happened – everything from human spaceflight, to science, to aeronautics, to space technology. NASA has wrapped up a very successful 2014 and looks forward to an equally busy and rewarding year ahead. SpaceX-5 was launched successfully last Saturday morning.

With regards to the budget, NASA finally received a budget from Congress – an omnibus fiscal year (FY) 2015 funding Bill that funded the Agency at the \$18.01 billion (B) level. This funding reaffirms the bipartisan support NASA has had, and it is going to help maintain NASA's leadership in exploration and scientific discovery. Mr. Bolden noted that what is most important about that budget is the fact that there was almost a half billion dollar increase over the President's Budget Request. The increase came in areas that are exceptionally important; for example, \$100 million (M) in aeronautics. He indicated that he had never seen that since he has been the NASA Administrator, and it probably had not happened very much before that. The remarkable thing about it was that it was an unencumbered \$100M. The only word that came back from Congress was, "Take this money and put it against the adjustments in your Aeronautics Strategic Plan and use it wisely." NASA doesn't get that kind of money from Congress very often, and the Agency intends to follow that direction and is working on the plan for how to invest those funds. It was exciting to see that level of funding. The Bill also serves NASA's initiative to return human space flight launches to the U.S. It will enable ground-breaking technology development and aeronautics research, and it will move NASA forward with the SLS and Orion on the journey to Mars. Mr. Bolden acknowledged that he talks about Mars a lot, but he wants people to understand that it is not the only thing that this Agency is focused on. However, it is very important for NASA to keep it before the American public and stakeholders. Going to Mars is hard enough to do it physically and technically. It is really hard to do it if the Agency

cannot engender the support from the American public, the Administration, and the Congress. The only way to do that is to talk about it constantly.

Everything is on schedule for the release of the FY 2016 President's Budget Request on February 2, 2015. Mr. Bolden indicated that he would have more details about that soon.

Among the milestones since the last Council meeting, one of the largest was what Mr. Bolden considers to be the unqualified success of the Orion spacecraft's first test flight, known as Exploration Flight Test-1 (EFT-1) in December 2014. It was an absolutely spectacular flight from beginning to end. In terms of test flight, it was about as close to flawless as possible. Mr. Bolden noted that he had an opportunity to see the vehicle and to get "up close and personal" with it last week while he was at the Kennedy Space Center (KSC). The physical condition of the vehicle is remarkable, and the teams did a great job getting it ready.

Mr. Bolden expressed his thanks again to the best navy in the world, the U.S. Navy, for their Orion recovery operations. He noted that NAC member Mr. Miles O'Brien would have been proud to be onboard the USS Anchorage for the Orion recovery operations. Mr. Bolden had an opportunity to go out several months ago for the final test and recovery of the engineering unit, which was the life-sized mock-up of Orion. The crew of the USS Anchorage is typical of every military organization in this country – they are young people. The commander of the deck while the ship was underway was a 2011 graduate and she, a Navy lieutenant, was driving around this billion dollar ship and picking up the mock-up of NASA's couple billion dollar spacecraft, and she hit it dead on the eye. They did it over, and over, and over again. Mr. Bolden stated that he could not thank the U.S. Navy enough for their dedication to that particular mission.

NASA will be studying the recovered capsule extensively over the coming months. The team is already disassembling pieces and parts of it. They have taken core samples out of the Thermal Protection System (TPS) and are analyzing massive amounts of data that was gathered from the flight.

Orion EFT-1 was a huge step forward for NASA, and it was a very critical part of NASA's work to pioneer deep space on the journey to Mars. The team did a tremendous job putting Orion through its paces in a real environment that it will endure as the boundary of human exploration pushes forward in the coming years.

Mr. Bolden noted that for those NAC members going on Friday's tour of Michoud Assembly Facility (MAF) in New Orleans, they would have an opportunity to actually see some of the hardware that is already in processing for SLS. It is incredible to look at the work force and the efforts that are going on at Michoud right now. NASA has approved the SLS Program's progression from formulation to development, something that no other Exploration-class vehicle has achieved since the Agency built the Space Shuttle.

On January 9, 2015, NASA also had the first successful test of the RS-25, formerly known as the Space Shuttle Main Engine (SSME). Four RS-25s will power the SLS on future missions, including to an asteroid and Mars. The engine fired up for 500 seconds on the A-1 test stand at Stennis, and it provided NASA engineers with critical data on the engine controller unit and in-depth pressure conditions. This was the first hot fire of the SSME engine since the end of the Space Shuttle engine testing back in 2009.

With regard to the Commercial Crew Program (CCP), last week the Government Accountability Office (GAO) notified NASA that it had denied Sierra Nevada Corporation's protest of the Commercial Crew Transportation Capability (CCtCap) contract. For NASA, that was incredibly good news. The GAO's decision allows the Agency to move forward and continue working with Boeing and Space Exploration Technologies (SpaceX) on the initiative to return to launches of crewed spacecraft from American soil. This will enable safe and reliable crew transportation to and from the International Space Station (ISS) on American spacecraft launched from American soil, and it will end the Nation's sole reliance on Russia for space transportation.

NASA also approved the completion of Boeing's first milestone in that company's path toward launching crews to the ISS. The Certification Baseline Review is the first of many more milestones, including flight test from Florida's Space Coast, which will establish the basis for certifying Boeing's human space transportation system. The CCP and the Agency's industry partners completed 23 agreement and contract milestones in 2014 and participated in thousands of hours of technical review sessions.

In September 2014 under the Commercial Resupply Services (CRS) contract, SpaceX-4 delivered supplies and experiments, including the Earth science instrument, RapidScat, to the ISS. This instrument inaugurates a new era of Earth observation that will leverage the Space Station's unique vantage point in space. Data from RapidScat will support weather and marine forecasting, including tracking storms and hurricanes.

Mr. Bolden noted that in his opinion, RapidScat was a turning-point in NASA's ability to adapt to the technology and the capabilities of today. Without having something like Dragon, the ISS, and a team that really sat down and said, "Okay, we've got to get this data, because we need a lot of data about the oceans," NASA still could not have been assured of convincing the Congress and the Administration that the U.S. Government should spend \$600M for a satellite such as RapidScat. The team looked at the concept and said, "Okay, we think we can come up with a down-scaled instrument that will accomplish the same thing. Granted, it won't be in the orbit that would be much more effective, but we think if we put it on the ISS, it will be good enough."

RapidScat was installed on the ISS robotically by telerobotic operators at Marshall Space Flight Center (MSFC). Once it was turned over to them, they began the operation to take the two major pieces of the instrument out of the Dragon cargo module and install them in their places on the Station. Within days, RapidScat was up and operating and producing data.

Mr. Bolden compared this to the traditional way of doing things. Traditionally, it would take months for NASA to accept it from whoever built it. Then, it would have to be checked out before it could be turned over to NOAA, and that takes months. Frequently, it is a year before a weather-related or a climate satellite goes into operation. With RapidScat, NASA was operating it and obtaining official data, and that data was turned over to NOAA within weeks. This represents an incredible new approach.

Last week, SpaceX-5 delivered cargo and experiments, including the Cloud-Aerosol Transport System (CATS) to the ISS. Much like RapidScat, CATS is another one of those instruments that will monitor cloud and aerosol coverage that directly impacts global climate. SpaceX-5 also delivered student experiments that had been lost as a result of the Orbital (Orb)-3 Antares launch failure in October 2014. This was a good lesson for the students. Mr. Bolden explained that when he goes to schools, he tells them, "Don't be afraid of failure. Things like that happen." Many of the students watched their experiments go up in flames when the Antares launch vehicle was lost. Then the NASA team said, "Look, if you all can work hard, we can get them back up again." NASA's Associate Administrator for Human Exploration and Operations, Mr. William Gerstenmaier, told them that NASA could try to get the experiments on the SpaceX-5 launch, and NASA did. Those students faced failure real-time, but they worked really hard to get their experiments ready to go fly again, and they flew them on SpaceX-5. Mr. Bolden noted that this was a huge deal to those students. Everyone was certainly disappointed by the loss of Orb-3. However, Orbital is bouncing back and has announced that it will launch again later this year.

Down-select for the Asteroid Retrieval Mission (ARM) is proceeding, and NASA hopes to be able to announce that soon. Mr. Bolden acknowledged that this is rather a "sore point" with the NAC and indicated that they would talk about it more. It is much more complex than what it would appear to be on the surface. One of the approaches to capture a small asteroid uses an inflatable system that was developed at NASA's Jet Propulsion Laboratory (JPL), similar to a bag. The other approach would actually capture a large boulder from a much larger asteroid using a robotic arm. The approach that will be selected will be determined by what NASA feels would provide the most value to the path to Mars.

Science at NASA continues its relentless pace in innovation and discovery. NASA selected the instruments for the Mars 2020 Rover, including instruments to select and store samples for eventual return to Earth. NASA intends to return to Mars to unlock the mysteries of its past and demonstrate how future explorers can use the planet's natural resources.

India's Mars Orbiter Mission (MOM) represents an incredible accomplishment because that was India's first attempt to get to Mars, which is hard. The team had a lot of help, and JPL was of significant assistance to them throughout the course of the mission. The Mars Curiosity rover has reached its prime destination, Mount Sharp, and has begun its track up the mountain.

NASA had a small but important role in the European Space Agency's (ESA) Rosetta mission that recently successfully landed on a comet. Mr. Bolden thought it was an incredible achievement, and it captured the world's imagination for a period of time. That is what NASA must do – achieve one small victory at a time and keep people dreaming. A NASA instrument named Alice recorded the first ultra-light spectra of the comet's surface. NASA looks forward to building on Rosetta's success, exploring the solar system through studies of near-Earth asteroids and NASA's upcoming mission on the Origins Spectral Interpretation Resource Identification Security – Regolith Explorer (OSIRIS-REx).

On December 6, 2014, after a voyage of nearly nine years and three billion miles, the farthest any space mission has ever traveled to reach its primary target, NASA's New Horizons spacecraft came out of its hibernation for its long-awaited 2015 encounter with the Pluto system. New Horizons' encounter with Pluto represents the farthest that NASA has ever tried to reach a primary target.

In Space Technology, NASA continues to analyze data from last summer's successful flight of the Low-Density Supersonic Decelerator (LSD). The project won recognition in "The Best of What's New" in *Popular Science* magazine. NASA also completed a complex series of tests on one of the largest composite hypersonic fuel tanks ever manufactured, bringing the aerospace industry much closer to designing, building, and flying light-weight composite tanks.

NASA Aeronautics keeps working to achieve breakthroughs not only in air travel, but also new ways to use air space. In October 2014, the Agency announced NASA Langley Research Center's one-year agreement with the Department of Interior's U.S. Fish and Wildlife Service to test small unmanned aerial systems (UAS) for the detection of brush and forest fires.

In December 2014, NASA began flight testing computer software that shows promise in improving flight efficiency and reducing environment impacts of aircraft, especially in communities around airports. Mr. Bolden noted that he had the privilege of traveling to Dallas/Fort Worth and actually going to the airport tower with the Vice President of American Airlines where NASA's Aeronautics Research Mission Directorate (ARMD) has worked with the FAA to put a number of systems in place. One system is an air traffic management system (ATM) to try to help smooth the flow of air traffic from point A to point B by observing weather and making decisions autonomously on what route the traffic should take to keep airplanes safe and make an orderly progression around a storm system. Today, that work is done manually. The system was given by NASA to American Airlines and their dispatchers love it – it is a system that looks at existing conditions and the planned route of a flight and makes recommendations based on saving fuel or dollars. The dispatcher can take that new route suggestion and move it as far away from the storm or as close to it as they feel comfortable. It continually updates the fuel projection. If it is significant, the dispatcher hits a button and the new route then goes up to the FAA simultaneously with the crew onboard the American Airlines aircraft, and they are automatically rerouted, saving dollars.

There is another NASA system that is in test now in Charlotte, North Carolina, with U.S. Airways, and it helps the air traffic flow. Mr. Bolden indicated that he has been paying personal attention to it since he flies through Charlotte frequently. It helps the dispatcher determine when to release an airplane from the gate. They don't tell the pilot to start engines and back away from the gate until the software system that is looking at weather, air traffic flow, and everything around Charlotte says the airplane can go out to the runway. The airplane will be cleared within X minutes for take-off and climb-out. Mr. Bolden recounted his experiences through Charlotte recently – when the plane backed away from the gate, it immediately taxied out onto the runway and took off. It appears that the system is working well right now, but it will be a year in test. Another software program for airborne spacing for terminal arrival groups is designed to give pilots specific speed and guidance information so that planes can be more precisely spaced, enabling pilots to fly in much more efficient "follow-the-leader" approach to their destination airport.

Mr. Bolden concluded his prepared remarks by saying that NASA is looking forward to a busy and rewarding 2015 with the New Horizons arrival at Pluto, the launch of the Magnetospheric MultiScale (MMS) mission, and the first one-year crew aboard the ISS, to be launched on Soyuz in March, and much more. An exciting and challenging new year lies ahead.

Council Discussion

Dr. Squyres thanked Mr. Bolden and opened the floor for questions by the Council members. Dr. Hubbard asked Mr. Bolden to comment on the new Congress. Mr. Bolden responded that NASA has worked well with the people who are taking over and that he has met with Senator Ted Cruz. Mr. Bolden noted that the 2010 NASA Authorization Act remains in effect and guides NASA. He expects NASA to include Congress as a member of the team and for NASA to engage actively with Congress more than has been done in the past. Ms. Marion Blakey, Aeronautics Committee Chair, complimented Mr. Bolden on the support that NASA has been providing to the FAA on NextGen. She remarked that it would be timely and well advised for NASA to put effort into media public relations on the NextGen front to help establish credibility with the airlines. Mr. Bolden thanked Ms. Blakey. He noted that two Chief Executive Officer (CEO) forums had been held this year, rather than a single one. One forum was restricted to aeronautics and included the rotary-wing community, small businesses, and systems and communication companies. The participants were advised that NASA needed their help. NASA's aeronautics budget received a large "plus-up" this year, possibly because the participants had been advised that they can be quiet and get nothing, whereas space businesses are loud. Ms. Blakey confirmed that that had an impact.

Mr. Miles O'Brien noted that it had been reported that Senator Cruz does not support the ARM. Mr. O'Brien asked Mr. Bolden to comment on that report. Mr. Bolden responded that it would be nice to fly astronauts to an asteroid; however, getting to an asteroid is harder than getting to Mars. The ARM does contribute to developing the necessary technologies for sending humans to Mars, and to being able to maneuver around non-Earth bodies. He explained that the ARM will smooth the path to getting to Mars and that it is important to work in cislunar space before sending humans to Mars.

Dr. Wanda Austin congratulated Mr. Bolden on NASA's successes during the past year. She asked Mr. Bolden to comment on concerns that had been raised over the Russian RD-180 rocket engine used on United Launch Alliance's (ULA's) Atlas 5 rocket. Mr. Bolden explained that NASA is working on this issue with the Department of Defense (DoD) and that efforts continue to be made to obtain a replacement system. He noted that ULA is funding, on its own, a new engine-development effort led by Blue Origin, the rocket company led by Amazon.com founder Jeff Bezos. The bill for that will have to be paid when it becomes due; however, it will not cost as much as a rocket developed by the U.S. Government. Mr. Bolden acknowledged the practicality of commercial space. He observed that Orbital could have given up after the loss of the Antares launch vehicle but did not. Instead, the company called other rocket manufacturers to find a substitute launch vehicle and settled on the Atlas 5, which they said could fly the Cygnus cargo module to berth with the ISS by the end of the year. When that happens, people will understand what is meant by commercial space.

Mr. Young questioned the value of the 2025 ARM mission as a step to Mars, because it does not provide experience in long-duration spaceflight. Mr. Bolden responded that 5-10 years operation in cislunar orbit is necessary.

Dr. Squyres stated that it took longer than usual for the Agency to respond to the NAC's recommendations from its prior meeting at NASA Langley Research Center in July 2014. He explained that the Council is concerned about the projected low flight rate of the SLS system and that the Council had recommended that NASA conduct a study on what would be a safe flight rate. The Council was pleased that the Agency agreed to do that study, which would help inform budget issues and the Agency's strategic approach. With respect to the ARM, the Council has been favorably disposed to two elements: the search for near-Earth objects, and the ability to maneuver objects in deep space. The Council has accepted the idea that cislunar space is a sensible proving ground. The Council is concerned, however, with the ARM itself and has recommended that there be an independent cost assessment for Option A and Option B. The Agency's response did not give the sense that the Agency would obtain that independent cost assessment. Dr. Squyres advised that missions should be flown and built by optimists, but costs should be estimated by pessimists. Mr. Bolden responded that obtaining the independent cost assessment before doing a down-select between Option A and Option B would cause a significant slip in the schedule. However, an independent cost estimate is going to be needed and will be begun this year. Mr. Gerstenmaier noted that the cap for the program was \$1.25B, without including the launch vehicle. Mr. Bolden concurred and added that that always has been NASA's position. He noted that the ARM mission would be a high-risk mission that could fail; it cannot be a multi-billion dollar mission and would be scaled back if necessary. It will demonstrate that a rock heading toward the sun can be moved. It would not save the planet, but it would help inform others involved in planetary defense.

Dr. David McComas, Science Committee Chair, expressed the science community's interest in having a mix of missions and the importance of flagship missions. Mr. Bolden explained that NASA will do flagship missions when the scientific objectives demand them. He noted that during the first term of the Obama Administration he had committed to not seeking additional flagship missions. He did that because NASA was struggling and had enough flagship missions at the time, and because he wanted to get some things accomplished first. There are going to be interesting flagship missions in the next 20 years, but not in all four NASA Science divisions. Dr. McComas stated that there is a need for a balance across the spectrum. Mr. Bolden responded that the ARM does not detract or delay NASA from getting to Mars by one day. He added that some people do not like the ARM because it would keep people from going to the Moon. The next mission to the Moon may be headed up by a nation other than the U.S., because that nation is not going farther than the Moon. Dr. Squyres suggested that the cost for the OSIRIS-REx mission, which will be returning 100 grams from an asteroid, be compared with the cost for the ARM.

Dr. Squyres thanked Mr. Bolden for his time and for his comments.

NASA Human Exploration Strategy

Dr. Squyres introduced Mr. William Gerstenmaier, the NASA Associate Administrator for Human Exploration and Operations Mission Directorate (HEOMD). Mr. Gerstenmaier noted that there had been a very effective joint meeting earlier in the week between the NAC Human Exploration and Operations (HEO) Committee and the NAC Science Committee. He explained that it is healthy to look for cooperation between the two committees and that joint meetings should continue in the future. He noted that the U.S. crew on the ISS earlier that day had been forced to evacuate the U.S. Segment due to a faulty sensor triggering concerns over a potential ammonia leak. He reported that the cooperation with the Russians on the evacuation had been outstanding.

Mr. Gerstenmaier discussed the strategy for going to Mars. A chart entitled "Journey to Mars" was presented showing three elements: Earth Reliant, Proving Ground, and Earth Independent. He explained that the ARM was the best way to use the Proving Ground to buy-down risk and that the mission could be accomplished for \$1.25B. Two options, Option A and Option B, are under consideration; there will be a down-select, followed by an independent cost assessment. In response to a question from Dr. Squyres, Mr. Gerstenmaier explained that the cost assessment can lead to a conclusion that the mission would cost too much. In response to a question from Dr. David McComas, Mr. Gerstenmaier explained that the costs for the two options were not expected to be significantly different. He noted that the solar electric propulsion (SEP) bus for the mission would be the same bus used for both Mars and for the ARM and would also be available for science. Dr. Squyres questioned whether using a piece of NASA hardware in lieu of a captured asteroid might provide the same opportunity for gaining experience in manipulating objects in deep space. Mr. Gerstenmaier responded that that trade had not been considered. Dr. Scott Hubbard opined that the ARM does not benefit deep space exploration. Mr. Gerstenmaier explained that the ARM technology demonstration is defensible in terms of the Mars architecture. Dr. Squyres noted that going to Mars does not require relocating a 5-meter space rock.

Mr. Bolden explained that being unsuccessful in getting a rock to lunar orbit would not deter humans from getting to Mars. There are three parts to NASA's Asteroid Initiative. NASA got into trouble early on by referring to it as a "mission," as if all three elements had to be successful. It is necessary for humans to go to the Proving Ground in cislunar space. It is not necessary for the rock to get there. It is a bonus if the rock gets there, because it will inform the people engaged in planetary defense who are charged with saving the planet. The distinct separation of these phases was not clarified from the beginning. In response to a question from Mr. Hubbard, Mr. Bolden stated that he could not justify the ARM if it was a \$3B mission. In that case, it would be too expensive and the rock would be eliminated. Mr. Young suggested that there is a logical inconsistency in saying that the ARM is very important in the strategy for going to Mars, but is not worth more \$1.25B and is okay to fail. Dr. Squyres confirmed that it would be okay with him if the asteroid is not retrieved. Mr. Young noted that an SEP demonstration could be accomplished in several ways. Dr. Squyres concurred and stated, "It is the damn rock that we are having trouble with." Mr. Bolden stated that NASA is trying to do different things to satisfy different people and get disconnected things together. With regard to planetary defense, one possibility would be for the Department of Defense to eliminate a threatening asteroid with a nuclear weapon. Mr. Young stated that redirecting an asteroid has nothing to do with going to Mars. Mr. Bolden agreed. In response to a statement from Dr. McComas, Mr. Bolden explained that the mission is not intended to serve planetary defense, although it may inform others with that mission. He noted that NASA has been engaged in identifying threatening asteroids for over 50 years.

Mr. Gerstenmaier presented a chart showing principles for sustainable exploration. He explained that the principles have been modified based on the NAC's prior input. The principles are:

- 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; and
- Substantial international and commercial participation, leveraging current International Space Station and other partnerships.

Mr. Gerstenmaier discussed the Evolvable Mars Campaign (EMC). Its goal is to define a pioneering strategy and operational capabilities that can extend and sustain human presence in the solar system including a human journey to explore the Mars system starting in the mid-2030s. He noted that NASA is not ready for a new design reference mission or pathway and in the interim would use Design Reference Architecture 5.0. A chart on FY 2015 Forward Study Work was presented.

Dr. Squyres asked Mr. Gerstenmaier to describe how NASA is engaging with the international partners. Mr. Gerstenmaier explained that the International Space Exploration Coordination Group (ISECG) has been looking at the activities and has a very strong interest in the Moon but does not discuss much beyond that. It is interested in robotic activities and capabilities. He believes that the international partners will come forward and join NASA in the effort to go to Mars. At that time, NASA will make the necessary risk decisions with respect to putting them in the critical path.

Mr. Gerstenmaier concluded his presentation with a quotation from President Obama's April 2010 speech on Pioneering Space:

"Fifty years after the creation of NASA, our goal is no longer just a destination to reach. Our goal is the capacity for people to work and learn and operate and live safely beyond the Earth for extended periods of time, ultimately in ways that are more sustainable and even indefinite. And in fulfilling this task, we will not only extend humanity's reach in space – we will strengthen America's leadership here on Earth."

Dr. Squyres thanked Mr. Gerstenmaier for his presentation.

Radiation and Human Exploration of Mars

Dr. Squyres introduced Dr. Richard Williams, NASA Chief Health and Medical Officer. Dr. Squyres remarked that radiation is an issue that is very important to the Agency and to the Council.

Dr. Williams explained that there are a number of formidable human health challenges involved in a Mars mission. The Human System Risk Board (HSRB) has identified 30 human spaceflight health risks. However, there are no known health risks that should be considered "mission-stoppers" for a human mission to Mars. Radiation is among the foremost of those risks. There is a collaborative effort underway to fully measure and understand the radiation environments encountered in a Mars mission. Dr. McComas expressed concern over basing the risk analysis on the single good set of measurements that has been obtained from Mars. Mr. Edward Semones, participating telephonically from NASA's Johnson Space Center (JSC), addressed that issue. Dr. Squyres remarked that a detailed briefing on the issue will be needed; perhaps the NAC Science Committee could address this at a future meeting.

Dr. Williams stated that there is a robust research program underway to reduce radiation exposures and to provide radiation countermeasures. However, based on current knowledge, NASA would exceed career radiation dosage

limits for astronauts engaging in a mission to Mars. Based on advice NASA received from the National Institute of Medicine, NASA has developed a process to exempt the career radiation standard for individual astronauts based on ethical principles and responsibilities. This allows NASA to proceed to Mars without considering radiation an insurmountable barrier to Mars mission planning and execution. There is a robust research program underway to reduce radiation exposures and to provide radiation countermeasures. Dr. Williams noted that other risks of great concern are emerging, such as inter-cranial pressure and vision alteration. He asserted that there is a duty to follow astronauts throughout their life to understand what happens to their health. For over a decade, NASA has been seeking Congressional action for additional occupational health care for astronauts over their lifespans. Mr. Bolden noted that he has battled Congress every year over the need for NASA to take care of its astronauts for life, but Congressional approval has yet to be forthcoming. He also discussed the difficult ethical decision that a future NASA Administrator would need to make in authorizing astronauts to fly to Mars. He indicated that he would allow them to fly. Ms. Blakey observed that there are analogies in the area of military service. Mr. Bolden explained that it is an ethical issue and that the Nation needs to have a debate on the value of human space flight. No other nation is ready to surpass the U.S. as the leader in space exploration. Mr. Gerstenmaier stated that Mars is achievable technologically, but noted it will be a multi-decadal undertaking that requires much work to reduce risks, avoid starts and stops, and will be accomplished as a multi-nation activity.

Dr. Squyres thanked Dr. Williams for his presentation.

Council Discussion

Dr. Squyres concurred with the conclusion that the radiation issue is an ethical issue. Mr. Ken Bowersox, HEO Committee Chair, observed that NASA managers and astronauts have been making similar decisions for years. He explained that in his own case as a NASA astronaut, his willingness to accept the risks inherent in flying on space missions was attributable to his personal commitment to expanding humanity's presence into the solar system. Dr. McComas stated that he is a supporter of human space exploration, but does not disagree with the radiation risk analysis; it needs more work. It is important for the technical analysis to be performed correctly so that the right decisions can be made. Mr. Young remarked that every day the U.S. places people at higher risk for the Nation than was noted in the presentation, i.e., warfare. Dr. Squyres agreed that the military makes similar decisions all the time. Ms. Blakey explained that a Proving Ground entailing risk is acceptable in terms of the society's and government's tolerance, as long as people go into it with eyes wide open. Mr. Hubbard stated that he was extremely impressed with the presentation, and that the issue would benefit from some additional work. He was pleased with the conclusion that radiation is not a "show-stopper" for Mars exploration.

Dr. Squyres expressed the Council's pleasure with the progress on NASA's Human Exploration Program. He noted that there is strong agreement among the Council members that cislunar space is the next place to go. The only disagreement is over the \$1.25B needed to divert a small asteroid from its orbit. There is concern over whether the Agency budget will ever be sufficient to allow a mission to Mars. Mr. Young opined that Mr. Gerstenmaier has done an extraordinarily good job under the circumstances in developing the EMC. However, he asserted, it is "delusional" to view it as an executable strategy. Mr. Hubbard concurred with Mr. Young. Mr. Young remarked that there is no reason to spend \$160B over the next two decades on the Evolvable Mars Campaign unless there is a realistic opportunity to put humans on Mars. Mr. Bolden remarked that the circumstances faced by Mr. Gerstenmaier in our system of government will not change, and that he, as the NASA Administrator, has to go on faith that somebody will see the need for funding; otherwise, it will never happen.

In closing, Dr. Squyres challenged the Council members to think about ways to provide actionable advice to the NASA Administrator. Mr. Bolden remarked that it had been incredibly valuable for him to join the Council members during the meeting.

Adjournment

Dr. Squyres adjourned the Council meeting for the day at 5:00 pm.

Thursday, January 15, 2015Call to Order, Announcements

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

Opening Remarks by Council Chair

Dr. Squyres explained that the NAC’s second day would focus on hearing reports from its five committees and on Council deliberations over recommendations and findings. He noted that in the afternoon a favorite part of the meeting will be hearing from several early career NASA scientists and engineers at NASA Stennis Space Center.

Human Exploration and Operations Committee Report

Dr. Squyres introduced Mr. Ken Bowersox, who briefed the Council on the HEO Committee’s status and activities. He reviewed the Committee’s membership and presented a chart on HEOMD’s organizational structure. Major events since the last NAC meeting were discussed. Regarding the ISS, there has been two successful Soyuz launches and landings. NASA Stennis successfully tested the RS-25 rocket engine, an essential part of the SLS Program. The projected launch date for SLS has slipped from late 2017 to early 2018. The EFT-1 mission which tested the Orion crew capsule was successfully completed this past December. Eighty-five out of 87 flight test objectives were met. Commercial Crew Transportation Capability (CCtCap) contracts were awarded by NASA to Boeing and SpaceX. Mr. Bowersox described the subjects covered by the HEO Committee at its last meeting earlier in the week. HEOMD and Science Mission Directorate (SMD) joint activity areas were reviewed. A chart showing activities at the ISS was presented. ISS Increment 42 highlights were reviewed. He noted that RapidScat was launched on SpaceX-4 and within days was producing operational data products on sea surface winds for use in weather forecasting worldwide. Dramatic results were produced by the Alpha Magnetic Spectrometer (AMS) on the ISS. Its observations show the existence of a new phenomenon that is of either particle physics or astrophysical origin. HEOMD accomplishments in 2014 and milestones for 2015 were reviewed.

The upcoming ISS one-year mission was described. In March 2015, Astronaut Scott Kelly and Cosmonaut Mikhail Kornienko will be launched to the ISS for 12 months – the longest mission ever assigned to a U.S. Astronaut. Mr. Kelly’s twin brother, retired Astronaut Mark Kelly, will be included in the study. The twins provide an unprecedented opportunity to research the effects of space flight on twin genetic makeup and to better understand the impacts of spaceflight on the human body.

A proposed HEO Committee Finding on expanding the NASA research community was presented to the Council for its approval for transmittal from the HEO Committee Chair to the HEOMD Associate Administrator:

The Human Exploration and Operations Committee endorses the NASA Human Exploration and Operations Mission Directorate effort to broaden participation in the NASA research community evidenced by the recent NASA Research Announcement in Space Biology, in which 75 percent of the submitted proposals were from principal investigators new to Space Biology, and 62 percent of the awards were to new principal investigators. This result followed a year of effort at major scientific conferences to publicize the opportunity to conduct biological research on the International Space Station. Broadening the community and engaging the best new ideas for research from the nation’s scientists will greatly strengthen the foundations of space research and enhance the productivity of NASA’s investments. NASA should continue to seek to bring in new investigators, within the limits of its available resources, and continue to track this metric.

The Council approved this Finding. Mr. Young suggested that Council time would be better spent focusing on the massive, big issues facing the Agency. In response to a question from Dr. McComas, Dr. Bette Siegel confirmed that the proposals had been subjected to standard scientific peer review.

Mr. Bowersox discussed the impact that the NASA Procedural Requirements (NPR) 7120.5E/NASA Space Flight Program and Project Management Requirements has on program affordability and sustainability. The document establishes the requirements by which NASA formulates and implements space flight programs and projects. He explained that users understand the need for a guidance document on program management and believe that the document is useful for training purposes. Tailoring of the requirements, however, is too difficult. Mr. Bowersox presented to the Council for approval a proposed Recommendation encouraging NASA to focus on affordable program management:

The Council recommends that NASA take action to make programs and projects more affordable by:

- 1. Examining the current approach for tailoring mandatory NASA management requirements and making changes to expedite the resolution of tailoring requests.*
- 2. Working with groups that are currently conducting separate reviews of programs to minimize the number and maximize the benefit of reviews and reviewing groups.*

Mr. Bowersox noted that the Commercial Orbital Transportation System (COTS) program was exempted from NPR 7120.5E. That program produced two launch vehicles and three orbital variables for approximately \$850M. Estimation models indicate that it would have cost NASA three to ten times that amount to obtain the same products through the normal procurement process. Dr. McComas observed that many science projects could be implemented more efficiently if not hampered by NASA's requirements. Mr. Young suggested that the NAC should be briefed on the issue by NASA's Chief Engineer, who has responsibility for the document. At Dr. Squyres' suggestion, this proposed Recommendation was tabled to allow a briefing by the Chief Engineer at the next NAC meeting.

Mr. Bowersox invited all Council members to attend the HEO Committee's meetings.

Dr. Squyres thanked Mr. Bowersox for his presentation.

Council Discussion

Dr. Squyres began by thanking Mr. Gerstenmaier for his presentation and the vigorous Council discussion that followed it. He reported that NASA has concurred with the Council's previous recommendation that NASA take a hard look at the safety issues associated with the SLS flight rate. That will be followed with interest. Dr. Squyres noted that one of the biggest issues facing the Agency over the next several years will be the ARM. The HEO Committee has not presented a recommendation on that issue. Mr. Hubbard suggested that the Council consider a recommendation approving two ARM elements: (1) SEP; and (2) maneuvering in a low gravity environment in deep space. The third ARM element, snaring an asteroid and moving it to cislunar space, while having some relationship to planetary defense, would be supported by the Council only if the independent cost assessment for it does not exceed \$1.25B. Dr. Squyres observed that the proposed recommendation would assure retaining the two critical elements needed to get to Mars if the estimate for the asteroid element exceeded \$1.25B. Mr. Bowersox, Mr. Young, and Dr. McComas concurred with that approach. Dr. Squyres advised that as decisions get made on the architecture, it is necessary to have a set of decision criteria that make sense and are agreed to upfront.

Mr. Bolden stated that he was encouraged by the proposed recommendation. He explained that there are three individual missions wrapped into one that has been called by default the "ARM." The first element, asteroid identification, has been ongoing for over 50 years. The asteroid redirection element cannot be the thing that prevents NASA from going to Mars. In an effort to avoid offending anyone, confusion may have been generated by naming the entire effort the ARM. It is necessary to think clearly about the words to describe what is important for the Nation, which is pushing forward on sending humans to Mars.

Mr. Young remarked that Mr. Gerstenmaier was doing a great job with "the hand that he has been dealt." However, just because something is a "policy" issue does not make it right. Dr. Squyres stated that the Council, when advising the Agency, has to walk a difficult line and give the NASA Administrator advice that is actionable at the Agency level. He would like Mr. Hubbard's recommendation to be crafted in a manner that would not set the Agency against National Space Policy. He noted that it would be useful to have a discussion on whether the Council should ever take a stand that is contrary to that policy. Dr. Squyres noted that that issue is broader than the ARM by a substantial margin and that there would be time later in the agenda for discussion on that topic. He added that the Council's

written recommendations and findings are the only on-the-record consensus views of the Council. He explained that he is frequently called on to testify or to present the NAC's views to external audiences, and he never adds anything that goes beyond the Council's written recommendations and findings.

Science Committee Report

Dr. Squyres introduced Dr. David McComas, who briefed the Council on the Science Committee's status and activities. Dr. McComas reviewed the Committee's membership. He reviewed recent science results in heliophysics, planetary science, astrophysics, and Earth science. The Solar Dynamics Observatory (SDO) has captured an image of an enormous coronal hole near the Sun's southern pole. The hole can cause space weather events with potential impacts on Earth. NASA, using the German Aerospace Center's Gravity Recovery and Climate Experiment (GRACE) mission, has quantified groundwater depletion in the Colorado River Basin. Production statistics from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) sensor have been used to show that increases in agricultural productivity explain as much as a quarter of the observed changes in the atmospheric carbon dioxide (CO₂) seasonality. A study using satellite altimetry observations concluded that observed estimates of the top 2200 feet of the global ocean warming since 1970 are likely biased low. A study that NASA-funded scientists conducted about the Amundsen Sea Embayment of West Antarctica shows that the acceleration of mass loss there has nearly tripled during the last decade. A slide was presented showing emission from ionized magnesium in Mars's atmosphere following the Siding Spring Meteor Shower, imaged by the ultraviolet spectrograph on the Mars Atmosphere and Volatile Evolution (MAVEN) mission. Recent work by the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) was described. The group detected solar wind-produced water in irradiated rims on silicate minerals. The Hubble Space Telescope (HST) has identified three Kuiper Belt targets that are potentially reachable by NASA's New Horizons spacecraft after it passes by Pluto in mid-2015. Using three NASA X-ray telescopes – Swift, Chandra, and NuStar – scientists have found evidence that the supermassive black hole at the center of the Milky Way may be producing high-energy neutrinos.

Dr. McComas reviewed the NASA Science Mission Directorate (SMD) organization chart. Slides showing the Heliophysics Roadmap and key milestones for heliophysics were presented. The Cloud-Aerosol Transport System (CATS) instrument was launched to the ISS in early January 2015. It is a light detecting and ranging (LIDAR) remote-sensing payload designed to improve model-based estimates of climate forcing and predictions of future climate change. Dr. McComas described the Soil Moisture Active Passive (SMAP) mission, scheduled to launch in late January 2015. A chart listing Planetary Science mission events was presented. International collaboration successes were discussed. Much excitement was generated from NASA's collaboration with the European Space Agency (ESA) on their Rosetta mission, which successfully landed on the comet Philae. A chart showing accomplishments and plans for NASA's James Webb Space Telescope (JWST) was reviewed. Mr. Young reported that the GAO has issued a "yellow flag" for the project. Mr. Bolden explained that personnel changes in management on the project had been made, and there have been improvements in performance. Dr. Squyres requested a briefing on JWST at the next Council meeting.

Dr. McComas described the joint session that had been conducted earlier in the week between the NAC Science Committee and the NAC HEO Committee. He reported on the Planetary Protection Subcommittee of the Science Committee. It is addressing an issue on how the U.S. Government can ensure compliance with planetary protection requirements by non-governmental U.S. entities through the Outer Space Treaty (OST) Requirements for Planetary Protection. Mr. Young suggested that the National Academy of Sciences could have a role. Dr. McComas advised that it may be necessary in the near future to move the NAC Planetary Protection Subcommittee from the Science Committee to a higher level. He discussed NASA's response to a previous Council Recommendation on infusing new technologies into small- to medium-class missions. NASA did not concur with the Council recommendation due to its specificity. Dr. McComas reported that the Science Committee did not understand the rationale for non-concurrence. The new Ad Hoc Task Force on Big Data was discussed.

A proposed Council Recommendation to reduce loss of efficiency and scientific productivity from the over-application of travel regulations was presented by Dr. McComas. He explained that NASA's unnecessarily restrictive interpretation of travel regulations was artificially limiting the number of scientists allowed to attend foreign conferences. Dr. Squyres concurred that this is a "self-inflicted wound" that should be fixed to the extent possible. The Council approved the following Recommendation:

The Council recommends that NASA change its definition of the class of persons (specifically, “contractors”) who are subject to the travel restrictions externally mandated for Civil Servants. This definition could continue to provide travel controls on those personnel that NASA considers appropriate (for example, scientists at specific institutions), but should not include others, such as those at most universities, non-profits, and private companies funded through mission contracts.

Dr. Squyres thanked Dr. McComas for his presentation.

Institutional Committee Report

Dr. Squyres introduced Ms. Kathryn Schmoll, Chair, Institutional Committee. Ms. Schmoll reviewed the Committee’s membership. She presented a slide showing the Committee’s Work Plan, including an excerpt from NAC 2014 Work Plan:

- Overhauling NASA’s Information Technology (IT) Governance Structure, and Ensuring the Security of NASA’s IT Systems: Review and assess Agency’s plans to overhaul the current IT governance structure and ensure the security of NASA’s IT systems.
- Acquisition Reform, and Ensuring the Integrity of the Contracts and Grants Processes: Review and assess Agency plans for acquisition reform and ensuring the integrity of the NASA contracts and grant process.

Ms. Schmoll discussed 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. They are:

- Overhauling NASA’s Information Technology (IT) Governance Structure
- Ensuring the Security of NASA’s IT Systems
- Managing NASA’s Infrastructure and Facilities
- Ensuring the Integrity of the Contracting and Grants Processes and the Proper Use of Space Act Agreement

A chart describing the Institutional Committee’s fall 2014 meeting topics was presented. Ms. Schmoll reviewed the Committee’s observations from that meeting. The Committee commended sustainability achievements in the facilities arena, for the new communication strategy/thrust, and the NASA Shared Services Center (NSSC) at Stennis. Ms. Schmoll presented a chart showing topics on which detailed briefings have been requested for future Committee meetings.

Dr. Squyres thanked Ms. Schmoll for her presentation.

Ad Hoc Task Force on STEM Education

Dr. Squyres introduced Mr. Donald James, the new NASA Associate Administrator for Education. Dr. Squyres explained that when the NAC was reorganized, in addition to establishing the standing committees and at-large members, two Ad Hoc Task Forces were established. One was the Ad Hoc Task Force on Big Data. The other was the Ad Hoc Task Force on STEM (Science, Technology, Engineering, and Mathematics) Education, which is a topic of passionate interest to the Council. The Ad Hoc Task Force on STEM Education will report directly to the Council.

Mr. James described his NASA career, which began in 1982 as a Presidential Management Intern at NASA’s Goddard Space Flight Center (GSFC). He explained that while at Goddard, “he got the NASA disease where they take you into a room and inject you with passion.” He acknowledged Mr. Hubbard for his leadership and NASA’s Ames Research Center (ARC), where Mr. James worked when Mr. Hubbard served as Center Director.

Mr. James discussed his priorities as NASA Associate Administrator for Education. Those priorities are:

- Develop and implement NASA’s education programs that strengthen student involvement and public awareness about NASA’s scientific goals and missions
- Communicate NASA’s unique position and capabilities in STEM education

- Lead the Education Coordinating Council
- Serve on the Office of Science and Technology Policy's (OSTP's) Committee on STEM (Co-STEM) to continue coordinating and leveraging NASA's education programs and opportunities with other Federal agencies

Mr. James discussed a slide showing the areas in which NASA education will focus. Those areas include:

- STEM Education and Accountability Projects Competition
- National Science and Technology Council (NSTC) and CoSTEM
- Office of Management and Budget (OMB) relationship
- Interagency Working Groups (IWGs)
- NASA Education Federal collaborations and partnerships

Mr. James discussed the data that is provided by the Office of Education Performance Management (OEPM). He presented a chart showing the budget for NASA's Office of Education. The FY 2015 Enacted Budget is \$119M. Mr. O'Brien reported that there have been complaints over the lack of discretion in the budget. Mr. James responded that he has not observed missing opportunities. Mr. Bolden remarked that all four items in the Office of Education's budget are Congressionally mandated. He noted that NASA had worked well with the Department of Education last year, essentially becoming its subcontractor. Mr. James explained that NASA provides curricula supplements. Mr. Young asked about NASA's role in educating its young engineers. Mr. James responded that his office does not train NASA's young engineers; that is handled elsewhere in the Agency. His office does however, ask NASA engineers to participate in NASA Education activities. Mr. Young remarked that many young engineers during the Apollo program developed their expertise by working on sounding rockets at NASA's Wallops Flight Facility. He opined that his college degree in engineering had "taught him the discipline of engineering" but that his time as a young engineer at NASA had "made him an engineer." He lamented that the Sounding Rocket Program at Wallops is entirely contracted-out today, at an enormous loss to NASA.

Dr. Squyres thanked Mr. James for his presentation.

Dr. Squyres described two "homework" assignments that were to be worked on over the lunch break by Council members. Mr. Hubbard was asked to draft a Council recommendation on the ARM. The other assignment was for Council members to consider how to give advice when that advice might be contrary to National Space Policy. Dr. Squyres explained that Council-level "findings" are a tool not previously utilized by the Council. Findings are not "recommendations"; they are expressions of the opinion of the Council and are not actionable. Findings may be a way for the Council to go on record publicly with an expression of its opinion on a topic that may be contrary to National Space Policy, with no need for a response from the Agency. He cautioned that a finding should not be a recommendation that is disguised as a finding.

Public Input

Dr. Squyres invited comments from the public.

Mr. Robert Zimmerman identified himself as a former NASA employee. He suggested it would be helpful if more information could be made available on rebuilding the space biology community. He explained that it might be useful to indicate the number of principal investigators and institutions that were brought in with the \$12.5M given to the program, and to identify the topics that are now covered better through the expanded program.

Dr. Squyres thanked Mr. Zimmerman for his comments.

Aeronautics Committee Report

Dr. Squyres introduced Ms. Marion Blakey, who briefed the Council on the status and activities of the NAC Aeronautics Committee. She began by presenting a dramatic photograph of NASA's Hanger One as it is being renovated at NASA's Ames Research Center (ARC) in California. She reviewed the Committee membership and the areas of interest explored at the Committee's most recent meeting at ARC. A chart giving an overview on Aeronautics research at ARC was presented. Ms. Blakey described two success stories about ARC technology

transfers. The first involved the transfer to the Federal Aviation Administration (FAA) of Terminal Sequencing and Spacing (TSS), Precision Departure Release Capability (PDRC), and Traffic and Atmospheric Information for General Aviation (TAIGA). The second involved transferring Dynamics Weather Routing (DWR) technology to American Airlines.

Ms. Blakey presented a slide showing a notional scenario for Unmanned Aerial Systems (UAS) Air Traffic Management (UTM). Progress by the FAA on Air Traffic Management (ATM) has been extremely slow, a conclusion shared by both the FAA and industry. Ms. Blakey explained that the technical challenge is to safely enable UAS operations at lower altitudes and that infrastructure to support operations at low altitudes was missing. She noted that NASA has tackled the issue of aircraft control. UTM One Design Option was discussed. External partners from academia, industry, and other governmental agencies are collaborating on the concept. International interest has been expressed by South Korea, France, Poland, and Japan. A slide showing a schedule for UTM research and development driven by various “builds” was presented. The Build 1 Demo was described. A proposed Committee Finding for NASA’s Aeronautics Research Mission Directorate (ARMD) was presented. The Finding supports ARMD’s approach to the UTM. The Finding was approved by the Council for transmittal from the Aeronautics Committee Chair to the ARMD Associate Administrator as follows:

The Aeronautics Committee supports the approach that the NASA Aeronautics Research Mission Directorate (ARMD) has taken toward establishing a research effort for Unmanned Aerial System Traffic Management. In particular, ARMD efforts taken thus far to proactively engage the right stakeholders and partners in the process will be critical to reducing implementation barriers. The Committee encourages ARMD to broaden the scope of community engagement even further to enlist all stakeholders in being part of the solution and helping to enable a broader acceptance of this important area of aeronautics research.

Ms. Blakey discussed the FAA’s UAS Center of Excellence (COE). She noted that the 2014 Consolidated Appropriations Act had mandated \$1.144M for the UAS activity and specified that the purpose for the funding was:

“ . . . to complete the establishment of a UAS center of excellence to provide recommendations for airspace designation for manned and unmanned flight operations, conduct research to support UAS interagency requirements, coordinate research and development activities with other agencies, and provide recommendations on aircraft certifications.”

A chart describing the UAS COE’s evolution was shown. The COE has 11 technical focus areas:

1. Air Traffic Control Interoperability
2. Airport Ground Operations
3. Control and Communication
4. Detect and Avoid
5. Human Factors
6. Low Altitude Operations Safety
7. Noise Reduction
8. Spectrum Management
9. Unmanned Aircraft Crew Training and Certification, Including Pilots
10. Unmanned Aircraft Systems Traffic Management
11. UAS Wake Separation Standards for UAS Integration into the NAS

Ms. Blakey discussed the status of research on aircraft software verification and validation (V&V). She remarked that today’s airplanes are “flying computers.” She noted that the complexity of current-day flight-critical systems poses significant challenges to safety assurance. Software V&V is particularly costly and time-consuming. It accounts for approximately 50 percent of the cost for recent commercial aircraft development. The NAC Aeronautics Committee had previously advised NASA to demonstrate progress in applying new techniques to certification problems and to develop more comprehensive solutions. In 2014, NASA’s Aviation Safety Program adopted additional program-level milestones to provide greater emphasis on V&V technology transfer. A chart was presented on near-term V&V research stakeholder coordination. Ms. Blakey explained that the Aviation Safety Program V&V research will transition to the Airspace Operations and Safety Program (AOSP) as part of a NASA ARMD restructuring. AOSP projects hosting V&V research were described. A chart was shown on the constant

lifecycle evolution of assurance elements for support V&V and certification of ATM systems. Ms. Blakey presented a proposed Committee Finding that endorses the ARMD program restructure. The Council approved the Finding for transmittal from the Aeronautics Committee Chair to the ARMD Associate Administrator, which states:

The Aeronautics Committee endorses the current NASA Aeronautics Research Mission Directorate (ARMD) program restructuring, but stresses that critical areas of aviation safety research need to be maintained as the former Aviation Safety Program elements are transitioned in the new structure. The Committee finds that it is especially imperative for ARMD to maintain its commitment to research in verification and validation since this is a critical national need and an important area of work for NASA.

Ms. Blakey described the “Big Question” approach for addressing difficult problems. It is a new process being employed to focus on major system level questions and challenges that require NASA and the aviation community to think beyond current concepts, architectures, and relationships. It uses workshops, brainstorming, and crowdsourcing. ARMD will fund 1- to 3-year feasibility research and development (R&D) grants for the most promising and innovative solutions that have the potential to be game-changers for the aviation community. As a demonstration, two FY 2015 Big Questions have been posed:

1. Can we create an aviation system with maximum efficiency and minimal environmental impact?
2. Demonstrate the feasibility for urgent medical transportation from the wilderness of Alaska to the Mayo Clinic without human interaction.

Dr. Squyres thanked Ms. Blakey for her presentation.

Technology, Innovation and Engineering Committee Report

Dr. Squyres introduced Dr. William Ballhaus, Chair, Technology, Innovation, and Engineering Committee. Dr. Ballhaus, due to illness, participated telephonically. He congratulated NASA on the increase in the Aeronautics budget, nearly all of which was unencumbered. He reviewed the Committee’s membership and the presentations given to the Committee at its last meeting. A chart on Agency Capability Leadership Areas was shown to the Council. He discussed a slide showing the NASA’s Space Technology strategic themes: “go there, land there, live there, and observe there.” A chart on the “Technology Path to Pioneering Mars” was presented. The Space Technology Pipeline was described. A slide showing several Space Technology Mission Directorate (STMD) successes was presented. A chart showing major STMD events and milestones from 2014 through 2021 was reviewed.

Dr. Ballhaus discussed the NASA response to a previous Council Recommendation on the infusion of new technologies in small- to medium-class science missions. He stated that the NASA response contained statements that were contradictory.

Dr. Ballhaus presented a chart on Technology Infusion – Discovery ’14. This is a partnership between SMD and the Game-Changing and Technology Demonstration programs of STMD. He discussed a chart on the STMD Game Changing Program supporting Mars 2020. STMD and HEOMD will develop instrument payloads for infusion into the Mars 2020 mission. A slide was presented showing how the technology portfolio supports missions. Updates to the Technology Roadmap and to the Strategic Technology Investment Plan (STIP) were discussed. A chart providing an overview on the Roadmap update was presented. Aeronautics has been added as new Technology Area (TA) 15. Dr. Ballhaus described NASA’s successful Low-Density Supersonic Decelerator (LDSD) Supersonic Flight Dynamics Test (SFDT) No. 1. He discussed the status of the SEP program. The Roll-Out Solar Array (ROSA) has reached Technology Readiness Level (TRL) 5. The Mega Flex Solar Array has reached TRL 5. The 12.5 kilowatt (kw) Electric Propulsion (EP) Thruster has been tested and reached approximately 60 percent efficiency.

Flight experiments on the Orion EFT-1 were described. Radiation environment monitors measured radiation inside Orion while it passed through the Van Allen radiation belts. The Advanced Caution and Warning System operated in shadow mode during the flight to detect faults in Orion’s power system. A slide was presented on the Bigelow Expendable Activity Module (BEAM). The purpose for BEAM is to test a berthing mechanism.

Dr. Ballhaus presented a proposed Committee Finding on the importance of developing a new domestic rocket main engine and the need for NASA to play a key role in that activity. Mr. Young stated that this item is a critical national issue and should be approved as a Council Finding. Dr. Squyres concurred. Mr. Bolden remarked that this issue is being worked at his level with the Department of Defense and others. He explained that it would be an opportunity for STMD to collaborate with HEOMD. In response to a question from Mr. Young, Mr. Bolden explained that the Administration would not invest in a new engine unless there is also a plan for integrating the engine with a launch system. Mr. Gerstenmaier explained that there would be no impact from the loss of the RD-180 rocket engine because there are sufficient alternative resources between the Delta 4 and Atlas 5 rockets. In response to a question from Dr. Ballhaus, Mr. Gerstenmaier stated that the Atlas 5 is sustainable without National Security Space launches. Dr. Squyres stated that the proposed Committee Finding, without changing its substance, would be crafted into a Council Finding:

The Council believes that it is important for NASA and the nation to assess the need for a new domestic alternative to the currently available foreign hydrocarbon rocket main engines, and to invest accordingly. The Council also believes NASA can and should play a key role in this activity, especially in the development and understanding of advanced materials and metallurgy technologies for a future domestic hydrocarbon rocket main engine.

The Council approved this Council Finding.

Dr. Squyres thanked Dr. Ballhaus for his presentation.

Council Discussion

Mr. Hubbard presented a draft Council Recommendation on the ARM. Dr. Squyres explained that the SEP and deep space maneuvering are both highly important for getting to Mars, while the asteroid segment has many small items that also contribute to the Mars mission. Mr. Bowersox stated that the recommendation was reasonable but contained unnecessary inflammatory language. In response to a question from Mr. O'Brien, Mr. Bolden explained that the \$1.25B cost for the ARM reflects guidance that he gave to HEOMD and is not an official budget cap. Mr. Hubbard expressed opposition to "moving the goalpost." After further discussion, the proposed Council Recommendation was deferred for revision and additional discussion later in the meeting.

NASA Stennis Space Center (SSC) Early Career Employee Presentations

Dr. Squyres indicated that the time had come for one of his favorite parts of Council meetings: the presentations by NASA's early career scientists and engineers at the NASA Centers. He re-introduced the Stennis Center Director, Dr. Gilbrech, who then introduced the three SSC early career presenters to the Council. Dr. Gilbrech first introduced Dr. Howard Conyers, SSC Engineering and Test Directorate. Dr. Conyers gave a presentation entitled "*Expanding In-House Capabilities: From Kronos to Early Career Initiative.*" In response to a question from Mr. O'Brien, Dr. Conyers stated that the hardest part about his program was learning all the reporting requirements. Then Dr. Gilbrech introduced Mr. Andrew Guymon, SSC Engineering and Test Directorate. Mr. Guyman gave a presentation entitled "*Morpheus Engine Testing and Support of Tether and Free-Flights at NASA Johnson Space Center/NASA Kennedy Space Center.*" Mr. Guymon noted that one of his favorite parts of the test activities was getting to stay in the Astronaut Crew Quarters at Kennedy Space Center. In response to a question from Mr. O'Brien about what is next for him, Mr. Guymon replied that he was not sure and that the issue is whether there is money to do more. Dr. Gilbrech then introduced the final speaker, Ms. Amanda Stein, SSC Engineering and Test Directorate. Ms. Stein gave a presentation entitled "*Highlights of J-2X and RS-25 Engine Testing in the A-Complex.*"

Dr. Squyres thanked Dr. Conyers, Mr. Guyman, and Ms. Stein for their excellent presentations. The Council applauded the presenters.

Council Discussion

Mr. Hubbard's proposed Council Recommendation on the ARM was re-presented to the Council with revisions resulting from the earlier Council discussion on the item. Dr. Squyres observed that everyone was in agreement on the revised language. The Council Recommendation was approved as follows:

The Asteroid Redirect Mission (ARM) has two objectives that are particularly important contributors to Humans to Mars (H2M): Large scale solar electric propulsion (SEP) and maneuvering in a low gravity environment in deep space. As work on ARM goes forward and costing is completed, focus on a mission architecture that will preserve these two key H2M objectives if the redirection of an asteroid must be descoped.

Mr. Young then presented a proposed Council Finding as follows:

The Council does not believe that the redirection of an asteroid or part of an asteroid to cislunar space contributes significantly to the national objective of sending humans to Mars. We believe the cost and utilization of important but limited human exploration expertise for asteroid redirection is not justified by the expected low contribution to the Humans to Mars endeavor.

Due to a lack of unanimity among Council members and the need for time to work on achieving a consensus, deliberation on this Finding was deferred at Dr. Squyres's request. The Council agreed to hold further deliberation on the proposed Finding at a special NAC "virtual" meeting to take via telecon/WebEx, at which time all Council members would have an opportunity to participate in the discussion. The suggested date for this NAC virtual meeting was February 23, 2015, subject to the schedule availability of all Council members. Ms. Rausch was asked to poll all Council members in the near future concerning their availability for this virtual meeting. In response to a question regarding FACA, Ms. Rausch explained that since the Council would be having deliberations on proposed advice to the Agency, the virtual meeting would be a public meeting and must have public accessibility. Dr. Squyres asked that the public meeting notice be sent to the Federal Register by Monday, January 19, 2015, if possible. At the request of Dr. McComas and Mr. Hubbard, Dr. Squyres agreed that read-ahead materials about the ARM would be provided to Council members in advance of the proposed February 23 virtual meeting.

General Discussion

Mr. Young observed that NASA today takes minimal advantage of using the Sounding Rocket Program at NASA's Wallops Flight Facility to educate its young engineers. Dr. Squyres concurred and noted that the concept could be expanded to any program that allows young engineers to build and fly hardware with a quick turn-around time. NASA's High Altitude Balloon Program is another example. Dr. Squyres stated that providing hands-on education to NASA's early career engineers is critically important to the Agency, and he requested that the topic be covered in a future briefing to the Council by NASA's Chief Engineer.

Dr. Squyres then addressed a previous Council Recommendation on the mismatch between NASA's budget and its aspirations for human space flight. Mr. Young opined that if NASA implemented the capabilities long-term strategy for the Evolvable Mars Campaign (EMC) as currently presented, NASA would have spent \$160B and only be negligibly closer to sending humans to Mars than where NASA is today. Council members debated whether it was disingenuous to characterize the EMC as a strategy that is executable. It was noted that having the debate was healthy and valuable. Dr. Squyres stated that as the Council has said previously, the mismatch between NASA's aspirations and the budget is the biggest problem facing the Agency. He expressed consternation over the fact that the Agency's response to the recommendation was not delivered to the Council in time for it to be fully considered during the current Council meeting. At his request, the item was tabled and rescheduled for the next NAC meeting as an agenda item. Ms. Rausch indicated that the next Council meeting would be held on April 8 and 9, 2015, at NASA Headquarters. [Note: The dates for the next Council meeting have since been changed to April 9 and 10, 2015, at NASA Headquarters.]

Dr. Ballhaus remarked that the Agency's response to the prior Council Recommendation on technology infusion was confusing. Dr. Squyres stated that the response had been received so late that it could not be put on the Council meeting agenda. He encouraged the Science Committee and the Technology, Innovation and Engineering Committee to continue working on the issue. He counseled that stubbornness is an important characteristic for an advisory committee to have.

Dr. McComas stated that the Science Committee dislikes always having to meet on the Monday and Tuesday prior to the Council meetings. Dr. Squyres agreed to consider alternative scheduling. Ms. Schmolz expressed concern over

compelling people attending the next Council meeting to travel on Easter Sunday. She also stated that she enjoys hearing from NASA's early career employees and suggested considering having a panel in the future to interact with them.

Mr. Hubbard explained that, with proper attention to program systems engineering and program architecture, the NASA Human Exploration Program can begin to benefit from the same things that the NASA Science organizations have painfully come to grip with over the past decade. Mr. Young remarked that the highlight of this Council meeting was to have Mr. Bolden and Mr. Gerstenmaier present for almost the entire meeting.

Wrap-up and Final Acknowledgments

In closing, Dr. Squyres stated that the Council is the most powerful group that he has ever chaired and in his view, is one of the best advisory groups that NASA has ever assembled. He reminded the members that, quoting from Spiderman, "with great power comes great responsibility." He expressed appreciation to Mr. Bolden for being present throughout the meeting to see how the Council agonizes down to the level of individual words. Dr. Squyres thanked the people at NASA Stennis Space Center for their outstanding help and support, and he stated that it was a pleasure for the Council to come to Stennis. He thanked the staff from NASA Headquarters for their support and gave special acknowledgment to Ms. Mary Floyd and Ms. Marla King, who were applauded by the Council members. Dr. Squyres thanked the Committee Chairs and Executive Secretaries for their efforts and explained that the NAC could not be successful without their hard work.

Adjournment

Dr. Squyres adjourned the Council meeting at 5:04 pm.

NASA ADVISORY COUNCIL

**NASA Stennis Space Center
Roy S. Estess Building
Building 1100, Room 321
Mississippi**

PUBLIC MEETING

January 14-15, 2015

Wednesday, January 14, 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 NASA Stennis Space Center	Dr. Richard Gilbrech Director, NASA Stennis Space Center
1:30 – 2:15 pm	Remarks by NASA Administrator	Mr. Charles F. Bolden, Jr. NASA Administrator
2:15 – 2:30 pm	Council Discussion	
2:30 – 3:15 pm	NASA Human Exploration Strategy	Mr. William Gerstenmaier Associate Administrator for Human Exploration and Operations Mission Directorate NASA Headquarters
3:15 – 4:00 pm	Radiation and Human Exploration of Mars	Dr. Richard Williams Chief Health and Medical Officer NASA Headquarters
4:00 – 5:00 pm	Council Discussion	
5:00 pm	Adjourn	

Thursday, January 15, 2015

9:00 – 9:01 am	Call to Order, Announcements	Ms. Diane Rausch Executive Director NASA Advisory Council NASA Headquarters
9:01 – 9:03 am	Remarks by Council Chair	Dr. Steven W. Squyres Chair, NASA Advisory Council
9:03 – 9:45 am	Human Exploration and Operations Committee Report	Mr. Kenneth Bowersox, Chair
9:45 – 10:15 am	Council Discussion	
10:15 – 11:00 am	Science Committee Report	Dr. David McComas, Chair
11:00 – 11:45 am	Institutional Committee Report	Ms. Kathryn Schmoll, Chair
11:45 am – 12:00 noon	Ad Hoc Task Force on STEM Education	Mr. Donald James Associate Administrator for Education NASA Headquarters
12:00 noon – 1:00 pm	Lunch	
1:00 – 1:10 pm	Public Input	
1:10 – 1:45 am	Aeronautics Committee Report	Ms. Marion Blakey, Chair
1:45 – 2:30 pm	Technology, Innovation and Engineering Committee Report	Dr. William Ballhaus, Chair
2:30 – 3:00 pm	Council Discussion	
3:00 – 3:15 pm	Break	
3:15 – 4:00 pm	NASA Stennis Space Center (SSC) Early Career Employee Presentations: <i>Expanding In-House Capabilities: From Kronos to Early Career Initiative</i>	Dr. Howard Conyers SSC Engineering and Test Directorate
	<i>Morpheus Engine Testing and Support of Tether and Free-Flights at NASA Johnson Space Center/ NASA Kennedy Space Center</i>	Mr. Andrew Guymon SSC Engineering and Test Directorate
	<i>Highlights of J-2X and RS-25 Engine Testing in the A-Complex</i>	Ms. Amanda Stein SSC Engineering and Test Directorate
4:00 – 4:45 pm	Council Discussion	
4:45 – 5:00 pm	Wrap-up and Final Acknowledgments	
5:00 pm	Adjourn	

NASA ADVISORY COUNCIL

Membership – January 2015

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

**NASA ADVISORY COUNCIL
 NASA Stennis Space Center
 Mississippi
 January 14-15, 2015**

MEETING ATTENDEES

NASA Advisory Council Members:

Dr. Steven W. Squyres, <i>Chair</i>	Cornell University
Dr. Wanda Austin	The Aerospace Corporation
Dr. William Ballhaus (<i>via telecon</i>)	The Aerospace Corporation (Ret.)
Ms. Marion Blakey	Aerospace Industries Association
Mr. Ken Bowersox	U.S. Navy (<i>Ret.</i>)
Prof. G. Scott Hubbard	Stanford University
Dr. David McComas	Southwest Research Institute
Mr. Miles O'Brien	Independent Journalist
Ms. Kathryn Schmolz	University Corp. for Atmospheric Research
Mr. A. Thomas Young	Lockheed Martin (Ret.)
Ms. P. Diane Rausch, <i>Executive Director</i>	NASA Headquarters

NASA Attendees:

Bevis, Jim	NASA/Stennis Space Center (SSC)
Breen, Sally	NASA/SSC
Cerut, Monica	NASA/SSC
Denning, Elaine	NASA HQ
Emery, Katrina	NASA/SSC
Galloway, Thomas R.	NASA/SSC
Gerstenmaier, William	NASA HQ
Girten, Beverly	NASA HQ
James, Donald	NASA HQ
Jones, Dorsie	NASA/SSC
King, Marla	NASA HQ
Pelletier Travis, Ramon	NASA/SSC
Robinson, Shawanda	NASA HQ
Siegel, Bette	NASA HQ
Smith, Erin	NASA HQ
Watkins, Toni	NASA/SSC
Williams, Greg	NASA HQ
Williams, Rich	NASA HQ

Other Attendees:

Cockrell, Mike	RPT
Frankel, David	PB Frankel, LLC

WebEx/Telecon Attendees:

Billings, Linda
Broadwell, Marguerite
Dinwiddie, Cynthia
Eng, Andy
Feeley, T. Jens
Gazarik, Michael
Killebrew, Jane
Lawson, Kimberly
Liskowsky, David
Malkin, John
Moloney, Michael
Proudfoot, Robert
Pugel, Betsy
Semones, Eddie
Stein, William
Woodard, Daniel
Zimmerman, Robert

**NASA ADVISORY COUNCIL
Stennis Space Center
Mississippi
January 14-15, 2015**

LIST OF PRESENTATION MATERIAL

- 1) John C Stennis Space Center [Gilbrech]
- 2) NASA Human Exploration and Operations [Gerstenmaier]
- 3) Radiation and Human Exploration of Mars [Williams]
- 4) Human Explorations and Operations Committee Report [Bowersox]
- 5) Science Committee Report [McComas]
- 6) Institutional Committee Report [Schmoll]
- 7) Aeronautics Committee Report [Blakey]
- 8) Technology, Innovation and Engineering Committee Report [Ballhaus]
- 9) *Expanding In-House Capabilities From Kronos to Early Career Initiative* [Conyers]
- 10) *Morpheus Engine Testing and Support of Tether and Free-Flights at JSC/KSC* [Guymon]
- 11) *Highlights of J-2X and RS-25 Engine Testing in the A-Complex* [Stein]

Other material distributed at the meeting:

Health Standards for Long Duration and Exploration Spaceflight – Ethics Principles, Responsibilities, and Decision Framework, Committee on Ethics Principles and Guidelines for Health Standards for Long Duration and Exploration Spaceflights, Board on Health Sciences Policy, Institute of Medicine of the National Academies [Kahn, Liverman, and McCoy, *Editors*].