National Aeronautics and Space Administration

Technology, Innovation, & Engineering Committee
of the
NASA Advisory Council

NASA Headquarters
Washington, DC
April 7, 2015

Meeting Minutes

G. Michael Green, Executive Secretary	**William F. Ballhaus, Jr., Chair**

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TABLE OF CONTENTS

Meeting Report prepared by
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Welcome and Overview of Agenda/Logistics

Mr. G. Michael Green, Executive Secretary of the NASA Advisory Council (NAC) Technology, Innovation, and Engineering (TI&E) Committee, opened the meeting with a review of the agenda. There have been some leadership changes at NASA. Mr. Steve Jurczyk has been named the new Associate Administrator (AA) of the Space Technology Mission Directorate (STMD). Mr. Dennis Andrucyk is the new Deputy AA of STMD.

Opening Remarks and Thoughts

Dr. William Ballhaus, TI&E Chair, welcomed the Committee members. He reported that at the last NAC meeting, the NAC carried forward the TI&E recommendation regarding the need for a hydrocarbon engine.

Space Technology Mission Directorate FY 2016 Budget Request and Update

Dr. James Reuther, Deputy AA for Programs, STMD, provided an overview of STMD activities. STMD successes to date include development of deployable solar arrays, which have been produced with less mass and volume at a lower cost. STMD has also tested a composite cryogenic propellant tank and International Space Station (ISS) technology test beds. Current work involves testing advanced Hall thrusters and the CPUs to go with them, as well as extra-vehicular activity (EVA) suits and the technologies needed to use smaller spacecraft. STMD continues work on entry, descent, and landing (EDL) technologies. Efforts pointed toward the future include green propellant infusion, deep space optical communications, solar electric propulsion (SEP), a flight demonstration for the Deep Space Atomic Clock (DSAC), and further demonstrations on ISS.

Budget

The President's budget request (PBR) for fiscal year 2016 (FY16) includes $725 million for STMD. The actual appropriations in recent years have been closer to $600 million. That gap makes a huge difference in the Directorate's ability to execute. The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) expenses are incurred regardless of the STMD bottom line and take an increasing percentage of the overall STMD budget. This limits the Directorate's ability to grow its technology development portfolio, as civil servant full-time employees (FTEs) costs go up as well and are also built into the budget, so STMD's purchasing power is affected.

Dr. Ballhaus observed that the budget cuts affect STMD's ability to move forward on its plan. He heard the university program was cut back. He asked about the most compelling arguments, the pull, and what was urgent. Dr. Reuther said that STMD, unlike the other mission directorates, does not have associated centers. Instead, STMD work has about equal distribution across all 10 centers. The investments are largely proportional, much of the work he discussed is done in partnership with industry, and the Directorate is trying to serve the needs of the Agency as a whole. This lack of concentrated constituencies makes things more challenging. On the other hand, STMD is always trying to strike a balance. He did not see how STMD could maintain the status quo and stay a true technology organization.

If NASA is going to put people on Mars and bring them back safely, there will need to be a lot of technology work in areas like EDL. The technology investments NASA is making today, compared to the investments that a Mars mission needs, are insufficient. STMD has made tremendous progress in understanding what is necessary and where to invest. STMD is not slowing NASA down; it could build a habitat for Mars today except the development costs do not exist in the budget.

Dr. Matt Mountain observed that the pressure in this appropriations round is enormous. He believed the PBR for STMD was optimistic without a breakout strategy by which STMD can convince Congress that this level of funding is essential. The lack of a credible Agency plan is the problem for technology. Dr. Reuther explained that the Agency as a whole received more than it sought in the last round of appropriations, and that the current PBR is a small increase. In addition, Congress has been open to supporting NASA. In a very strict budget scenario, however, STMD must have a strategy for a flat budget. The last 2 years, the Directorate has planned for $600 million. The list is 20-30 deep of $5-10 million technologies that are ready to go and that industry or the centers want to do. STMD will be able to maintain its current path if it receives $600 million.

SBIR/STTR Funding

Dr. Reuther explained that SBIR/STTR technologies are selected by the mission directorates. STMD solicits their topics and the mission directorates evaluate the resulting proposals. So even though this activity is parked in STMD, the content goes elsewhere. Another strategy then would be to split this amongst the other mission directorates instead of it all being in STMD. STMD does use SBIR/STTR monies for some of its own projects, but those funds are not available for mid-technology readiness level (TRL) work. There are other small programs with mandates as well. Fewer mandated programs would allow STMD to adjust its content more easily, and STMD management would like to go to portfolios, possibly broken out by mid-TRL, high TRL, and early stage.

STMD needs to be careful here, because some stakeholders are highly invested, but TI&E could ask why the budget for SBIR/STTR comes entirely from STMD. Dr. Ballhaus noted that this idea went to the NAC a couple of years ago, with the explanation that this is a de facto cut for STMD. Dr. Reuther said that it squeezes discretionary spending, as it all comes out of STMD procurement. It will impede STMD's ability to move technology forward. The other mission directorates would not like having to pay for this, but their content indicates that they should pay. Dr. Ballhaus added that the top level argument is that the Administrator bought into having STMD, and the NAC has agreed that there should be a separate technology program. The question is whether NASA still wants it separate. If technology development goes to the mission directorates, it dissipates, however.

Dr. Reuther noted that in the early years, STMD struggled with Congress to explain the Directorate's existence. The House in particular did not support STMD. Now, however, both the House and the Senate support the separate program, and there are stakeholders saying that NASA needs a separate technology program. Dr. Ballhaus said that what needs to be shown is that STMD is not realizing what was intended. Mr. James Oschmann advised caution in promoting any change, stating that STMD needs the support of the other mission directorates.

Dr. Mary Ellen Weber asked about the funding impact of moving SBIR/STTR to the other mission directorates, specifically the percentage of their overall budgets. They are better able to absorb the increases. Without that data, they would balk at funding their portions, but if they saw that it was small for them but large for STMD, it could bring them around. Dr. Weber advised Dr. Reuther to change his budget chart to show the space technology research and development (R&D) funding instead of having the reader break it out. Dr. Weber added that he should not just show what goes to the other mission directorates, but also indicate the percentage of their budgets that SBIR/STTR would take.

Mr. Michael Johns pointed out that Congress does not understand that STMD handles all SBIR/STTR for NASA. That message does not get through. Dr. Weber added that if NASA's administration does not buy into this message, Congress will not, either. It has to be sold internally first. Dr. Reuther said that he would take that action.

Dr. Ballhaus said that with the mission directorates as the customers, STMD should determine what it takes to make them advocates for STMD. They might provide their support if a significant part of STMD were invested in technologies could positively affect their major projects in terms of cost and schedule risks. Dr. Reuther said that the mission directorates are more supportive of STMD than ever, and their leadership expresses that support with Congress. Dr. Mountain was concerned that STMD leadership was losing track of the fact that there are two things going on separately. He advised them to always separate the mandated budget elements so that they can keep making the point that STMD has a program that is mandated, but the Directorate cannot control its budget. Dr. Reuther agreed, and asked Mr. Green to note that.

Technology Demonstrations
Dr. Reuther showed the cadence of STMD's technology demonstrations. While there are a lot planned for the next year, the number falls off thereafter, reflecting the budget and effects of sequestration. There are activities in the pipeline, including oxygen recovery technologies and an EVA suit and glove technologies. For habitats, there is an inflatable and soft hatch. STMD is looking at radiation protection models to demonstrate on ISS. EDL tests are moving toward larger capabilities to test supersonic parachutes and inflatable decelerators. STMD is also partnering with SpaceX to obtain supersonic retro-propulsion. Other work involves cyrogenic storage and transfer technologies.

Dr. Ballhaus said that this shows effort but no committed outcomes, which makes it easy to cut. If there are committed outcomes associated with specific projects, they become capabilities that must be in place to support a program at a specific time. Dr. Reuther asked to come back to that thought. He listed other STMD activities involving the Science Mission Directorate (SMD), such as EDL for the next Mars mission, a possible thermal protection system, and deep space optical communications. SMD is funding much of this. The Orion EM-1 thermal protection system is on the critical path. The Asteroid Redirect Mission (ARM) needs in-space propulsion and power, with a high-power SEP demonstration and a possible demonstration of high-power solar arrays.

When Dr. Reuther showed the alignment of STMD with the Human Exploration and Operations Mission Directorate (HEOMD), Dr. Mountain suggested adding the deliverable times, and Dr. Dava Newman said that the alignment with mission directorates is what is needed on SBIR/STTR as well. Dr. Reuther showed the alignment of STMD with SMD. A big push is coming from the Wide Field InfraRed Space Telescope/Astrophysics-Focused Telescope Assets (WFIRST/AFTA) coronagraph. The Astrophysics Division could not do this without STMD, which is taking on the highest risk on the coronagraph technology. The potential is to open spectrum detection on exoplanets to determine possibilities for life.

STMD is looking at technologies as a tipping point for industry, and the Directorate has a number of public/private partnerships. SEP provides a strong story and is a game changer. These arrays offer lower cost, lower mass, and easier packing. Industry is switching to this. STMD is also taking forward thrusters and power processing units (PPUs). Optical Space Communication (OSC) is another important, cross-cutting technology. It enhances data downlinks at a time when competition for standard data bands is high. OSC is unregulated and has huge advantages, such as high security. STMD has a $250 million project to demonstrate the first generation geostationary relay OSC. The commercial side wants this capability for broadband communications. The Europeans are testing a similar technology that operates at different frequencies. STMD hopes to get this done for industry and other government agencies. The deep space capabilities would provide a ten-fold increase in the ability to communicate from Mars, Jupiter, and beyond.

Mr. Ballhaus said that it would be useful to know what impact budget cuts have on these technologies. Dr. Mountain said that these projects should lead the discussion, not trail it, so that the other mission directorates would support their urgency. When Dr. Reuther said that a 2-year delay would drop to zero, Dr. Weber advised using OSC to show how allocating the SBIR/STTR costs by mission directorate would be a win-win, rather than an antagonistic relationship.

Through grants and other programs, STMD partners with the nation's universities to advance space technology. In an effort to improve the probability of technology infusion, the Directorate has held and scheduled a series of technology workshops. The response has been excellent, with about 800 people viewing the space physics discussion. There was also a strong response to an industry-developed tipping point technologies Request for Information (RFI). Milestones for FY15 and FY16 include the next supersonic parachute test, which is in June. This was delayed by budget cuts, and while the plan had been to have three tests, there will be only one.

Mr. David Neyland said that at the previous meeting, TI&E had asked for an overlay between the vision/proposal and the reality in order to see the explicit impact of budget cuts. Mr. Green said that STMD had provided an impact statement to Dr. Ballhaus and was still working on the delays and descopes. Dr. Reuther added that they are working to provide information on the original proposed key projects, the dates and scope, the reality of the delay, and the impact on the mission directorates.

Update on NASA's Future Workforce: Gender and Diversity

Ms. Sherri McGee, Deputy Assistant Administrator of Human Capital Management (HCM) at NASA, presented a continuation of the gender and diversity discussion from the previous TI&E meeting. Along with her were Ms. Jane Datta and Ms. Jeri Buchholz, also with NASA HCM. Ms. Datta said that the hiring pipeline provides context on the workforce. Currently, the Agency has 500 students at work; they are not full-time. There are also about 17,000 employees at NASA. HCM breaks out employees into Science and Engineering (S&E) and non-S&E. The S&E population at NASA is 77 percent male, and the non-S&E population is 44 percent male. S&E attrition rates are lower than those for non-S&Es.

The student population is 68 percent male. Students are generally more diverse in terms of both gender and race, and that diversity is retained when these students enter NASA as employees. The non-student hires are reflective of the overall employees. This indicates that the internal pipeline of students has power to increase diversity. It is a generational change to achieve balance.

Dr. Ballhaus asked the average age of a Technology Fellow. Ms. McGee said that they were 50 and over, with 20 to 30 years of experience. They entered when the percentage of males was higher. The Fellows are not competed externally, but rather are selected from within. Ms. Buchholz added that they have worked up to GS-15 and higher. If women have opted out or not made it to that level, they are not under consideration. This says that the attention needs to be focused on creating a diverse population of people entering pipeline, then focusing on their advancement in order to have a more representative group.

The number of women engineers at Johnson Space Center (JSC) exceeds the percentage in the civilian labor force. Dr. Reuther added that STMD has a strong record with S&E diversity. Four of its nine technology fellows are women, and some aspire to be Agency-level technology fellows. There are mechanisms and pipelines by which to groom people.

Dr. Weber was concerned that TI&E was not getting the data she sought. She wanted to know what the GS-14 and -15 S&E pool looked like 20 and 30 years ago. It may be that the assumptions are valid, but she wanted the data for support. This topic came up in TI&E because of the Technology Fellows demographics. The Committee wanted to know how this happened, and if there

were biases or other mechanisms inhibiting female advancement. People think of NASA as the bellwether of science and engineering, so TI&E members were surprised that the message of the Fellows selection was that there were virtually no qualified women.

Dr. Mountain asked about the pool for the Fellows, and wanted to know what, if any, biases are operating. Mr. Neyland added that a non-competitive selection from within eliminates external candidates and creates a bias. Dr. Weber agreed, pointing out that the noncompetitive element creates a subconscious bias opportunity. Of NASA's approximately 10,000 S&Es, 1,000 might be qualified, and there should have been more women selected.

Dr. Ballhaus asked for data on the Senior Scientific and Technical (ST), Senior Level (SL), and GS-15 employees in each of the relevant disciplines. Ms. McGee said that HCM can explore that. The Office of the Chief Engineer (OCE) would have to help pull the data, as it is a manual search. The Technology Fellows are STs. Ms. Buchholz added that STs are world-class experts. In general, scientists become STs, while lawyers and other professionals become SLs. Ms. McGee said that there are currently 130 STs and SLs, 86 percent of whom are men, with 14 percent women.

Mr. Neyland asked how NASA hiring managers could know the pool. It looked like they choose the people they know, which is the antithesis of diversity. Ms. McGee said that 25 percent of GS-15s are female. Dr. Weber observed that if the pool being drawn from is a problem below, that is the issue. This is not about 20 Technology Fellows. The issue is in going from 25 percent to 10 percent.

Ms. McGee said that there is concern that there may be a higher pool of women engineers at lower grades. HCM is wondering if there is something that keeps them from knowing their career advancement opportunities. HCM believes there is a communication issue with the younger engineers. How do they become the experts who get selected? Ms. Buchholz said that they need to look at advancement at all levels, from hiring on up, in order to understand what is going on. She has been looking at this question for several years and has concluded that NASA is doing all the best practice activities and has been doing them for a long time. She decided that HCM should look at pipeline and advancement of women differently.

When HCM examined the Senior Executive Service (SES) advancement program for pre-certification as an SES, the group reached out to all the employee resource groups focused on women and asked them to encourage people to apply. After going through the process using gender/race-neutral standards, 10 of the 19 chosen were women. This shows that there are things NASA might be able to do to smooth out the career paths for women. NASA has 400 data elements on each employee, which are reported biweekly. The data are hard to retrieve, however.

Dr. Ballhaus said it looks like there is a much higher likelihood of a GS-15 woman going into SES than SL. He believed they would find that in the data. Dr. Weber cautioned that the data do not provide cause and effect. Ms. Buchholz said that HCM is partnering with the Jet Propulsion Lab (JPL) to examine the career paths of highly successful people within NASA. Part of that involves determining the career paths of men and women, and what that says.

Dr. Weber noted that they were focused on how to help women. If there is a top-down selection bias, educating women will help them fit into that bias. Ms. Buchholz restated this as Dr. Weber wanting NASA to set up a way that does not carry forward unintentional biases, for example, with diverse selection panels. NASA needs people to think whether they are gravitating toward the familiar or looking at what a person can bring to the job and the Agency.

Dr. Newman said that the pipeline does not solve itself. There must be mechanisms of entry at all levels and very clearly articulated goals. Although NASA cannot legally set percentages, the goal has to be set nonetheless. NASA must be proactive and not wait for the pipeline. Ms. Buchholz said that half of NASA's new hires are GS-11 and below, which is a legal goal and a more diverse

population. The Agency hires about 800 people per year and has a limited ability to reshape the workforce. Dr. Newman reiterated that the search process is completely biased for top levels. That has been established through research. The best person should get the job, and NASA should ensure that there is not a familiarity and cultural bias. More creative hiring options would help.

Ms. Buchholz said that HCM is open to working on this for all under-represented populations. Dr. Ballhaus noted that the Technology Fellows did in fact reflect the ST and SL pool. Mr. Neyland said that the pool would be broader if it included GS-15s. He suggested that TI&E recommend to the NAC that the selections be discouraged from being non-competitive, and state that non-competitive hiring is not in the best interest of NASA. Dr. Ballhaus said that they could develop a finding that 86 percent of ST/SLs and 75 percent of the S&Es are male, and NASA needs to address this. Dr. Weber added that the finding would be that there is bias in the selection process. Dr. Ballhaus said that the finding could state what TI&E learned about the pools and ask what the Agency will do.

Dr. Weber said she heard that there is a great effort to get women to do things differently. She did not hear that there is a top-down look at the selection process. The efforts are geared to get women to position themselves better. However, she would recommend examining the selection processes themselves, separate from workforce development. Ms. Buchholz agreed. HCM is now trying to better understand the process, what drives people's behavior and choices, where the representation of different groups of people falls off and why, in addition to what can they do.

Dr. Mountain said that this is well-documented. They know there is a bias. He wanted to know what they were doing about it other than trying to make women fit in to be more acceptable. Ms. Buchholz said that there are plans to do training about unconscious bias. The representation of S&Es among women at NASA is better than that in the civilian labor force. Dr. Newman said that NASA should recruit the best in the under-represented populations. Ms. Buchholz said that it might be helpful to have the people who do these analyses talk to TI&E.

Dr. Ballhaus said that the selection of only one woman as a Technology Fellow indicates that NASA should develop a more effective process for future Fellows and define future steps for a more diverse workforce. Dr. Reuther said that many of the GS-14s and 15s aspire to be Technology Fellows some day. Of STMD's university fellowships, about 25 percent of the doctoral fellows, who are the best of the best with truly outstanding criteria, are female. The pipeline is there.

Dr. Weber said that NASA should look at the divisions that have success and see what they do that could apply across the Agency. Dr. Ballhaus agreed, though this would be anecdotal. But they can look at it. The right finding will lead them to what they need to do. Dr. Reuther suggested using the data of the university fellowships, the female STMD fellows, STMD principal investigators (PIs), and the space technology research graduates. Ms. Buchholz said that the question then becomes whether NASA can hire them. The federal government hiring process gives preference to veterans, and the veterans with engineering degrees are mostly men. There are fewer veterans at the PhD levels, but this affects NASA's overall hiring profile. This will have an impact in another 20 years. Dr. Reuther said that the data still indicate that a disparity occurs between the GS-15 and the Technology Fellows. In addition, university faculty at the same level are 10-15 percent women. That is where the drop-off occurs.

SBIR/STTR Program Update

Mr. Robert Yang, an STMD Program Executive, explained that SBIR is a 33-year-old program to help develop small business opportunities in various parts of the government. Five federal agencies have both SBIR and STTR, and six have SBIR only. Across the federal government, the program is funded at about $2.6 billion annually in a legislative set-aside; NASA's investment is about $190 million. In FY15, SBIR is 2.9 percent of extramural R&D, and STTR is 0.40 percent of extramural R&D. In FY16, these increase to 3.0 and 0.45 percent, respectively.

Dr. Ballhaus asked how SBIR at NASA ensured the investment resulted in the maximum benefit. Dr. Yang explained that NASA makes its selections based on due diligence to develop products and results. There is accountability and close work with the mission directorates to help buy down their risk and provide alternative solutions. STTR is slightly different, as it is tied to the Space Technology Roadmap and aligns with center needs.

When Mr. Yang raised the subject of the budget, Mr. Green noted that in a flat scenario, SBIR/STTR eats at the STMD budget. Dr. Ballhaus added that it lessens the Agency's ability to maintain its labs and technical capabilities. Mr. Oschmann pointed out that the numbers do not make the case that SBIR/STTR is increasing over time. Dr. Mountain noted that Congress and the White House support SBIR. It fulfills a lot of STMD goals. Mr. Yang said that the funds going into small business increase capabilities. At NASA, most of those with SBIR/STTR grants only go through Phases 1 and 2. However, Phase 3 is the powerful part, where a user pulls the other phases into a program.

His program is trying to build bridges between Phases 2 and 3 via three programs. The goal of the continuation programs is to get the new technologies to TRL6. Only about 20 percent of the SBIR programs government-wide make it to Phase 3. The return should be higher, though not all of the 80 percent is wasted. While it is important to take some risks, the program has become more strategic, seeking direction from the mission directorates and further instructions from the centers.

Mr. Yang provided some examples of SBIR topics from the 2015 solicitations, including integrated flight systems, space transportation, robotic systems, sensors and detectors, and information technology. These all map to the mission directorates. STTR is not necessarily aligned with the directorates, however. Mr. Yang reviewed the awards by mission directorate. SBIR Select is a slightly different program that is much smaller and experimental, and can go to a higher TRL.

The selection rate is not uniform across the various areas. It ranges from 10 to 20 percent for Phase 1, and is higher in Phase 2. The selections are mapped to the roadmap priorities. Dr. Newman observed that there is an over-representation in the lower priorities. Mr. Neyland said that a presolicitation notice would give the community more time to prepare. That could be a recommendation, to encourage a presolicitation notice explicitly emphasizing the roadmap areas. This works well at the Department of Defense (DOD). Dr. Mountain added that stating priorities allows proposers to focus better. Mr. Oschmann agreed, advising Mr. Yang to highlight the top priorities both through presolicitation and in presenting the results.

Dr. Ballhaus suggested that the recommendation note that the value of SBIR/STTR would be enhanced by holding presolicitations reflecting NASA priorities. Mr. Yang said that there needs to be a balance between telling applicants what NASA is thinking and what NASA will fund. His group can work that with the NASA procurement and legal experts on this. Dr. Newman noted that there is the potential perception of a rigged system. Mr. Yang replied that every question must be fully vetted with an answer to go into the public domain. The program might need to go slowly with the presolicitation at first, but it would be worth testing.

Dr. Newman asked how Mr. Yang's program persuades the mission directorates to take a Phase 2 project to Phase 3. Dr. Ballhaus thought that the important thing is to define NASA's needs and priorities. The DOD presolicitation interactions increase the likelihood of successful technology alignment with priorities. Mr. Green confirmed that the STMD AA has the authority to implement this recommendation.

Mr. Yang presented the proposal data, noting that the program has improved its communications with the small business community. The goal is more Phase 3 projects and technology infusion. Dr. Newman called attention to the variability in the annual numbers, which Mr. Yang said reflected both funding and the random element in what works. In addition, a shift of solicitation dates meant

that there are no FY13 data. Another cause for disparities is technical veracity. Applicants receive a technology score, and the mission directorates weigh in. The program does not second-guess them. Mr. Neyland said that there appears to be a pro rata share by the mission directorates, which means that there could be funding for less valuable proposals by a directorate that has more funding. Mr. Yang said that the program discusses this with the mission directorates, which need to be able to justify their choices. There are commercialization scores generated by outside industry people, as well.

Mr. Yang discussed the Commercialization Readiness Pilot Program (CRP), which enables technology maturation for infusion and commercialization and awards up to three times the standard Phase 2 award. The actual funding for FY14 was $3.5 million, which was leveraged to $5.3 million, and the planned FY15 funding is $6 million. During FY14, CRP's first year, NASA funded 9 out of 17 applications.

New initiatives include greater outreach, especially to large companies that do not always think of the government when in search of new technologies. There will also be more conferences to bring in small businesses, one-on-one sessions with NASA staff, and listening sessions. Dr. Ballhaus asked how the program is trying to get the small business investment into the supply chain of the large prime contractors. Mr. Yang explained that the legislation precludes funneling funds to the large businesses. In Phase 2E, however, the program does give additional points to small businesses that are connected to larger companies that help fund the enterprise. The program needs to bring in the primes and explain that this is a way to use the SBIRs, but the funds go to small businesses. Dr. Ballhaus said that the primes will encourage their supply chain members to invest, which could be leveraged. Mr. Yang said that this could be any large company, and NASA would like to enable that. Mr. Green added that TI&E would be hearing about an innovative partnerships group that does this kind of thing.

Mr. Oschmann pointed out that the primes can propose in other parts, and can go through Phase 3. Mr. Yang said that SMD offers additional credit to companies that use SBIR technology. He ended his presentation by showing some examples of SBIR/STTR successes.

Annual Ethics Training

TI&E members had their annual ethics training session.

Office of Chief Technologist Update

Mr. James Adams, Deputy Chief Technologist, provided the OCT update on behalf of Dr. David Miller, the Chief Technologist, who was unable to attend the meeting. OCT is very passionate about connecting NASA with other agencies. Dr. Miller has regular closed meetings with the chief technologists of the National Reconnaissance Organization (NRO) and the Air Force. These meetings occur prior to meetings among the administrators of those agencies. The chief technologists have thus enabled a real technology discussion among the administrators.

Another priority is communicating the role of technology. Due to budget issues, OCT has not been able to fund a foundational engineering science initiative. Mr. Adams agreed with Dr. Ballhaus that there is a lot of foundational engineering science that needs to be done. OCT will seek funding for it again. The PBR was not that large.

Dr. Catherine Coleman is OCT's astronaut-in-residence, helping with ISS utilization. The process is not simple, and encompasses commercialization; allocating NASA utilization across science, technology, and education; and external engagement. Another priority is better defining and integrating the roles of science, engineering, technology, and architecture. As part of this, Dr. Miller wants to bring back the "blue skies" dialogues.

Among the accomplishments for the Asteroid Grand Challenge, OCT is particularly proud of the Topcoder Asteroid Data Hunter, which has been improved by crowd-sourcing. The Office has tried to spin off a few new things to other parts of the Agency. The Expert and Citizen Assessment of Science and Technology (ECAST) forums take the form of dialogues with the public regarding a number of programs. The effort helps to gauge communication and bring in new ideas.

OCT has issued grants in the area of space technology and will host a workshop in November. A version of NASA's new Techport was released to the public and is searchable in some fields. This is separate from the internal Techport. OCT uses it to produce an annual report on NASA progress. An independent review of the data and procedures advised having a beta version for the public, which OCT will consider. The Office did not vet the initial users. Press and feedback have all been helpful, and there have not been many bugs due to testing. A help desk is also available. The branding issue is internal; the review indicated that it was not clear how the Agency wants to use this.

In 2014, OCT began updating the 14 Technical Area Roadmaps, tying everything to a future concept. They will be made available to the public for comment as a way of keeping the review inexpensive and developing ways to help STMD meet its priorities. The National Research Council (NRC) will help set priorities from the many options that the Roadmaps encompass, then NASA will implement the priorities that funding allows.

Technology Transfer
Mr. Daniel Lockney, Technology Transfer (T2) Program Executive in OCT, presented a brief history of technology transfer at NASA, which operates out of seven objective areas that are assigned to the centers. This area receives a great deal of regulatory attention. Despite having shrunk due to funding pressure, however, the Program is doing core, basic technology transfer work with some new initiatives. OCT is trying to spin up something like the Regional Technology Transfer Center (RTTCs). T2's licensed technology is high TRL, but most of its work is low TRL.

Mr. Lockney reported that at one point, each of the NASA centers was doing something different in the technology transfer area. They are now working together as a group and competing with each other to see who can do the most for the Agency program. Royalty income is divided so that the first $5,000 goes to the inventor, who also receives 25 percent of the income. The rest goes to the center. There are annual awards for NASA inventors as well.

New Technology Reporting (NTR) is up, with a four percent increase from 2013. T2 did 120 NTR training sessions, among other initiatives to help reporters engage. The Program has a patent strategy that is only for commercialization. Patents give incentives to invest. Some patents are also going into the public domain, as certain patents are better as published patents than as licensed ones. Provisional patent applications grew in FY13 prior to the March 2013 effective date of the America Invents Act "First to File" initiative. Almost none of the patents pay for themselves.

NASA is way ahead of other government agencies in putting its patent portfolio into groups by application type. T2 has learned that 85 percent of higher TRL licensees are small business, which tells the program what and how to market to them. There is also public education content that is easily accessible across the whole portfolio. No other agency does this. The licenses are now up 35 percent. There are also evaluation licenses, which are like a test drive and have become increasingly popular.

It used to be that the publicly available software was hard to find and very dispersed among different websites. T2 pulled it together, described it in plain language, put it in a PDF, and published it. The response has been tremendous, simply by virtue of having the material in one place that is easy to find. T2 will soon launch online software transfer.

Part of technology transfer is demonstrating the public benefit. T2 has resumed promoting this through a monthly publication called NASA Tech Briefs (NTB), which has resulted in more content transfer. NTB is still the largest engineering design publication in the world. T2 has built on that with a spinoff publication and digital outreach. The Technology Transfer University (T2U) is a type of interactive business school tied in with 14 colleges and universities. T2U gives technology to business students to examine for commercial potential. Sometimes the students start a company themselves. T2 is trying to broaden this.

All of the T2 numbers are up while the budget is down. Mr. Lockney presented the metrics by which the Program tracks its progress. Each strategy has a goal, program plan, and schedule.

Office of Chief Engineer Update

Mr. Ralph Roe, NASA Chief Engineer, said that the OCE is trying to address the fact that the funding model goes through programs or projects. Under constrained budgets, there are short-term decisions that might not be in the best long-term interest of the Agency. For example, when centers need to compete for these limited dollars, they may grow and duplicate capabilities that exist elsewhere. Therefore, OCE is trying to provide NASA leadership with an annual assessment of technology capabilities across the entire Agency. OCE is implementing this using the 15 Technology Fellows, with Agency-wide teams of subject matter experts (SMEs) who are doing capability assessments in each discipline.

OCE will report back to the Agency on those assessments in order to develop a more efficient operating model. In 2014, OCE conducted four assessments, which resulted in specific recommended actions. Those actions are:

- Establish an operating model for each discipline so that the engineering community can operate as more integrated, Agency-wide teams rather than being optimized around the centers;
- Align these integrated teams to current and future Agency projects, to include how current projects would leverage the teams, right-sizing the teams in the integrated operating model, and evaluating decisions for the right balance of the workforce;
- Look at the facilities the disciplines use, identifying overlap and gaps, and recommending cost savings aimed at efficiency;
- Make recommendations regarding the gaps identified in each discipline; and
- Determine what is needed to sustain each program.

The 15 NASA Technology Fellows are applying these actions to ensure that NASA can meet its future needs.

The teams are made up of representatives from all of the centers having a particular skill. Teams present their findings and recommendations to Mr. Roe and the engineering management board of the centers. The board will concur with the findings and recommendations, which will be passed on to Agency leadership, including relevant mission directorates, in the fall of 2015. Mr. Roe expects the engineering management board to develop common themes and integrate across the disciplines to form recommendations for the Agency budget.

Dr. Ballhaus said that Mr. Roe noted that with the way the country does funding, it is a challenge to maintain key capabilities for current and future projects. He thought what Mr. Roe presented sounded effective in eliminating overlap and duplication, and in promoting efficiency. This might lead to some "make versus buy" decisions, and NASA will want to nurture some capabilities in order to maintain the smart buyer capability. Mr. Roe said that the assessment will identify gaps and weaknesses to address, as well as efficiencies. This is the only way to address the situation when faced with a flat budget.

Dr. Ballhaus raised the workforce diversity issue, noting that the STs and SLs are 86 percent male, and the GS-15s are 75 percent male. The younger workforce is more diverse. TI&E planned to take to the NAC a finding about the need to bring diversity forward. He asked for Mr. Roe's thoughts. Mr. Roe replied that OCE looked at the same data and did some surveys with women and minorities regarding ST and SL positions. Most were not even aware of the career path for those positions. OCE wants to target them for recruitment to make sure that they are at least aware of these opportunities. The goal is to broaden the selection pool. OCE plans on having a goal of bringing in new hires at a level that is substantially more diverse than that of the overall population. For the new ST technology fellows, it is possible that two of the next four will be women. That would be aggressive. Mr. Bolden wants a focus on this.

Centennial Challenges Program Update

Mr. Samuel Ortega, Program Executive for the Centennial Challenges, provided a program update. The Centennial Challenges are designed to promote opportunity, innovation, and communication. The goal is to use competitions to stimulate development of innovative solutions for technology problems in areas of interest to NASA. Almost all of the funds go into the prizes themselves.

The Program seeks to advance technologies that are at TRLs 4, 5, and 6 – not yet ready for a mission, but out of the lab. The Challenges help to move the technologies up and generate interest. This has resulted in many areas in which the program has infused technology. Prizes can be as much as $50,000, though none have been that much at this point. The funds do not expire, but are available until they are awarded. This allows the Program to set funds aside for the 2 to 5 years it takes to complete the competitions. Federal employees and contractors can participate, but not in their employment areas. The total funding is appropriated to STMD to manage, and is assessed by the STMD AA. Once the AA determines how much to allocate, the process goes back to the Office of Management and Budget (OMB) to establish the account as "no-year" funds.

The Agency fit is across different areas. The citizen scientists are an example, in that they engage in participatory science opportunities. These are all consolidated in NASA Solve (nasasolve.gov), within OCT. There have been 26 prize competitions since 2005 in six technology areas. Flexible astronaut gloves designed through the program are supposed to go into operations eventually.

Dr. Ballhaus said it was not clear how much had actually happened to affect operations. As noted, the gloves are not in use yet, and the sample return robot will not be in use for a while. Mr. Ortega cited instances of infusion in the areas of general aviation and green flight. In addition, the technology from the power beaming competition was rolled over and is now with DOD and used commercially on guard fences. Dr. Newman observed that it helps change NASA culture by bringing in new ways of doing things. Mr. Ortega agreed. When a technology is brought in, it changes the way mission planners think.

The second-place competitor in the astronaut glove competition is a show business designer who has now partnered with another person to make space suits for exploration. A laser mosquito zapper also came out of this competition. The Challenge has an outreach and social media manager, has begun running some competitions in-house out of Ames Research Center (ARC) and Marshall Space Flight Center (MFSC), and is also partnering with nonprofit organizations.

There are three active challenges: sample return robot, cube quest, and Mars ascent vehicle. The sample return robot finds random objects and determines which are qualified to return. Cube quest advances cubesats. Prizes factor in design envelopes, distance, lunar orbit, etc., and this all relates to a technology roadmap by miniaturizing technology and taking NASA to a destination.

When NASA has a partner in this, both parties will share ideas on what the challenge should be. NASA provides provide guidance and expertise, and each Challenge must relate to NASA. The

Agency's administrative costs cover 4.7 FTEs, plus marketing promotion, outreach, workshops, and travel.

The Mars ascent vehicle competition was taking place at MSFC that week, partnered with a student launch. The Program is developing more Challenges in areas like habitats, space robotics, and tissue engineering. Robotics competitions are very slow, as they are essentially coding a brain into a robot. Tissue engineering is with the Methuselah Organization, which came up with the idea. Mr. Ortega showed how the Challenges align with the technology roadmaps. It is a broad portfolio. The Challenges started in 2005, the 100-year anniversary of the Wright Brothers flight, which accounts for the name "Centennial." The program looks for unconventional solutions, like the Wright Brothers did.

Dr. Ballhaus said that STMD is spread thin and doing extra things when it cannot even fund core activities. This seems independent of the core activities. Mr. Neyland thought the Program should ask if there are nuggets out there that might be more relevant than doing a composite tank that has no customer. Some of these are more relevant than others. If an astronaut is hurt on Mars and a year away from a hospital, tissue generation is important. Dr. Ballhaus was concerned about whether these Challenge efforts move the STMD plan forward.

Mr. Ortega explained that a good prize or Challenge should support NASA and have a model leading to business opportunities. The Program tracks the non-winners, as those who place just below the winner often make meaningful advances.

There are programmatic and technology goals that require multiple competitors, a business model, and infusion opportunities. The NRC sets priorities for the assessments, and the Program takes those into consideration. Investment details are being collected for current Challenges; the Program has notional aggregate values from heritage Challenges. The portfolio is broad, but it would be helpful to share the expertise of the Program and work with NASA's technology people to evaluate what best executes missions. The Program also does outreach to other federal agencies.

Discussion and Recommendations

Dr. Ballhaus led the Committee in discussion of what to take forward.

STMD Funding

The first topic was the level of funding for STMD. Focus was on the Directorate consistently lacking sufficient resources to deliver on NASA's plans for technology development, the fact that up-front investments have not been made, and examples of technologies that have been proposed but were delayed or cancelled.

Mr. Green presented a chart showing the delivery and launch of missions from 2012 onward. Mr. Neyland observed that there was a conscious decision for STMD to not be on any program's critical path. That means that NASA can execute programs without STMD, and some STMD investments are things that no one would miss. This calls for examining what NASA is trying to accomplish over the next 20 years and determining how to accelerate those investments on the critical paths. Dr. Ballhaus said that STMD investments need to address mission costs, schedules, performance, and risks. A measure of technology development is the extent to which these are exercised.

Dr. Weber suggested that since TI&E was trying to address the impact of the budget cuts, the recommendation to STMD should be to emphasize where missions would be with more technology funding. The Directorate is focused on where things are and not looking at where they might have been. Dr. Mountain gave the example of what might happen if STMD were not working on the WFIRST/AFTA coronagraph. It is hard to develop these hypothetical situations off of the critical path. Dr. Ballhaus added that one of STMD's jobs is to produce things the mission directorates do

not yet know they need. For example, what technologies should NASA invest in for future launch vehicles? Since the Agency uses existing launch vehicles, this gets pushed further back.

Dr. Weber pointed out that STMD has done a great job of identifying what it can do. What the Directorate has not done is to develop an impact statement on what is being lost. TI&E should ask STMD to look at the half-empty part of the glass. That exercise could help the Directorate ask for more support and give TI&E the basis for taking a strong recommendation to the NAC.

Dr. Ballhaus added to the focus points that STMD should identify the urgency argument and clearly identify the problems and solutions. Dr. Newman said that what was missing was a clear articulation of prioritization. The vision has to be articulated. STMD needs a prioritized portfolio that includes the needs for exploration. The top five or six priorities should be up front.

Dr. Ballhaus pointed out that in selling major facilities, one starts with basic assumptions, then backs them up with data so that the assertion becomes a fact. He sees a lack of compelling advocacy in STMD. To make a strong advocacy argument, the data are necessary. Maybe the argument does not exist for everything, but it certainly does for SEP.

Dr. Neyland wanted to know the real amount of the discretionary budget, which means taking out the civil servant costs. STMD's intrinsic value is in moving technology forward, not paying people. Dr. Ballhaus pointed out that NASA needs scientists and engineers to be part of the teams that support the projects. Mr. Neyland replied that if there is a pro rata cut, the whole picture needs to be looked at as opposed to a sum cost.

STMD management briefed Senate authorization staff on the impact of not getting the needed budget. The first thing to go is new solicitations. Dr. Weber noted that while this is true, it does not state the impact. Mr. Green said that the previous STMD AA told the House staff that in order to get beyond low Earth orbit (LEO), a certain level of investment is needed to even make it possible. Dr. Weber said that that kind of argument is what is missing. Dr. Mountain added that STMD should state what the missions would look like if the Directorate had the funds, describing the transformative changes. STMD has to get people to get excited about its work.

Dr. Ballhaus said that in private industry, some corporate vice president would say what he or she would do with $100 million. STMD can make a similar argument, identifying the five most important things that could occur with technology and a timeframe, and the most compelling options that STMD could put forth to enable missions. Mr. Green noted that STMD has the urgency stories, and has had to step away from the nine big projects it promoted previously. Dr. Newman advised categorizing projects in terms of early, middle, and late development.

Dr. Mountain said that TI&E did not yet have the data to help STMD, only knowing that "if you cut it, it doesn't bleed." STMD should be more forward about what it can do. Mr. Oschmann observed that TI&E could spend days on this, but STMD needs to define the urgencies and how the portfolio supports them. He thought the recommendation should be that STMD develop that story. Mr. Andrucyk agreed, and said that he was prepared to do that. Dr. Weber said that STMD should define the empty part of the glass, the pain and the lack felt from the absence of full funding, and the bleak picture for NASA.

Dr. Ballhaus suggested saying where NASA could be with SEP, stating that the Agency slips because of the funding cuts. The program has been limited by budget availability. If NASA is trying to go to Mars, this is where the Agency is being held up. There are other capabilities for which that argument can be made, as well. Dr. Mountain mentioned the ripped parachute photo, which says it all. The Agency is not ready. Dr. Ballhaus added that due to the budget, STMD you can only test one new design instead of three. That is a schedule risk for Mars.

Discussion shifted to SBIR/STTR funding. Dr. Weber said that it is a question of what STMD wants to do. If it is important to STMD, the Directorate could come up with an argument and make the case with the mission directorates. Dr. Ballhaus noted that the data do not seem to support that SBIR/STTR funding takes away from the STMD discretionary budget. However, if the STMD AA can convince the Administrator that the discretionary budget is squeezed, Mr. Bolden may look at how to deal with this.

Dr. Newman said that the connections with industry should be centrally managed. Dr. Weber added that management of the programs should stay in STMD, and the funds that go out in grants should come from the mission directorates, which can absorb those increases. There needs to be a close look to see what STMD really wants to do in this area. The data are not present to understand the impact. It would be premature to weigh in without that. Dr. Ballhaus agreed that it was too early to take a recommendation to the NAC. Nor did he want TI&E to get ahead of the new STMD leadership. However, he did want to highlight the problem of the discretionary part of budget.

Dr. Ballhaus returned to the idea of taking a finding to the NAC stating that STMD consistently lacks the resources needed to deliver the technology developments required across the TRL spectrum in order to meet NASA's mission goals. But this is an assertion, not a fact. He wanted supporting data to prove it. It might help to state that several years ago, NASA said what the Agency wanted from STMD in order to meet the Agency's goals, but the funding has not materialized.

Dr. Reuther noted that NASA has repeatedly called for development of cryo-propellant storage and transfer (CPST). That was a $400 million project that, for budget reasons, was descoped into a $57 million ground test demonstration that would not advance the technologies. In addition, SEP is significantly delayed. Yet everyone says that these two technologies are needed. In the case of SEP, STMD has slipped year for year. STMD has learned a lot and made progress on EDL, but that is the exception.

Dr. Weber advised that TI&E add to the recommendation a statement about STMD being inordinately constrained by the budget situation. Dr. Ballhaus put that in, noting the specific missions that Dr. Reuther had mentioned and asking if NASA was slipping a year for year on the human mission to Mars due to a constrained budget. Dr. Reuther thought it was more than a year for year.

Dr. Ballhaus had the recommendation stating that specific technology advances have been defined that are required to support NASA's future missions, and when STMD was established, a plan was formulated to include well-defined deliverables and the necessary budget. However, STMD has consistently lacked the sufficient discretionary resources to deliver the technology developments required across the TRL spectrum to meet NASA's mission goals. The statement noted the CPST descope, the SEP delay, and the slippage on the human Mars mission. Dr. Ballhaus said that this was a good starting point.

The following was agreed to as a Finding for the full NAC:

STMD Budget Finding:

- Specific technology advances have been defined that enable NASA's future exploration missions.
  - Strategic Space Technology Investment Plan (2012)
- When Space Technology was established, a plan was formulated including well-defined deliverables and the necessary budget to execute the program.
- However, STMD has consistently lacked the sufficient discretionary resources to deliver all the technology developments required across the TRL spectrum to meet NASA's future mission goals.

Diversity and the Technology Fellows
The next topic was the Technology Fellows selection and the diversity issues the selection raised. The preliminary statement noted that the selection resulted in only 1 female out of 15 Fellows. There is a need for NASA to follow best practices for future selections and to determine what additional steps should be taken to effect a more gender-diverse workforce. The statement included supporting data on gender diversity among S&E ST/SLs, GS-15 S&Es, and S&E SESes.

Dr. Weber cautioned against dismissing the ratios due to age. There has not been the necessary mentoring and nurturing, and the selection methods are an issue. She was concerned that there was too much emphasis on whether women are aware of these opportunities, and she wondered if the men are. She said she would support a recommendation to have NASA look at the process itself. Dr. Newman asserted that there is no sustained, conscious effort to change things. Dr. Reuther said that leaving the selection process for STs untouched is asking for this to continue. The STs are not competitively selected. Dr. Ballhaus said that TI&E would seek the data and sources.

The following was agreed to as a Finding for the full NAC:

NASA Workforce Gender Diversity Finding:
- The recent OCE Tech Fellows selection resulted in only 1 female out of 15 Fellows.
- The Committee found that a gender diversity issue extends beyond OCE Tech Fellows.
- There is a need for NASA to follow best practices for future selections and to determine what additional steps should be taken to effect a more gender-diverse workforce.
  Supporting data:
  - Out of 138 S&E ST/SLs, 86% male
  - GS15 S&Es, 75% male
  - S&E SES, 81% male

SBIR/STTR Proposals
The Committee statement on SBIR/STTR opportunities said that NASA does not conduct presolicitation interactions with industry in advance of SBIR/STTR solicitations. The value of SBIR/STTR proposals to NASA would be enhanced by conducting such interactions with industry in order to define NASA technology needs and priorities. Dr. Ballhaus wanted to relate this back to the discretionary budget, noting that SBIR/STTR management and budget are consolidated and well-managed in STMD. However, as STMD planned budget increases have not materialized, and as the mandated budget lines has increased, STMD's primary programs have been severely impacted. The supporting data would be added.

The following was agreed to as a Finding for the full NAC:

Pre-Solicitations for SBIR/STTR opportunities:
- NASA does not currently conduct pre-solicitation interactions with industry in advance of SBIR/STTR solicitations. The value of SBIR/STTR proposals to NASA would be enhanced by conducting such interactions with industry to define NASA technology needs and priorities.
  - The Committee notes that DoD has an effective process for conducting pre-solicitation interactions that helps industry align proposals with agency priorities.

Impact of Congressionally mandated SBIR/STTR funding increases:
- SBIR/STTR management/budgets are consolidated and well managed in STMD.
- However, as the STMD planned budget increases have not materialized, and as SBIR/STTR allocations have increased as mandated by Congress, STMD's primary programs have been severely impacted.

Adjournment
Dr. Ballhaus adjourned the meeting at 6:19 p.m.

APPENDIX A

Agenda

NAC Technology, Innovation, and Engineering Committee Meeting
April 7, 2015
NASA Headquarters

April 7, 2015 – 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 FY 2016 Budget Request and Update Dr. James Reuther, Deputy Associate Administrator for Programs, STMD
9:15 a.m.	Update on NASA's Future Workforce: Gender and Diversity Ms. Sherri McGee, Deputy Assistant Administrator, Human Capital Management
10:00 a.m.	Break
10:15 a.m.	SBIR/STTR Program Update Mr. Bob Yang, Program Executive, STMD
11:15 a.m.	Annual Ethics Training Ms. Katie Spear, NASA OGC
12:15 p.m.	Lunch
1:00 p.m.	Office of Chief Technologist Update Mr. Jim Adams, NASA Deputy Chief Technologist
2:00 p.m.	Office of the Chief Engineer Update Mr. Ralph Roe, NASA Chief Engineer
2:30 p.m.	Centennial Challenges Program Update Mr. Sam Ortega, Program Executive (Acting), STMD
3:30 p.m.	Discussion and Recommendations
5:00 p.m.	Adjournment

APPENDIX B

Committee Membership

Dr. William Ballhaus, Chair
Mr. G. Michael Green, *Executive Secretary*
Mr. Gordon Eichhorst, Aperios Partners, LLC
Mr. Michael Johns, Southern Research Institute
Dr. Matt Mountain, Space Telescope Science Institute
Dr. Dava Newman, Massachusetts Institute of Technology
Mr. David Neyland
Mr. Jim Oschmann, Ball Aerospace
Dr. Mary Ellen Weber, Stellar Strategies, LLC

APPENDIX C

Meeting Attendees

Committee Attendees:
William Ballhaus, Jr., *Chair*
G. Michael Green, *Executive Secretary*
Michael Johns
Matt Mountain
Dava Newman
David Neyland
Jim Oschmann
Mary Ellen Weber

NASA Attendees:
W. James Adams
Dennis Andrucyk
Anita Babb-Bascomb
Jeri Buchholz
Jane Datta
Anyah Dembling
Katie Gallagher
Joseph Grant
Steven Hirshorn
Sherri McGee
Daniel Lockney
Patrick Martin
James Reuther
Natalie Simms
Katie Spear
Robert Yang

Other Attendees:
Amy Reis, Zantech
Elizabeth Sheley, Zantech

WebEx Attendees:
Ralph Roe, NASA

APPENDIX D

Presentations

1) Space Technology Mission Directorate FY 2016 Budget Request and Update [Reuther]
2) SBIR and STTR Programs [Yang]
3) Office of the Chief Technologist Update [Adams]
4) T2 Status and Initiatives [Lockney]
5) Centennial Challenges Program [Ortega]