National Aeronautics and Space Administration

Technology & Innovation Committee
of the
NASA Advisory Council

NASA Headquarters
Washington, DC

July 30, 2013

Meeting Minutes

G. M. Green, Executive Secretary

Charles M. Mountain, Acting Chair

William F. Ballhaus, Jr., Chair

Technology and Innovation Committee
NASA Advisory Council
NASA Headquarters
Washington, DC
July 30, 2013

Meeting Minutes

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Meeting Report prepared by
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Technology and Innovation Committee

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Welcome and Overview of Agenda/Logistics

The NASA Advisory Council (NAC) Technology and Innovation (T&I) Committee meeting was convened by Mr. G. M. (Mike) Green, Executive Secretary, who welcomed everyone to the meeting. He announced that the meeting was a Federal Advisory Committee Act (FACA) meeting open to the public, and he reviewed the agenda for the meeting. Logistics for the meeting were reviewed by Mr. Green. He announced that Dr. William Ballhaus, Committee Chair, was attending the meeting on-line and that other people may be attending the meeting via telecom. At Mr. Green's request, the Committee members and meeting visitors introduced themselves. Mr. Green noted that minutes from the last meeting have been sent out for the members' comments. He announced that after this meeting, the Office of Chief Technologist (OCT) will assume responsibility for providing support to the Committee, and Ms. Kathleen Gallagher will serve as the Committee's Executive Secretary. The Committee's charter will remain unchanged.

Opening Remarks and Thoughts

Mr. Green introduced Dr. Charles (Matt) Mountain, who would serve as the Chair for the meeting. Dr. Mountain suggested that everyone take note of the budget allocations. Dr. Ballhaus reiterated Dr. Mountain's suggestion and recalled that a cogent argument had been made previously on what would be a logical budgetary percentage for NASA to allocate for new technology. He suggested retrieving that information and updating the logic trail. Mr. Green distributed a spreadsheet on the pending authorization and appropriations legislation. He noted that the House bills were in the range of $16 billion, while the Senate Bills were in the range of $18 billion. Dr. Mason Peck, NASA Chief Technologist, explained that budgetary pressure is being felt throughout the Agency. He expressed concern that budgetary proposals could obliterate space technology, and he advised that the Space Technology Mission Directorate (STMD) would be well served if other NASA divisions, such as Space Launch Systems (SLS) and the Science Mission Directorate (SMD) advocated on its behalf. Dr. Erik Antonsson concurred with Dr. Peck's comments and suggested that distaste for the asteroid mission may be the key

reason some politicians wanted to reduce NASA's budget. Dr. Green reported that the recent "Technology Day" on the Hill event had been a success. Dr. Randall Correll explained that technology sells itself when there is proper outreach.

Space Technology Mission Directorate Update

Dr. Mountain introduced Dr. Michael Gazarik, Associate Administrator, STMD, who briefed the Committee on the Directorate's status and its progress since the Committee's meeting in April. They are seeing engineering units develop and they are seeing universities engage in the Space Technology programs. The previous week they sponsored Technology Day on the Hill. It was the most widely attended NASA event ever on the Hill. The budget uncertainty is the biggest challenge for 2014. The support from the community has been good, and there has been no negative feedback. Dr. Mountain asked how projects would be prioritized, given the budget challenges. Dr. Gazarik responded that the large Technology Demonstration Mission (TDM) projects drove the previous budget increases and will absorb the decline, through schedule delay or descoping. STMD will accept the risk that some projects that have started may not be completed. Dr. Peck observed that STMD has done an excellent job aligning the small business programs, Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR), with space technology objectives. Mr. David Neyland observed that the mandatory funding for SBIR/STTR masks the real budget that is available for technology development. In response to a question from Dr. Susan Ying, Dr. Gazarik concurred that the Program was looking at a "haircut," across all the TDMs. In response to concern expressed by Dr. Ballhaus, Dr. Gazarik explained that the Program has activities across STMD's four divisions.

Dr. Mary Ellen Weber requested an update on the status of robotics. Dr. Gazarik advised that Robonaut 2's (R2) legs would be sent to the International Space Station (ISS) in September, giving him more mobility.

Dr. Mountain asked what message the Program would like the NAC to hear. Dr. Gazarik responded that there is a need to reinforce the arguments on why STMD needs to stand alone; that this is the time to invest in technology; and that good investments have been made that need to be completed. Mr. Gordon Eichhorst counseled that lessons learned are that you should never stop pursuing support for the technology budget, and that there is always going to be a battle over who owns the technology budget. Dr. Peck noted that technology development is economically beneficial and has a high return on investment; however, reasoned articulation will not necessarily prevail. He asserted that it should be possible to rise above partisan politics and discuss technology's value to the nation and to NASA, without referring to the President's priorities. Dr. Gazarik

asserted that space technology is a non-partisan issue. Dr. Mountain recommended asking the NAC for suggestions on how to advocate on the Program's behalf. He would like the NAC to take the position that technology is important to the future of NASA and the nation. Dr. Correll added that the benefit is nonpolitical. Dr. Antonsson recommended making an argument that technology investment has a positive impact on jobs. Dr. Ying advised that technology investment also leads to improvements in competitiveness. She explained that in China, space technology is a high priority investment. Mountain observed that STP is taking a disproportionate "hit" in its budget compared to other programs at NASA.

Dr. Mountain thanked Dr. Gazarik for his comments.

Science Mission Directorate Technology Overview

Dr. Mountain introduced Dr. Timothy Van Sant, Chief Technologist, SMD. Dr. Van Sant explained that he is on SMD's senior staff and that the division directors are his peers, although only the division directors have responsibility for funds. Dr. Peck noted that Dr. Van Sant is SMD's technology strategist and has a role similar to the role that OCT has with NASA's Directorates. Dr. Van Sant noted that the SMD technology budget is sizable and runs in the hundreds of millions of dollars. Technology is managed at the SMD Division level and runs from Technology Readiness Level (TRL) 1 to flight hardware. SMD's technology investments are science-driven and responsive to the recommendations outlined in each division's respective Decadal report. The technology process emphasizes peer-reviewed competition, usually through the ROSES (Research Opportunities in Space and Earth Science) omnibus NASA Research Announcement (NRA). SMD has four divisions: Astrophysics, Planetary Science, Earth Science, and Heliophysics. Recent technology developments were described. Technology spending makes up approximately 15 percent of the Astrophysics budget. This does not include the James Webb Space Telescope (JWST). The Astrophysics Research and Analysis (APRA) program funds technology development in the earliest phases. The Strategic Astrophysics Technology (SAT) program matures technologies that address the needs of a specific future mission, taking them from the feasibility demonstration to a lab demonstration of a design that meets specific performance requirements (TRL 4 through 6). The final maturation stages (TRL 7 through 9) focus on proving the technology's flight-worthiness for a mission-specific application. The primary technology focus in astrophysics is in detectors. Current projects are the 16 megapixel H4RG-10 near-infrared (IR) detector array, the Technology Development Module, the Visible Nulling Coronagraph, and Advanced Starshade Technology.

In Planetary Science, the main interest is going to difficult-to-reach places that have nasty environments. Planetary Science technology investments are distributed across multiple programs and projects. In Earth Science, the overarching goal is to advance Earth system science, including climate studies, through space borne data acquisition, research and analysis, and predictive modeling. That division's major activities include: developing technologies to improve Earth observation capabilities; the Instrument Incubator Program; Advanced Component Technologies; Advanced Information Systems Technology; and In-Space Validation of Earth Science Technologies. Key technology challenges are in active remote-sensing technologies, large deployables, intelligent distributed systems, and information knowledge capture. The goal in Heliophysics is to understand the Sun and its interactions with the Earth and the solar system. The highest priority Heliophysics technology needs are identified and discussed in the 2012 Solar and Space Physics Decadal Survey. These include auroral and airglow imaging instruments, improved Lidar instrumentation, energetic neutral atom imagers, ultra-thin foils, and CubeSat subsystems. Dr. Peck noted that every mission directorate has CubeSats embedded in the mission development. He explained that CubeSats democratize science, augment portfolios, grow Principal Investigators (PIs), and teach NASA how to develop things cheaply and quickly. Components for CubeSats can be purchased off-the-shelf. Dr. Mountain asked whether SMD shares that enthusiasm. Dr. Van Sant counseled that there is a need for realism and that CubeSat performance has been mixed.

Dr. Ballhaus described serving on the Jet Propulsion Laboratory (JPL) Advisory Board and meeting with technologists who complained about spending too much time writing proposals. He asked whether this was a problem. Dr. Van Sant responded that writing a proposal is thrilling and that scientists "strut our stuff" by winning competitions. Dr. Mountain cautioned that very high oversubscription rates can be a disincentive. Dr. Van Sant suggested it would be sufficient to use fine-tuning to obtain the proposals that they are interested in evaluating. Dr. Peck advised that the competitive model is viable for getting the best ideas possible, and that it is up to JPL to decide how many proposals to submit. Dr. Ying questioned whether a two-step review process could be used to eliminate proposals early in the process. Dr. Van Sant responded that a two-step science process would be very elaborate. Dr. Antonsson noted that the asteroid initiative had not been discussed during the presentation. Dr. Peck explained that the asteroid initiative accounts for only $20 million within SMD's budget, and he opined that the asteroid initiative is receiving disproportionate attention.

Dr. Mountain thanked Dr. Van Sant for his presentation.

Technology Demonstration Missions Program Update/Green Propellant Infusion Mission

Dr. Mountain introduced Dr. Randy Lillard, Program Executive for TDM. Dr. Lillard noted that TDM's mission statement is "Infusing revolutionary, crosscutting technologies to benefit NASA and the Nation." He presented charts on TDM's major events, milestones and portfolio. Dr. Lillard discussed several TDM projects. The Green Propellant Infusion Mission (GPIM) in the TDM portfolio was described. The mission will be a spaceflight demonstrating a complete propulsion system for spacecraft attitude control and primary propulsion using the "Green Propellant," AF-M315E, developed by the Air Force Research Laboratory (AFRL) as a substitute to hydrazine. Using AF-M315E will significantly reduce the safety restrictions and complexities placed on hydrazine operations, while substantially increasing performance. The propellant is an ionic salt blend of HAN (Hydroxylammonium Nitrate) solid oxidizer with water and a compatible fuel. It is less toxic than caffeine and provides a greater than 50 percent improvement in volumetric performance over hydrazine. A slide was presented on Hall thruster development. Several slides were presented on the development of telerobotics for human operations. The Sunjammer mission was described. It is the demonstration of a mission infusible solar sail. Dr. Lillard described the Low Density Supersonic Decelerator (LDSD). It is intended to enable a new class of planetary entry vehicles, with improvements over the Mars Surface Laboratory (MSL) by allowing a one metric ton increase in landed mass, a 25 percent increase in elevation, and a three times reduction in the landing ellipse. Charts were shown on the project's component milestones and the plans for a LDSD flight test to be conducted soon in Hawaii. A brief movie was shown on a rocket sled test at China Lake.

Dr. Dava Newman asked how TDM projects align with the space technology roadmaps. Dr. Lillard responded that the TDM projects all align with and cover nine of the 14 roadmaps. Some roadmaps have not been worked on due to declining budgets. Dr. Peck added that the roadmaps are Agency-wide, and that there is not a requirement for TDM to cover each roadmap.

Dr. Mountain thanked Dr. Lillard for his presentation.

The meeting was recessed.

Overview of Space Technology Role in Asteroid Retrieval Mission

The meeting was reconvened in Room 9H40 for a joint session with the Human Exploration and Operations (HEO) Committee. The meeting was chaired by Mr. Richard

Kohrs, Chair, HEO Committee. At Mr. Kohr's request, the HEO Committee members and the T&I Committee members introduced themselves. Mr. Kohrs explained that he had requested the joint session due to the interest spurred at the last HEO Committee meeting regarding the Asteroid Retrieval Mission. Dr. Mountain noted that he wanted to understand how the Asteroid mission relates to the Space Technology Investment Plan (STIP). Dr. Ballhaus explained that the T&I Committee interest in this presentation was: (1) to understand the rationale behind the mission; and (2) to understand what the technology "long-poles" are and what the "pull" would be on the technology program. Mr. Kohrs advised that the technology long-pole is Solar Electric Propulsion (SEP) technology.

Dr. James Reuther, Deputy Associate Administrator for Programs for the STMD, was introduced by Mr. Kohrs. He described STMD and its role in the Asteroid Mission, and he discussed how STMD supports the plans for NASA's horizon target—Mars' surface. STMD wants to enable a new class of missions and deliver innovative solutions that dramatically improve technologies and affordability for NASA missions. In addition STMD wants to contribute to creating new marketplaces and spurring innovation. Dr. Reuther explained that the challenges for deep space exploration have not changed in the past 20 to 30 years. NASA has been involved in many studies on what would be required for deep space exploration. In the area of communications, higher bandwidth is needed; in terms of Environmental Control and Life Support Systems (ECLSS), the current capabilities on the ISS will not be practical for deep space missions. Reasonable solutions to radiation problems are needed. The propulsion technology roadmap shows technology hurdles; NASA has made very little progress in terms of high-powered SEP or a nuclear propulsion capability.

Dr. Reuther described recent trends. They include the new paradigm of small spacecraft (e.g., CubeSats), robotics that interact with and support people (e.g., R2 on ISS), additive manufacturing and transition to composites (e.g., the SLS future upper stage), entry, descent and landing (EDL), propulsion, and communications.

STMD has several key principles that guide strategy. The Space Technology programs follow the NASA Strategic Plan and the NASA Space Technology Roadmaps. STMD developed the roadmaps and a National Research Council (NRC) report has prioritized them. STMD is using the NRC report to set priorities and justify investments for the future. STMD invests in a comprehensive portfolio, spread across the entire TRL spectrum. A low-TRL project can be a nine-month study, while a high-TRL project can stretch over seven years. STMD generally uses a competition-based model to select its portfolio. At the lower TRLs, almost all the projects are competed; at a higher TRL, a project may be directed to where NASA has a workforce attuned to that job. NASA no

longer engages in open-ended research projects. All projects have fixed start dates, fixed end dates, milestones, and a budget. If progress is not being made, STMD will stop the project and invest elsewhere. The philosophy is “infuse rapidly or fail fast.” The goal is to get NASA back to the cutting edge of technology. Mr. Bohdan (Bo) Bejmuk asked whether the guiding principles include collaboration with industry. Dr. Reuther responded that while collaboration is not expressly listed as a guiding principle, it is embedded in everything STMD does.

Dr. Reuther described the nine program areas in STMD. In TDM, there must be a contribution from another entity. The collaboration there is built into the solicitation. Game Changing projects tend to be partnered with other government agencies. The Exploration Technology Development Program (ETDP) is focused on human exploration initiatives. Low-TRL developments include NASA Innovative Advanced Concepts (NIAC), the Center Innovation Fund (CIF) (a grass-roots development at the Centers to bring about a culture of innovation), and Space Technology Research Grants (grants to universities that are working on space technologies applicable to NASA). For developing new marketplaces, STMD has Centennial Challenges, SBIR/SBTT, and the Flight Opportunities Program. Centennial Challenges motivates new participants into the aerospace domain. The Flight Opportunities Program is using suborbital platforms for an integrated marketplace. Cryogenic Propellant Storage and Transfer (CPST) is a $400 million, seven-year lifecycle demonstration project. It is a key capability needed for human exploration. STMD’s “big nine” projects are the cost drivers in its budget. They are high profile and receive a lot of press attention. The other large elements of the budget are the workforce and SBIR/SBTT. Several flight demonstrations have already occurred, such as Robonaut in 2012. The SEP demo and CPST demo are further out in the timeline.

Dr. Reuther discussed the Asteroid Initiative. It is the first-ever mission to capture and redirect an asteroid to Earth-Moon space. NASA will also lead a “Grand Challenge” to find all asteroid threats to human populations and figure out what to do about them. The Grand Challenge goal is to develop a mitigation strategy in the event there is an asteroid that poses a threat. The Asteroid Mission and the Grand Challenge are collectively referred to as “the Asteroid Initiative.” The Asteroid Mission has three elements: detection and characterization of candidate asteroids (filling needs for both the Grand Challenge and the Mission), asteroid capture and redirection, and a human mission. For the Asteroid Mission, Space Technology will focus on high-powered SEP. This would be used for asteroid rendezvous and redirection, not the human mission. However, SEP would also enable deep space exploration. SEP is being used today for satellite station-keeping and transfer orbits, but neither is considered “high-power.” The maximum power demonstrated today has been 15kW per thruster. Any deep space

mission beyond cis-lunar space in terms of months would be hugely leveraged by a human-class SEP system. The STMD goal is to demonstrate extensive SEP technology at 30-50kW of power that could be extended to higher powers.

The robotic asteroid rendezvous and redirection mission cannot be accomplished without SEP. In response to a question about the mission's cost, Dr. Reuther explained that the mission feasibility review is evaluating the cost and that a prior study had estimated $2.5 billion for the robotic mission. It now appears that the cost would be about half that, but this is very preliminary.

Dr. Reuther discussed the timeline. There should be a final target selection by 2016. A SEP-powered robotic mission could be launched in 2017-2018. That would be followed with an Orion mission, probably Exploration Mission (EM)-3. By the EM-3 and EM-4 timeframe, the Agency will need some additional objectives. Based on current projections, NASA does not have the budget to do any other mission in 2022-2023. The ARM happens in the right timeframe and provides an affordable target when NASA only has Orion and SLS as exploration assets.

Dr. Reuther discussed STMD's role in the Agency asteroid strategy. Early-stage programs will foster innovation in asteroid detection and mitigation/defense, and asteroid proximity operations. Game Changing will complete high power SEP technology development as a precursor to doing an SEP demonstration of 30 to 50kW-class solar arrays. ARM's FY2014 budget includes funding to cover flight hardware solar array procurements and electric propulsion thruster engineering development units. The Centers primarily involved are Glenn Research Center (GRC) and the JPL. These Centers have expertise and ongoing work in SEP. In terms of square footage, today's largest geocom satellites (advanced geocoms) can be sized up to 25kW per wing. The arrays can be up to 100 feet long and six feet wide. They are solid panel, fold-out arrays. What is different about the NASA demonstration is the packaging—the arrays will store in one-third the volume of the current arrays and are one-half the mass, which is non-trivial. Geocom is very interested in the larger power levels.

In response to a question, Dr. Reuther noted that the asteroids that NASA is considering as potential targets for the Asteroid Mission are near-Earth, with orbits similar to Earth. The delta-v to Earth must be relatively small: 2 k/sec or less. These are asteroids that fly by Earth more than once.

There are two vendors for high-powered solar arrays: Deployable Space Systems (DSS) and Alliant Techsystems Inc. (ATK). The ATK array technology was baselined on the Mars Phoenix mission. It has been demonstrated on many occasions, but the size is

larger than anything in the past. The rollout arrays can be done by Z-folding or with a blanket technology. In terms of the thruster units, the real breakthrough in Hall thruster technology was in magnetic shielding. We have analytical models that will predict the right shade to minimize metallic erosion. The next generation of Hall thrusters should have almost unlimited capability. In terms of tanks, new Xenon tanks are needed to carry the Xenon propellant for the mission.

The Naval Research Laboratory (NRL) and the Defense Advanced Research Projects Agency (DARPA) are interested in SEP. SEP is great for orbital debris removal. Satellite servicing is another application. There are many science mission applications that can use SEP.

To date, the Advanced Extremely High Frequency (AEHF) satellites have the largest SEP. They are in the 16kW class and can fire two thrusters at a time. The ARM will have 50kW and Hall thrusters. Exploration missions in the 2030s will have 300kW SEP.

Dr. Reuther discussed the synergy between STMD and HEO Mission Directorate (HEOMD). STMD does not do systems-level development; it transfers technology projects at TRL 6. The Advanced Explorations Systems (AES) program is the place within HEOMD where the technology systems work is infused. STMD also works with the HEOMD Human Research Program (HRP) for radiation mitigation.

The ARM will help NASA develop SEP for cargo/logistics, deep space Guidance, Navigation and Control (GNC), crew operations beyond low-Earth orbit (LEO) (Orion), crew return from beyond LEO–HS entry (Orion), and heavy lift to beyond LEO (SLS). The first two are STMD/ ETDP and HEOMD/AES investments; the latter three are joint HEOMD/Exploration Systems Development (ESD)/AES investments. Dr. Reuther described the infusion of Game Changing and TDM technologies into ETDP.

In response to a comment from Mr. Kohrs, Dr. Reuther concurred that for SEP at 40-50 kW and six metric tons Xenon, the mission could launch on an Atlas vehicle and spiral out. However, for 12 metric tons Xenon without the spiral out, the mission would need to go on SLS. With SEP and a range of launch vehicles, there is no need to wait for a specific launch window for a near-Earth object (NEO).

Mr. Kohrs thanked Dr. Reuther for his presentation. The meeting was recessed. The T&I Committee reconvened in MIC 5A.

Chief Technologist Update and Update on Agency Grand Challenge

Dr. Mountain introduced Dr. Mason Peck, Chief Technologist, NASA OCT. Dr. Peck offered to address any topic that interested the Committee. Dr. Mountain noted that the Committee's charter had recently been revised to include information technologies (IT). Dr. Peck explained that all new technology is within OCT's charter and, by implication, is also within the Committee's charter. There is some overlap between OCT and NASA's Office of Information Technology (OIT). OCT cares about IT, while OIT manages it.

Dr. Mountain requested an update on the initiative to establish a Foundational Engineering Science (FES) program. Dr. Peck explained that the Committee's recommendations in support of this program have been very valuable and were adopted by the NAC. He expects something to be proposed by the Administrator, acting on the advice of the Chief Technologist, Chief Scientist, and Chief Engineer, for the 2015 budget. The purpose for the program would be to nurture NASA's basic engineering science enterprise. That would be pre-TRL work where fundamental questions are asked about what nature will allow us to do. There is no organization that provides support for this and there are no longer funds for this within the Centers. The program will bring NASA together with universities and other government labs. It response to a question from Dr. Antonsson, Dr. Peck reported that while the Administrator and the Centers recognized the need for the program, the response from the Mission Directorates has been lukewarm. In response to a question from Mr. Eichhorst, Dr. Peck reported that steps have not been taken to find support for the program from other government agencies. He believes it would be difficult in the current environment to find an advocate.

Dr. Peck described technology across NASA. The STMD is the flagship for NASA technology and balances push with pull. The portfolio has a large Aeronautics and IT component. There is a technical relationship with SMD. Dr. Mountain noted that SMD is preparing thirty-year roadmaps. Dr. Peck explained that he expects a better engagement from SMD in developing the next generation of roadmaps, and that the new roadmaps will include IT. He noted that as Chief Technologist he cares about all technology investment that is being made within the Mission Directorates, but it is hard to coordinate it all. The overall total for technology spending in the Agency is approximately $1.5 billion. One helpful tool is the "Techport" database, which is used throughout the Agency to report technology expenditures.

Dr. Peck described the Asteroid Initiative and the Grand Challenge. The purpose of the Grand Challenge is to find all asteroid threats to human populations and know what to

do about them. The Grand Challenge has five segments: detection, tracking, characterization, mitigation, and communication. In response to a question, Dr. Peck explained that pursuant to international treaty, celestial bodies may not be used for commercial purposes. In response to a question from Dr. Correll, Dr. Peck asserted that DoD and NASA can collaborate in orbital debris mitigation. He noted that whether an asteroid could be considered debris is a question that is open to debate. In response to a question from Dr. Ying, Dr. Peck reported that Russia is not interested in participating in this effort for free.

Dr. Ballhaus noted that the Committee had previously recommended setting aside or fencing off a budget for technology, and that the percentage of the budget attributed to technology was unknown at that time. The budgets for the SBIR/STTR programs are now combined with the budgets for STMD's technology programs. This has a disadvantage from an optics standpoint because it creates the appearance that STMD has more discretionary funds for technology than are actually in its budget. He observed that Dr. Gazarik is doing a great job making sure that the funds spent in the SBIR/STTR programs are aligned with STMD's interests in technology. Dr. Antonsson noted that technology activities in the past had been hidden in budgets, and that doing so was unproductive. He expressed concern that those activities once again would become hidden in a budget constrained era. Dr. Peck concurred that there is concern in the Mission Directorates that STMD or OCT might attempt to take their technology budgets away or tell them what to do.

Dr. Mountain thanked Dr. Peck for his presentation.

Update on NASA Commercial Spaceflight Status

Dr. Mountain introduced Mr. Phil McAlister, Director, Commercial Spaceflight Development Division, HEOMD. He discussed the status of Commercial Cargo, Commercial Crew, and the Certification Products Contracts (CPCs). SpaceX successfully completed the last milestone in its Commercial Orbital Transportation Services (COTS) contract in May 2012, and has started resupply flights to the ISS. Orbital Sciences successfully completed a maiden test flight of its Antares rocket in April 2013, from the Mid-Atlantic Regional Spaceport. Orbital is ready for its final COTS milestone: the COTS demonstration mission to the ISS, which is scheduled for Sep 14-19, 2013. Mr. McAlister explained that the Commercial Cargo program was supposed to facilitate U.S. private industry demonstration of cargo space transportation capabilities with the goal of achieving safe, reliable, cost effective access to LEO. The program produced two new low-cost U.S. launch vehicles, two new spacecraft able to carry cargo to and from the ISS, and two new privately developed launch facilities. Dr.

Mountain observed that there is to be no recovery of the $800 million that NASA spent on this program. Mr. McAllister noted that Falcon and Antares are now available for the SMD and that Falcon is creating a competitive threat to Arianne.

Mr. McAlister presented a chart showing the Commercial Crew Program (CCP) roadmap and discussed the Commercial Crew integrated Capability (CCiCap) contracts. NASA awarded these Space Act Agreements (SAAs) to three partners: Boeing, Sierra Nevada, and SpaceX. Each partner is doing very well in CCiCAP, and the program is starting to mature. Boeing has successfully completed 8 of 19 milestones to date. Sierra Nevada has completed 5 of 9 milestones. SpaceX has completed 6 of 14 CCiCAP milestones. The advantage to using SAAs is that the partners can move very fast in the development phase. They just have to meet milestones and do not have to come to NASA to approve changes.

Simultaneous with the SAAs, the partners are working under CPCs to deliver early-lifecycle certification products, which allow each partner to propose their standards to be evaluated by NASA. CPCs are fixed-price contracts with defined deliverables and are used because SAAs are inappropriate where certifications are required. Dr. Ballhaus asked whether the standards will be incorporated into future contracts and whether the standards can change over time. Mr. McAlister responded that there is a requirement for NASA to approve changes in the standards and that they will be captured under some legal mechanism. Commercial Crew Transportation Capability (CCtCAP) is the next phase (Phase 2). It will cover all aspects for developing and certifying a crew transportation system, including design, manufacturing, testing, qualification, production, and operation. The draft Request for Proposal (RFP) for CCtCAP was released on July 19. Mr. McAlister explained that prematurely eliminating competition is one of the primary risks to satisfying the goals and objectives of the program.

NASA Administrator Charles Bolden joined the meeting and noted that a SAA might be used to get things started if there is commercial interest in human exploration beyond LEO. The service would have to be obtained, however, through a Federal Acquisition Regulation (FAR) contract. He explained that SAAs are being used because we need to get our crews to the ISS. He cautioned that the longer it takes to come out from SAAs, the longer it would take to get crew to the ISS, and that more destinations are needed than just the Station or the program would not survive. Dr. Mountain commended Mr. Bolden for adopting this flexible approach. Mr. McAlister concurred that there has to be some potential for non-government customers because it would be hard for the partnership model to work when the government is the only customer.

Mr. McAlister discussed the collaboration synopsis. A chart entitled “Genesis of Collaborations Synopsis” was presented. It stated that the U.S. National Space Policy 2010 goals were to energize competitive domestic industries and to actively explore the use of inventive, non-traditional arrangements. The chart indicated that Commercial Crew partners have requested over 1,000 existing NASA documents, data, and test results. It also asserted that NASA needs a better understanding of commercial space capabilities to inform NASA’S deep space architecture.

Dr. Mountain thanked Mr. Bolden for his comments and thanked Mr. McAlister for his presentation.

NASA Aeronautics Program Overview and Update

Dr. Mountain introduced Mr. Robert Pearce, Director for Strategy, Aeronautics Research Mission Directorate (ARMD). Mr. Pearce began his presentation by presenting a slide with a quote from Ms. Marion Blakey, Chair, NAC Aeronautics Committee: “ARMD provides critical support to our nation’s Aeronautics research efforts. They have a strong track record of leading complex, collaborative research with multiple federal agencies, academic, government labs, and industry.” Slides demonstrating the importance of aeronautics research were presented. Aviation accounts for $1.3 trillion in the U.S. economy and 5.2 percent of U.S. Gross Domestic Product. Charts were presented to illustrate benefits in Aeronautics from NASA. A chart was presented showing five ARMD programs: Fundamental Aeronautics Program, Integrated Systems Research Program, Airspace Systems Program, Aviation Safety Program, and Aeronautics Test Program.

Mr. Pierce discussed the ARMD Strategic Implementation Plan, and he described four important strategic trends: economic growth in China and India; worldwide urbanization; middle-class growth in China and India; and accelerated technology development. He explained that these trends create three aviation “mega-drivers” which are: global growth in demand for high-speed mobility; global climate change, sustainability and energy transition; and technology convergence. The International Air Transport Association (IATA) predicts that by 2050, annual air-traffic will have grown to 16 billion passengers. Escalating fuel prices have a large impact on aviation. According to the IATA, fuel is the only major cost item in aviation that has become significantly larger over time. Four strategies for reducing transportation-related greenhouse gas emissions were discussed: reduce the total volume of transportation activity; shift transportation activity to modes that emit less greenhouse gas; increase the energy efficiency of each mode of transportation activity; and reduce the greenhouse gas emissions associated with the use of each unit of energy.

The ARMD Strategic response to the three mega-drivers is found in six strategic research and technology thrusts: safe, efficient growth in global operations; innovation in commercial supersonic aircraft; ultra-efficient commercial transports; transition to low-carbon propulsion; real-time system-wide safety assurance; and assured autonomy for aviation transformation. A chart was presented showing the vision: "A Revolution in Sustainable, High Speed Global Mobility." Mr. Pierce described ARMD's strategic management actions since 2008: reorganized programs and strengthened technology transfer; established top-down strategy and systems analysis; strengthened interest and partnership with the aviation community; and instituted high-TRL integrated systems research and seeding fund. The objectives for the next steps in strategic management are: pursue innovative solutions aligned to the strategic thrusts; incentivize multi-disciplinary "conversion" research; and enable greater workforce and institutional agility and flexibility. The objectives will be accomplished through the following actions:

- Improve Seeding Fund based on lessons learned and add Challenge Prize to promote focus, excitement, and action on innovative solutions to the critical problems aligned with the Strategic Thrusts;
- Develop an initiative to organize universities around ground-breaking research directed toward critical problems aligned with the Strategic Thrusts;
- Incentivize use of innovative approaches to research, such as Open Source Development and more Agile Flight Research;
- Expand partnerships beyond traditional aeronautics industry to capture leverage from energy innovation, autonomy, and other fast developing technologies; and
- Continue to work with the Agency to evolve and transform Agency aeronautics capabilities.

Charts were presented on ARMD's relationship to the NASA Strategic Space Technology Investment Plan (SSTIP), on ARMD's efforts in hypersonics, and on promising areas of planned collaboration between ARMD and STMD. Dr. Antonsson noted that on the space side of the agenda there is only an infant commercial environment; he advised that there may be useful lessons to be derived from ARMD and its more mature relationship with commercial entities. Dr. Yang asked whether there has been an analysis with the European Union investments on framework programs, to which Mr. Pierce responded that there has been none. Dr. Mountain asked whether the "technology shelf" has been depleted due to lack of investment. Mr. Pierce responded in the affirmative.

Dr. Mountain thanked Mr. Pearce for his presentation.

Committee Support Reorganization

Dr. Mountain reintroduced Dr. Peck to discuss the reorganization and the support that NASA is providing to the Committee. Dr. Peck explained that Mr. Bolden wants the Committee to serve the interests of the Agency's entire technology enterprise. For that reason, the responsibility for providing support to the Committee will be shifted from STMD to OCT. This is not intended to minimize the value that STMD provides to the Agency. Dr. Antonsson asserted that having the Committee be assigned to OCT will strengthen OCT's role in providing guidance to the Agency. Dr. Peck concurred and added that the Committee would still hear from STMD and Dr. Gazarik in future meetings. He advised that there is a need for the Committee to look more at innovation. Mr. Neyland recommended that the Committee visit the various NASA Centers. Dr. Newman concurred. Mr. Green explained that the budget prevented that from happening at this time. Dr. Antonsson counseled that it is important to get out in the field and see what people are doing.

Dr. Mountain thanked Dr. Peck for his comments.

Discussion and Recommendations

Mr. Green reviewed the spreadsheet on proposed legislation for NASA's budgetary authorizations and appropriations. Dr. Mountain observed that the spreadsheet shows a large cut for space technology. Dr. Weber noted that the Committee's past recommendation for technology to receive a fixed percentage of NASA's budget would get nowhere in the current environment. She advised that since the SBIR/STTR budget is going to be held harmless, it should be a separate line item; she believes that NASA should clearly identify the discretionary portion of STMD's budget. Ms. Gallagher cautioned against moving SBIR/STTR into a separate line item. Dr. Ballhaus noted that some programs are relying on the development of technology, and he suggested that an impact statement be developed. He advised that for the STP to be successful, it needs the other Mission Directorates to advocate for STMD. Dr. Ballhaus explained that the university and SBIR/STTR communities should be the Program's advocates; however, they are not well organized. Dr. Mountain asserted it is necessary to make a clear statement to the NAC that STMD is being made overly vulnerable to cuts due to its structure, and that the nature of the cuts will adversely impact programs in other areas. Dr. Newman opposed any recommendation that supports the asteroid mission. She asserted that sending humans to an asteroid has no credibility or justification. Mr. Eichhorst advised that the STP should either be properly funded or dismantled completely. In response to a suggestion by Dr. Ballhaus, Mr. Green advised that the law does not allow taking a proportionate share from the SBIR/STTR budget. Mr. Eichhorst

asserted that the realizations that led to creating OCT have been ignored, and that it would have been better not to have created it.

Dr. Mountain suggested complimenting ARMD on its innovative models and noting that ARMD's technology shelf has been depleted. Dr. Newman suggested complimenting the close working relationship between ARMD and STMD. Dr. Antonsson noted that there is a vibrant commercial aircraft industry, and he cautioned that an argument could be made that the industry should be responsible for doing its own research and development.

Dr. Antonsson recommended acknowledging Dr. Peck for his superb work in navigating the politics and keeping the Program properly focused. Dr. Ballhaus concurred and suggested complimenting both Dr. Peck and Dr. Gazarik for their tremendous job in selling the importance of the space technology program.

Adjournment

Dr. Mountain adjourned the meeting at 5:08 p.m.

Agenda

NAC Technology and Innovation Committee Meeting
July 30, 2013
NASA Headquarters
MIC 5A

July 30, 2013 – FACA Open Meeting

8:00 a.m.	Welcome and overview of agenda/logistics (FACA Session – Public meeting) Mike Green, Executive Secretary
8:05 a.m.	Opening Remarks and Thoughts Dr. William Ballhaus, Chair
8:15 a.m.	Space Technology Mission Directorate Update Dr. Michael Gazarik, Associate Administrator, STMD
9:00 a.m.	Science Mission Directorate Technology Overview Dr. Timothy Van Sant, Chief Technologist, SMD
9:45 a.m.	Cryogenic Propellant Storage and Transfer (CPST) Update Ms. Susan Motil, CPST Project Manager, NASA Glenn Research Center

Recess meeting @ ~10:55 a.m in MIC 5A move to 9H40 for one-hour joint meeting with Human Exploration and Operations Committee

11:00 a.m.	Overview of Space Technology Role in Asteroid Retrieval Mission Dr. James Reuther, Deputy AA for Programs, STMD
12:00 p.m.	Lunch Break
1:00 p.m.	Reconvene T&I Meeting in MIC 5A
1:00 p.m.	Chief Technologist Update and update on Agency Grand Challenge Dr. Mason Peck, NASA Chief Technologist
2:00 p.m.	Update on NASA Commercial Spaceflight Status Mr. Phil McAlister, Director, Commercial Spaceflight Development, NASA HEOMD
3:00 p.m.	NASA Aeronautics Program Overview and Update Mr. Robert Pearce, Director for Strategy, ARMD
4:00 p.m.	Discussion and Recommendations
5:00 p.m.	Adjournment

NAC Technology and Innovation Committee Membership
[Updated 11/1/12]

Dr. William (Bill) F. Ballhaus, Jr., Chair	[retired]
Mr. G.M. (Mike) Green, Executive Secretary	NASA Headquarters
Dr. Erik Antonsson	Northrop Grumman Aerospace Systems Corporation
Dr. Randall Correll	Consultant
Mr. Gordon Eichhorst	Aperios Partners LLP
Dr. Charles (Matt) Mountain	Space Telescope Science Institute
Dr. Dava Newman	Massachusetts Institute of Technology
Mr. David Neyland	Office of Naval Research – Global
Dr. Mary Ellen Weber	STELLAR Strategies LLC
Dr. Susan X. Ying	The Boeing Company

NAC Technology and Innovation Committee
NASA Headquarters
Washington, DC
July 30, 2013

MEETING ATTENDEES

T&I Committee Members:

Ballhaus, William (Bill) – Chair *(online)*	*[Retired – not affiliated]*
Mountain, Charles (Matt) – Acting Chair	Space Telescope Science Institute
Green, G.M. (Mike) – Executive Secretary	NASA Headquarters
Antonsson, Erik	Northrup Grumman Aerospace Systems
Correll, Randall	*[Consultant – not affiliated]*
Eichhorst, Gordon	Aperios Partners LLP
Newman, Dava	Massachusetts Institute of Technology
Neyland, David	Office of Naval Research – Global
Weber, Mary Ellen	STELLAR Strategies, LLC
Ying, Susan	The Boeing Company

HEO Committee Members Attending Joint Session:

Kohrs, Richard, *Chair*	*[former Director, Space Station Freedom]*
Bejmuk, Bohdan, *Co-Chair*	*[former Shuttle Program Director, Boeing]*
Siegel, Bette, *Executive Secretary*	NASA Headquarters
Budden, Nancy Ann	Office of Secretary of Defense
Chiao, Leroy	*[former ISS Commander]*
Condon, Stephen "Pat"	*[former Commander, Ogden Air Logistics]*
Cuzzupoli, Joseph	*[former Apollo Program Manager, Rockwell]*
Longnecker, David	NAS/Institute of Medicine
Malow, Richard (telecom)	AURA
Odom, James	*[former AA, Space Station Freedom]*
Sieck, Bob	*[former Space Shuttle Launch Director]*

NASA Attendees:

Baker, Robert	NASA Headquarters
Bolden, Charles	NASA Headquarters
Gallagher, Kathleen	NASA Headquarters
Gazarik, Michael	NASA Headquarters
Klumpar, David	NASA Headquarters

Lillard, Randy	NASA Headquarters
McAlister, Philip	NASA Headquarters
Pearce, Bob	NASA Headquarters
Peck, Mason	NASA Headquarters
Rasco, Dorothy	NASA Headquarters
Saurbrunno, Rita	NASA Headquarters
Smith, Greg	NASA JSC
Steitz, Dave	NASA Headquarters
Stilson, Stephanie	NASA Headquarters
Van Sant, Tim	NASA Headquarters

Other Attendees:

Cohen, Ben	Commercial Spaceflight Federation
DiBiasi, Lamont	Southwest Research Institute
Frankel, David	P B Frankel LLC
Marsh, Celinda	OMB
Smith, Mike	Booz-Allen
Squyres, Steven	NAC
Terrell, Kim	KIMS

NAC Technology and Innovation Committee
NASA Headquarters
Washington, DC
July 30, 2013

LIST OF PRESENTATION MATERIAL

1) SMD Technology Development [Van Sant]
2) Technology Demonstration Missions Program [Lillard]
3) Space Technology Mission Directorate Briefing [Reuther]
4) NAC T&I Committee: OCT Update [Peck]
5) Commercial Cargo and Crew Update [McAlister]
6) NASA's Aeronautics Research Strategy [Pearce]

Other material distributed at the meeting:

1) Authorization and Appropriations Levels [Green]