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Meeting Minutes

G. Michael Green, Executive Secretary
William F. Ballhaus, Jr., Chair
NASA Advisory Council
Technology, Innovation and Engineering Committee
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TABLE OF CONTENTS
Welcome and Overview of Agenda/Logistics 3
Opening Remarks 3
Space Technology Mission Directorate Update 3
Space Technology Research Institutes Overview 6
NASA’s Barriers to Innovation and Chief Technologist Update 7
Update on STMD Strategic Implementation Plan 9
Small Spacecraft Technology Study Final Report 10
Entry, Descent and Landing Update 13
Discussion and Recommendations 14
Adjournment 15

Appendix A Agenda
Appendix B Committee Membership
Appendix C Meeting Attendees
Appendix D List of Presentation Material

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, welcomed the members and reviewed the meeting agenda.

Opening Remarks
Dr. William Ballhaus, TI&E Chair, welcomed the Committee members. He noted that the minutes from the previous meeting pointed toward some issues TI&E had been addressing. The agenda for this meeting included updates.

Space Technology Mission Directorate (STMD) Update
Mr. Stephen Jurczyk, Associate Administrator of NASA’s Space Technology Mission Directorate (STMD), began his presentation by discussing the Space Technology Research Grants. STMD is starting to measure the impact of the 2011-12 grants and is happy with the results. A significant number of the grants had results that moved into other projects, and there have been good products delivered and knowledge produced.

STMD made its first two Space Technology Research Institute (STRI) awards. The NASA Innovative Advanced Concepts (NIAC) awards were still in process at the time of the meeting, and the Center Innovation Fund was being aligned with other Agency elements. There was a brief on the four Early Career Initiative projects. The teams took good approaches that were lean and effectively iterative, with excellent technology developed. At least three of the four projects are going on to program funding. The challenge is how to scale that.

The Agency gave STMD an action to work on engineering research and analysis with the Office of the Chief Engineer (OCE) and the Office of the Chief Technologist (OCT). Dr. Ballhaus noted that the TI&E Committee had recommended formulating a program in basic engineering methods, and it seemed that it was being created in an ad hoc manner through this effort. Mr. Jurczyk agreed, though he was not sure it would be managed out of STMD. After making a recommendation to the Acting Administrator in July, he will provide an update. Dr. Ballhaus expressed misgivings about taking this work from STMD, but Mr. Jurczyk replied that the funds were not in the budget, and this construct will help in that regard.

Regarding significant grants that NASA once offered to universities, Mr. Jurczyk explained that in the mid-2000s, the Agency shifted its emphasis to development and terminated the remaining research funding. If the budget allows, NASA will re-establish the university grants, starting with two pilots.
In the commercial partnerships portfolio, STMD developed a more integrated Small Business Innovation Research (SBIR) solicitation across the Agency, removed redundancy in order to have single topics that are streamlined and less confusing. An industry day at the Ames Research Center (ARC) had 400 on-site participants, with hundreds more online, resulting in more relevant proposals that advance both NASA and business interests. There is also now a training module for small businesses to help with their entrepreneurial skills. Phase 1 selections were pending at the time of the meeting.

Mr. Jurczyk gave an example of how NASA is better integrating flight operations into the programs. Blue Origin is conducting microgravity work as a precursor to International Space Station (ISS) experiments. There is also an effort to increase the capabilities of high altitude balloons. A recent Tipping Point solicitation included the topic of small launch vehicles. Industry typically contributes 25 percent in these awards, though two recent awards involved contributions of 50 percent. Recent awards covered avionics, ceramic rocket engine components, suborbital vehicles, and materials, among others. The evaluations resulted in break points that made it obvious that these were the best offers.

There is a backlog of smallsats awaiting rides. This is due to lack of launch opportunities, and it goes beyond STMD. There are up to 30 small launch vehicles in development. The situation has made the secondary payload launches more attractive. NASA’s launch vehicle operations try to get up to 12 cubesats per launch, but these cubesats must be in a constellation or have the same destination. The small launch vehicles will provide more flexibility. There are a lot of plans, and while some small launch vehicle providers will be successful, others will not.

Dr. Ballhaus observed that some of the past incentives have changed or disappeared. Mr. Jurczyk replied that there are programs that create demand for commercial services, notably cargo and crew. NASA is also trying to advance technologies to market. There is more private investment than before, not only through the big names, but also through venture capital (VC), “angels,” and other means. Mr. Gordon Eichhorst said that while many start-ups have access to angel and VC funds, the challenge is that those funds must be deployed in a certain timeframe. To be sustainable, they need to succeed, otherwise there is a cycle with a trough. Mr. Jurczyk explained that some companies view research and technology (R&T) investments as long-term strategies. This leads to the ability of NASA to make collaborative investments, but business needs to figure out its portion. He is seeing some of the impact of the limited pool of people who have the abilities required. Apple and Uber have hired some NASA people, for example, and other non-aerospace companies are hiring aerospace engineers.

Mr. Jim Oschmann agreed. There are not funds to support everything, so investors look at the total market and how to leverage it. Eichhorst expressed misgivings about business plans predicated on the ability to sell data that are free. Mr. Jurczyk noted the need to provide the regulatory environment to enable commercial remote sensing. Mr. Oschmann pointed out that those that succeed take free data and add value that can be sold to meet a demand. Some of these efforts require an “anchor tenant” that is sometimes the U.S. government. He gave an example of two companies, one of which collapsed.
Mr. Jurczyk next discussed the Centennial Challenges. One Challenge involves a 3-D printed habitat, using Mars soil to create a structure. There are 28 teams, five of which are international and therefore ineligible for the award. Caterpillar, Inc., is running the challenge along with Bradley University. NASA hopes to leverage what is learned. These Challenges help investigators learn what is possible for future, while also bringing in non-traditional contributors. There is also a lot going on with Game Changing Development (GCD), where the Deep Space Optical Communication (DSOC) effort is transitioning. The Neutron star Interior Composition Explorer (NICER) and SEXTANT was on the launch schedule for ISS.

Another effort is an extreme environment solar power project, which seeks to use solar power in low light and low temperatures. More work is being done on Mars Entry, Descent and Landing (EDL) models. NASA just gave out a high performance computer award involving modular cores that can be added as needed, providing more flexibility. There has been some slow progress on materials for thermonuclear propulsion. A collaboration on two reactor designs could result in a need for greater funding for a prototype reactor, which would likely come from the Human Exploration and Operations Mission Directorate (HEOMD) budget. The goal is to reduce trip time. There are multiple challenges, however.

STMD and the Astrophysics Division (APD) are partnering on some Wide Field Infrared Space Telescope (WFIRST) technologies, particularly the coronagraph. The Deep Space Atomic Clock (DSAC) is ready to be sent to New Mexico for testing; it will need some work before deployment, however. Although the budget does not provide funds for the Asteroid Redirect Mission (ARM), STMD will proceed with the electric propulsion work that is in the budget.

STMD is working toward a 2019 launch for the Laser Communication Relay Demonstration (LCRD), with some funds from HEOMD’s Space Communications and Navigation (SCaN). The Mars Oxygen In Situ Resource Utilization (ISRU) Experiment (MOXIE) is in the concept stage, and terrain-relevant navigation is being worked on to direct landing. All other landings have been blind, but this will not be, enabling the avoidance of hazards. The Planetary Science Division (PSD) is working on a 2020 launch, but Mr. Jurczyk was not sure that that date will be met. There is an integrated Evolved Cryogenics (eCryo) test pending at the Glenn Research Center (GRC). In the area of satellite services, the Restore-L project, to refuel Landsat-7, is still in formulation. There will be a project design review (PDR) in the fall. STMD decided to fund a propellant transfer test on ISS, to fly in 2018.

Mr. Jurczyk next turned to the budget. The Fiscal Year 2017 (FY17) budget had not been enacted at the time of the meeting, and NASA was operating under a Continuing Resolution (CR). Mr. Jurczyk pointed out that there were only 7 legislative days before the April 28 expiration of the CR. He was not at liberty to discuss details of the FY18 President’s Budget Request (PBR), but STMD’s proposed budget was down about 1 percent, which was 4 percent when accounting for inflation. Restore-L would be cut by $88 million, which would not allow the flight portion of the effort to continue. The PBR also directed STMD to look at collaborating with the Defense Advanced Research Projects Agency (DARPA). Otherwise, they will need to transfer the technology to industry.

Mr. David Neyland asked about the impact of defunding ARM. Mr. Jurczyk replied that there was some synergy with satellite services that will be lost and which will hurt funding at the
Goddard Space Flight Center (GSFC). Also in the budget was some work planned for the Europa landing. PSD has its own technology program and will continue to work with STMD on a lander concept, but the STMD portion was taken out of the PBR, though Congress may put it back in. The Europa Clipper funding remains.

The HEOMD Associate Administrator, Mr. William Gerstenmaier, planned to discuss the maturation of the deep space exploration gateway at the upcoming NAC meeting. High-power Solar Electric Propulsion (SEP) is in every permutation, and there will be a need for cryogenic propellant storage and transfer. Significant progress has been made for locks with oxygen storage, but not for hydrogen storage. Mr. Gerstenmaier believes that these in-space elements need to be reusable. STMD will look at early-stage investments based on HEOMD plans.

**Space Technology Research Institutes Overview**

Dr. Jay Falker, STMD Early Stage Portfolio Executive, explained that the goal of the STRI program is to have a large, focused and sustained effort for each participant. The Institutes are based at universities and help develop the future talent base. The Program used a two-step review model. After receiving 40 preliminary proposals, the Program invited nine to submit for Stage 2 in two topics. All nine proposals were competitive. In each case, an outstanding proposal rose to the top. STMD is in the contract negotiation phase.

Each Institute will receive $3 million per year for five years, along with NASA guidance and the involvement of NASA personnel. STMD did not define the structure of the Institutes and sought multi-organization, multi-disciplinary efforts. The Program wanted to avoid duplication of work that could be done with other grants. The official Principal Investigator (PI) for each Institute must be a tenured scientist or engineer at a university, but co-Investigators (co-Is) could have other backgrounds. Industry and nonprofits were allowed to team, but at least 70 percent of the funds had to go to U.S. universities. In addition, Federally Funded Research and Development Centers (FFRDCs) could participate, but not receive funding. The Program sought to avoid pass-through situations.

The Program also hoped to encourage flexibility, as next steps take into consideration what is happening with industry and international efforts. The outcomes will include publications, which constitute a requirement, and some demonstrations. Regarding intellectual property, they will follow the NASA template. In most cases, the proposals showed what they had and why they could move onto next step.

The first topic was bio-manufacturing for deep space exploration and encompassed in situ microbial media production; in situ production of mission products; and in situ food production, which also has mission pull. The winner was a University of California-Berkeley-led team, the Center for the Utilization of Biological Engineering in Space (CUBES). STMD and CUBES are still negotiating the award. This team has proven success in some other areas that apply to the Mars environment.

The second topic was computationally accelerated materials development for ultra-high strength lightweight structures. This area has a history of almost 30 years at NASA and is almost at the tipping point, making it a great area for investment. The goal is to at least double the state of the art. Dr. Falker reviewed the project’s features and approach to developing and testing materials more rapidly. The top competitor was the Institute for
Ultra-Strong Composites by Computational Design (US COMP), led by Michigan Tech and organized into a framework of multiple parallel activities.

Mr. Neyland thought this was an interesting approach to address basic research, but the funds seemed relatively minor. Mr. Jurczyk explained that, after some debate, NASA chose to be very specific with the research requirements. They will learn from this and think about it moving forward. The duration was chosen as the result of conversations with universities. This seemed to be the minimum level needed in order to make significant advancements. At the same time STMD was conservative with the number of awards in order to commit to funding they were confident that NASA can provide. He did not want to put out a solicitation that might be pulled at a later date. Finally, they want to see how this goes. If it succeeds, they may consider extensions. Compared to previous projects, the Institutes comprise a mix of new and established groups.

**NASA’s Barriers to Innovation and Chief Technologist Update**

Dr. Douglas Terrier, Acting Chief Technologist, explained that OCT is rebuilding its staff to mirror the Office of the Chief Scientist (OCS). OCT will now do more analysis of the portfolio, and on a quarterly basis instead of annually. Part of his responsibility parallels that of industry, which would have someone watching external developments in order to anticipate potential disruption. NASA can do more of that through benchmarking and collaboration with industry and academia. OCT is also working closely with the Department of Defense (DOD) and others.

At the last TI&E meeting, the Committee gave OCT an action to report back on barriers to innovation. There has been significant NASA activity to identify these barriers, along with some external analysis. There have also been efforts to identify gaps and potential solutions. This has been communicated to the Administrator, and OCT will develop a framework to carry it forward. Dr. Ballhaus pointed out that incentives constitute another issue. He observed that there were fewer barriers in the early days of NASA, when there were also the incentives of publication and impressing center directors. These are some of the cultural issues to address.

Dr. Terrier described innovation surveys, which go back to the 2011 Employee Satisfaction Survey. The Survey found that 93 percent of NASA personnel were looking for things to do better, but only 74 percent felt encouraged to do so and just 61 percent felt that such efforts were rewarded. Dr. Ballhaus said that Research and Development (R&D) cultures have to be managed differently. New grads might not understand that certain steps are in place as a result of a past failure and the subsequent analysis. Dr. Terrier agreed that NASA wants to enable innovation yet retain the rigor. A recent survey found that NASA is first in innovation among large Federal government agencies in terms of adopting the best commercial practices.

In order to identify challenges, OCT defined innovation, broadly engaged all of the field centers, identified Agency-level barriers, and summarized barriers into categories. Risk aversion is appropriate in some projects but bleeds into all of them, so that must be tailored. Another issue is short-term focus where there should be long-term vision. Yet another problem is instability, along with lack of opportunity. Process overload, communication challenges, and organizational inertia are issues as well; the communications and organizational issues tie together.
OCT felt that this represented what was faced across the Agency. The Office then began looking for solutions, especially those that might address multiple categories of barriers. After identifying a number of solutions, OCT organized them into seven areas. OCT also hopes to be able to recognize those who made good attempts that might not have succeeded. The idea is to ensure that innovation efforts are rewarded. Funding is always an issue, however.

Dr. Terrier presented a solution matrix and gave examples of activities such as the innovation framework and innovation portal that OCT is developing in order to open communication and reduce stovepipes. Charles Bolden, the recently retired NASA Administrator, said that 10 percent of a NASA employee’s time should be for thinking that is not devoted to a specific issue. The innovation labs are a solution reflecting this statement, as they enable small-scale testing. OCT is trying to get the best practices from this area across centers. Mr. Michael Johns asked how long it takes a person to get funded on an innovation. Dr. Terrier said that a proposal to fund time and equipment can be a couple of pages, and the awards are made at least once a year.

Dr. Ballhaus described the mission pull in the 1950s and '60s innovation period. Budgets were less of a problem, and centers could provide funds. That, combined with intellectual leadership, was a strength. An engineer with a good idea could implement it. Since then, a series of administrators have shifted to a headquarters-centric model, resulting in a loss of speed, which is essential to innovation. He asked if it were possible to model anything from that time to improve innovation. Dr. Terrier said that more focus on specific missions is optimal. The Center Innovation Fund (CIF) complements resources at the centers, enabling internal research and local decision-making power. He is looking at how to support local center work, which would be a different mechanism.

Nearly all ongoing solutions tackle more than one barrier. There are over 120 solutions, some of which Dr. Terrier described. Prizes and challenges have increased in number and scope, providing continuous funding to innovative efforts while investing in future inventors and entrepreneurs. Dr. Ballhaus said that the NAC had discussed how to bring in young people to innovate. The thinking was to first assign young people to a big mission in order to learn how the system works. That way, they will have the structure when they move onto their own smaller innovations. Doing otherwise created problems in the past with launches that failed in the 1990s. Since the Jet Propulsion Lab (JPL) put this in place, there have been no more of these failures. Now NASA should tailor the processes to the needs and risk profile of the mission, which is a real art and something he would like to see emphasized.

Mr. Jurczyk said that there have been recent challenges in tailoring requirements. For example, there are four categories of missions, A-D, which can be tailored. However, making a transition from A&B to C&D is difficult. When risk amplifies, there is a cost increase, which leads to more caution and slows movement. Those are things STMD is working on. Mr. Oschmann said that sometimes the effort to do a detailed risk assessment takes more time and cost than it does to be cautious. It is getting better but still constitutes an issue. Mr. Jurczyk replied that the processes were put in place for a reason. Every failure results in a process. However, there is never a reset. Instead, the process is to address every problem that NASA has ever had. The Agency needs to empower people to use their expertise and judgment here.
Dr. Terrier reviewed a number of additional solutions, such as the innovation framework and portal, corporate time for creative thinking, and the center labs. The innovation framework unifies the Agency vision for innovation and allows citizens and civil servants to actively engage. The lack of creative thinking time has been reported as a big challenge, and the center labs support individual projects. The path forward emphasizes those capabilities. OCT is the corporate sponsor of those frameworks while expanding collaboration with external sources. The Office wants to provide access and is looking at coordination, augmentation, leveraging, and conducting a range of innovation activities in every NASA center and mission directorate.

Dr. Ballhaus observed that industry does not seem to have a mechanism to get sole-source funding for an idea and asked if there might be a way to get more innovation from industry earlier. Dr. Terrier said that the Air Force has mechanisms for innovation, and has invited NASA to join them on a scoring competition for very early stage and classified innovations. He would like to adapt that. They have to be creative to incentivize industry to share ideas.

Mr. Neyland asked about the difference between the March to the Moon and the current effort, and whether the current matrix would have allowed lunar exploration. Dr. Terrier replied that the current focus is on the smarter way to do things. If one looks at the Apollo missions, much work was done organically. Without a mission pull, NASA needs different incentives. Mr. Jurczyk added that when NASA gives a team a clear set of challenging requirements and the resources to innovate, they will do it. The talent and drive are still there. The issue is the lack of constancy of purpose and the disruption and change that has occurred in the last couple of decades. There has been neither a trajectory nor a national consensus on what to do. However, if one looks at the James Webb Space Telescope (JWST) as an example, and what had to be done to enable that, the results are impressive.

Mr. Oschmann noted that it is impossible to act on all the great ideas, which leads to disappointment. A larger purpose prevents that. Mr. Jurczyk said that the focus should be on human exploration of the solar system, which encompasses transportation and surface exploration goals, plus science missions.

Dr. Ballhaus pointed out that large companies have established processes and focus on keeping overhead budgets low. Processes have to be continually updated. Anomalies or hardware damage pull in management attention, and not everything is funded. This is not a widely known problem, but it is common. He was not sure how pervasive this is at NASA centers. Mr. Jurczyk said that NASA is trying to address this. There are some long-term processes and assumptions at NASA that predate most of the employees using them, which needs to be examined.

**Update on STMD Strategic Implementation Plan**

Ms. Trina Chytka, Acting Director of Strategic Integration and Planning for STMD, and Mr. William Cirillo, of the NASA Langley Space Mission Analysis Branch, provided an update on STMD’s Strategic Implementation Plan. Mr. Cirillo explained that the primary purpose of the effort was to reframe the strategy to emphasize challenges and outcomes, as opposed to methodology. One of the goals was to have a process to clearly articulate the potential ramifications of budget and schedule changes.
The current STMD strategic framework moves along a ladder from alignment of values to implementation. NASA is trying to pull stakeholder involvement higher up the ladder to an earlier step. STMD is trying to establish itself as providing value and furthering the national interest, while also addressing individual capabilities. HEOMD has a group to support strategic analysis, and STMD has members associated with all of those teams.

Dr. Ballhaus stated that TI&E has been concerned about the lack of long-term mission plans. It sounds like that communication is occurring in an ad hoc way. The Agency needs to identify the impact of changes with an independent agency analysis capability in order to explain that. Mr. Cirillo said that from an independent analysis capability standpoint, Langley has served that purpose for a while, though they could use more resources.

Mr. Cirillo reviewed the steps involved in this effort. In Step 1, the introduction of quantifiable capabilities (QCs), the team developed 38 QCs that are an integral part of the strategic framework. Step 2 was Transformative Themes, of which there were six, encompassing the 38 QCs and shifting from an internal, discipline-centric focus to a customer, impact-centric focus. The team put a series of strategic thrusts against the themes. Regarding themes of the new administration, the six Transformative Themes constitute the clearest articulation of that direction, to grow and utilize the U.S. industrial and academic base. Mr. Jurczyk added that there have been no significant changes in the goals thus far, so the strategy does not change significantly. The recent re-authorization signaled that they should stay the course. The Office of Management and Budget (OMB) wants to make some shifts, and Vice President Michael Pence wants to re-establish the Space Council with the integrated space enterprise across the nation, but nothing has yet been specified. Dr. Ballhaus observed that Republicans do not want to pick winners and losers, though they do they want increased emphasis on national security. Mr. Cirillo agreed, as did Mr. Jurczyk, who added that they like the commercial cargo/crew approach and want more of that.

Mr. Cirillo next reviewed the impact and challenges of the transformative themes. Each transformative theme has several associated thrusts. The last theme he listed was to grow and utilize the U.S. industrial and academic base. The final step of the process involves the mega-drivers, which are identified in discussions with stakeholders, along with research and analysis. This was just rolled out to STMD. Dr. Ballhaus said there is a need to articulate where STMD makes a difference, or where it should not become involved.

Dr. Chytka pointed out that this plan was developed with the involvement of the other mission directorates in order to ensure that they are all in alignment. Mr. Jurczyk explained that he has frequent discussions with industry. There needs to be a way to gather and analyze that information, and feed it into the strategy. It takes time to do strategic planning, but STMD is making progress.

Small Spacecraft Technology Study Final Report
Dr. Bhavya Lal, of the Institute for Defense Analyses (IDA) Science and Technology Policy Institute (STPI), presented the final report on the Small Spacecraft Technology Study. The purpose of the study was to identify the focus of STMD’s smallsat investments. The study team examined smallsat developments and STMD’s smallsat portfolio, while also identifying NASA’s small spacecraft needs, conducting a gap analysis, and making recommendations.
For purposes of the study, smallsats were defined as having a mass of up to about 200 kg, though there were occasional exceptions up to 500 kg. The team conducted about 60 interviews across industry, NASA, other government agencies, academia, and the nonprofit sector. Finally, the team developed its own database.

The first finding was that “industry” is a misleading term when it comes to smallsats. There are about nine elements in the value chain with various levels of actors. This is a very complicated industry with different parts moving at different speeds. About 70 countries have smallsats or are part of the smallsat ecosystem. Some countries have an academia-based ecosystem, whereas it is industry-based in the United States. Companies have global supply chains and customers. The trend is to functional disaggregation, and anyone can purchase turnkey service. The International Traffic in Arms Regulations (ITAR) are a concern in the United States; at least one company keeps its operations elsewhere because of them.

There is a perception of huge growth driven by market demand. The expectation is that at least 3,600 smallsats will launch in the next decade, with a large remote sensing market. The difference between the late 1990s and the current situation is that there are “deep pockets” for investment, while input technologies are much cheaper. There are also many more launch options worldwide. Dr. Ben Corbin added that the technological maturity of the systems and markets is higher, and the revenue pool is large. Dr. Lal noted that private funding, including VC, may exceed government funding by an order of magnitude or more.

The study team identified 139 U.S. actors in the “upstream” side, which is where STMD is most active. Most other government funding focuses on mid- and downstream actors. Private investment may not overlap STMD investment. Companies that focus on upstream technologies are not as effective as those in mid- and downstream areas. There is also an issue of keeping upstream work proprietary. Some companies do not conduct R&D, for example, beyond trying to make technologies cheaper. Mr. Neyland pointed out that there is a discontinuity between the study conclusions and what the company OneWeb is stating. He wondered if this might be too quick a dismissal. Dr. Lal said that the government will not always be at cutting edge of everything, but there are areas that private investors will avoid because there is no return, it is too early, or the information is proprietary.

Dr. Ballhaus asked about satellite builders moving to commodification. Dr. Lal replied that the interviews showed that it depends on the size and request of the customer. Some companies develop new concepts of buses with a mix-and-match approach. It is the “wild West” of satellite development. Government corrects for both market and systemic failures, areas in which the private sector avoids investment or even involvement. The smallsat ecosystem is multi-layered. Government should be involved in technology platforms, industrial commons, and strategic planning. Venture capitalists do not invest in early stage research. Mr. Neyland took issue with the last statement and did not believe the study team would have had access to the VC investment information. Dr. Lal replied that this came from the national VC association. Mr. Neyland explained that he asked for this study and supported the conclusion but wanted to get there in a different way. The total amount that seed funders provide is substantial. Dr. Lal said that they are investing in operations rather than developing the newest propulsion methods.
The team determined that STMD focuses on the needed technology areas and TRLs; the areas that are considered important are the areas that are funded. One of the challenges is that different parts of the ecosystem have different needs. Upstream firms need proven technology that is more affordable, while NASA needs technology to be state-of-the-art with lowered risk. NASA centers must be competitive for missions. Commercial operators sometimes just want NASA to buy their data and lack the perspective of the government’s history in development. Finally, some downstream firms are source-agnostic and do not distinguish among data by source. Another challenge is that STMD’s Small Spacecraft Technology Program (SSTP) has not articulated or broadcast a clear mission. There are organizational and management issues as well. These reflect an absence of metrics to assess if the program is being managed effectively or meeting expectations.

The study team’s first recommendation is to fund precompetitive R&D in platform technology and risk reduction, as well as industrial commons. The companies interviewed wanted to keep their information proprietary, however, so there may be inadvertent overlap of government funding. Regarding industrial commons, funding a virtual institute could address this area. Mr. Jurczyk said that there is a need to get to the point of using a more strategic approach rather than a target of opportunity approach.

Dr. Lal presented the second recommendation, to develop and communicate an SSTP mission statement as part of a broader STMD strategy. The third recommendation was to maintain independence from users. To ensure funding of high-risk, high-payoff technologies, the program should be managed from Headquarters rather than centers with parochial interests. Mr. Jurczyk said that science needs to be upstream early on. It is important to avoid putting an “island” on the critical path. Dr. Ballhaus cautioned against treating “island” people like subcontractors. They need to be more independent and not have the push.

Dr. Lal presented the fourth recommendation, to require transition partners on every project, whether there is a technology push or pull. The partners can be advocates for the project and program. Mr. Jurczyk noted that GCD only funds those projects with a path and a probability of infusing the technologies. Dr. Lal listed additional recommendations, for metrics, continual monitoring and evaluation, and autonomy for program managers. Dr. Matt Mountain asked what might be constraining the program managers. Dr. Lal replied that constraints include earmarks, designation of funds to particular centers, and other elements affecting the ease with which some projects can be done.

In summary, STMD is one of many investors in the smallsat ecosystems, and while it does support what stakeholders view as most important, the primary challenges relate to lack of communication and coordination. It is very important that STMD maintain independence, communicate a mission statement, and implement the recommendations.

Mr. Jurczyk said that at the next TI&E meeting, STMD will discuss how the Directorate will address the recommendations. He understood that the program is generally investing in the right things but needs to be more strategic. Mr. Neyland said that a clear articulation among the customers, stakeholders, and transition partners was still missing. It was an outstanding study, but he would have liked more on the relationships. NASA needs to do the hard things that no one else can do.

**Entry, Descent, and Landing Update**
Dr. Lanetra Tate, GCD Program Executive, and Ms. Michelle Munk, EDL Principal Technologist, provided an update on EDL activities. Ms. Munk described the EDL system goals. The external application is returning commercial assets from space. She listed quantifiable objectives and showed the current portfolio of programs in GCD.

The bulk of the work is focused on Mars. Ms. Munk showed a graphic of launch opportunities, robotic missions, and the tonnage needed to get to the surface. The goal is to land humans on Mars in the 2030s, which will require conveying 15 to 20 tons of mass to the Mars surface. The program will need accuracy of less than 100 meters and near global access for the humans. Global access would enable landing anywhere on the planet. NASA is now engaged in architecture selection, with flight tests on Earth and some work on Mars. This will need to scale up into implementation development in the 2020s, leading to system development and implementation in the 2030s.

The program has four QCs, grouped to be distinct but collectively comprehensive: 1. High Mass to Mars Surface (HMMS); 2. Planetary Probes and Earth Return Vehicles (PP/ERV); 3. Precision Landing and Hazard Avoidance (PLHA), which will be very cross-cutting; and 4. EDL Data Return and Model Improvement (DRMI). Modeling is particularly critical due to the limitations of replication and testing on Earth. Ms. Munk describes the heat shield sent on Curiosity Rover, noting how that compared to the model. NASA will use this approach again on Mars 2020. A color-coded chart showed the HMMS maturation approach. NASA is partnering with SpaceX on the Red Dragon 2020, and there are some candidate systems for landing on Mars. Ms. Munk also showed the PLHA maturation approach and the EDL Systems Overall Principal Technologist (PT) investment strategy.

Dr. Tate said that GCD strives to deliver infusion-ready technology in conjunction with academia, industry, and others. EDL constitutes 31 percent of the GCD portfolio for 2017. There is a clear infusion path for each technology, and STMD keeps the customers in mind when making investments. The Heatshield for Extreme Entry Environment Technology (HEEET) is being considered for both NASA and European Space Agency (ESA) projects. GCD is investing in two architecture study technologies.

Ms. Munk described the four candidates for the hypersonic entry technologies under consideration for a human Mars mission. All use supersonic retro-propulsion, as STMD has determined that parachutes are not viable for this. Dr. Tate next discussed the Adaptable Deployable Entry and Placement Technology (ADEPT). There will be a sounding rocket test to understand deployment and landing, as well as a drop test. The Hypersonic Inflatable Aerodynamic Decelerator (HIAD) takes on materials and the manufacturing process. Ms. Munk discussed the Cooperative Blending of Autonomous Landing Technology (COBALT) and the Propulsive Descent Technologies (PDT). The latter is a partnership with SpaceX for support to the Red Dragon technology demonstration mission being done as part of the commercial crew services contract.

As an example of infusion, Dr. Tate described how, following the deaths of 19 firefighters in 2013, some Langley engineers approached the U.S. Forest Service to discuss flexible thermal protection materials that NASA had been developing for its own purposes. Testing of these materials was about to take place, after which the Forest Service would look at infusing the materials into its system.
Dr. Mary Ellen Weber asked about ADEPT compared to HIAD. Ms. Munk said that they relied on two different material systems. The ADEPT system is more applicable to Venus or outer planet explorations, while HIAD is best for Mars. SMD has sought their continued development.

**Discussion and Recommendations**

Dr. Ballhaus did not see anything to take forward as a finding or recommendation, though he did think there would be some updates to NAC, especially since there is a new NAC chair. Dr. Mountain noted that the reauthorization bill explicitly called out technology development. Mr. Jurczyk added that there were some specific recommendations, like deep space transportation technologies that reduce trip time, and advancing satellite servicing capabilities. He found it a bit troublesome that the Administrator must certify that there are no redundant investments. STMD ensures that its investments are relevant and complementary, so that is not new, but the Administrator will have to sign a memo to that effect.

Dr. Ballhaus suggested that they remind the new NAC chair of the TI&E charter, which is technology across the Agency. This is broader than STMD. He wanted to then bring up the authorization language and show how TI&E connects back to that language. Mr. Jurczyk noted that SBIR accounts for 3.2 percent of extramural R&D and was just reauthorized. It is currently on a downward trajectory, and STMD has gained some flexibility. He did not see the need to raise it as an issue. Dr. Ballhaus agreed, preferring to review thrust areas requiring additional investment. He started with lightweight structures, and said TI&E might say they were encouraged to see the Agency continue to deepen its understanding and quantification of capability needs associated with human deep space missions. He also suggested they state that they recognize the value of the close working relationship among HEOMD, SMD and STMD.

Dr. Mountain observed that STMD needs to have a mission as a driver. Mr. Jurczyk advised waiting until after Mr. Gerstenmaier’s human exploration presentation at the NAC meeting. Dr. Ballhaus said that he would note that TI&E was concerned about generating and encouraging innovation within the Agency, and heard a presentation on that at this meeting. Mr. Jurczyk said that successful missions typically have funding profiles that reflect the normal flow of development work. He added that STMD will respond to the IDA study at a future TI&E meeting. Dr. Ballhaus said he would get from Mr. Jurczyk a list of milestones and significant accomplishments.

The STMD strategic implementation plan was organized by outcomes rather than disciplines. The Committee agreed to use a couple of the slides emphasizing the six themes. Dr. Ballhaus planned to describe the STRIs based on Dr. Falker’s presentation. He noted that, regarding Dr. Terrier’s presentation, OCT volunteered to address this topic. There was some discussion about the approach presented. Mr. Neyland thought it had been somewhat generic and reflected bureaucracy more than a clear mission. Dr. Weber said that she did not understand the presentation as offering solutions but rather as a survey pointing to the need for solutions. Mr. Eichhorst said that ownership is key, and that someone at the top needs to own the question of whether NASA has a culture of innovation. It needs to be enforced at every level.
Dr. Ballhaus saw clear impediments to innovation at NASA, noting the involvement of powerful intellectual leaders during the space race. Mr. Neyland pointed out that none of them had bosses who had been in their jobs for 35 years. It is symptomatic of a culture. The organization still has not identified the problem of innovation. Dr. Weber observed that NASA has a Chief Technologist and a Chief Scientist, but not a Chief Innovation Officer. Dr. Ballhaus was concerned that it is now difficult for those at NASA to get the time and funding to work on their ideas. Maintaining technology capabilities in some of these disciplines is difficult for NASA. Dr. Mountain said there is leadership in science missions because they are very specific. HEOMD is all over the place, however, reflecting the lack of a mission.

Mr. Jurczyk said that stakeholders want technology that will enable missions, and the funders are not interested in anything else. Even early stage investments have to be able to tell the story of where they will go. There is some effort now to free up discretionary funds at the centers, but the Agency is not thinking about going back to the way things were. Dr. Kathleen Howell said that cultures are not developed from the top down, but rather from the bottom up. That means that NASA must attract the game changers to the Agency, and there is no clear way to manage that. The first step may be to change the outside view of NASA. The best and brightest are often now attracted to small organizations where they can do more, and do it quickly. Dr. Ballhaus observed that some of those efforts will fail, but they will be exciting. Mr. Jurczyk explained the pipeline to JPL, the centers, SpaceX and other organizations.

Dr. Weber thought that the finding was that NASA is not an innovation-centric organization the way it once was. There is not a “sandbox” to explore the world of ideas. Perhaps the TI&E finding was to say that there are challenges that require changes. Dr. Ballhaus thought they were not ready for a finding. He planned to say that NASA is an innovative agency in the government, but there are increased barriers and impediments, and there is no major driving mission. Dr. Mountain noted that the science missions do have drivers, however, as well as technology demonstrations. He advised complimenting OCT and other organizations for their efforts to promote innovation. NASA has tried to eliminate some of the barriers. Mr. Jurczyk asked TI&E to bring their ideas to STMD so that the Directorate can address how to create opportunities in the current environment. Mr. Oschmann said that an alternative would be to have OCT organize and categorize priorities, and relate them to the priority areas. Dr. Ballhaus noted the importance of speed for innovation.

On small spacecraft, he planned to share the presentation’s findings and recommendations with the NAC. He also wanted to include the charter, a chart on process, and data sources. On EDL, he wanted to adapt a couple of slides showing technologies in development.

**Adjournment**
The meeting was adjourned at 4:57 p.m.
APPENDIX A

Agenda

NAC Technology, Innovation and Engineering Committee Meeting
March 28, 2017
NASA Headquarters
MIC 3A&B

March 28, 2017 – 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
Dr. William Ballhaus, Chair

8:15 a.m. Space Technology Mission Directorate Update
Mr. Stephen Jurczyk, STMD Associate Administrator

9:15 a.m. Space Technology Research Institutes Overview
Dr. Jay Falker, STMD Early Stage Portfolio Executive

9:45 a.m. Break

10:00 a.m. NASA’s Barriers to Innovation and Chief Technologist Update
Mr. Douglas Terrier, Chief Technologist (Acting)

11:15 a.m. Update on STMD Strategic Implementation Plan
Ms. Trina Chytka, Director, STMD Strategic Integration and Planning (Acting)

12:00 p.m. Lunch Break (Ethics Training for TI&E Members with Kathleen Teale, NASA OGC)

1:15 p.m. Small Spacecraft Technology Study Final Report
Dr. Bhavya Lal, IDA Science and Technology Policy Institute

2:30 p.m. Entry, Descent, and Landing Update
Dr. Lanetra Tate, Program Executive, STMD
Ms. Michelle Munk, EDL Principal Technologist

3:15 p.m. Break

3:30 p.m. Discussion and Recommendations (FACA Open session)

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
Dr. Kathleen C. Howell, Purdue University
Mr. Michael Johns, Southern Research Institute
Dr. Matt Mountain, Association of Universities for Research in Astronomy
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
Gordon Eichhorst
Kathleen Howell
Michael Johns
Charles (Matt) Mountain
David Neyland
Jim Oschmann
Mary Ellen Weber

NASA Attendees:
Christopher Baker
Kathleen Boggs
Trina Chytka
William Cirillo
Anyah Dembling
Prasun Desai
Jay Falkner
Stephen Jurczyk, STMD Associate Administrator
Rick Klief?
Michelle Munk
Andrew Petro
Dave Steitz
LaNetra Tate
Kathleen Teale
Douglas Terrier

Other Attendees:
Asha Balakrishnan, STPI
Pablo Buitrago, ServiTech
Ben Corbin, STPI
Ellen Green, STPI
Linda Karanian, Aerojet Rockledge
Bhavya Lal, STPI
Michael Ledford, Lewis-Burke Assoc.
Urvashi Mehra, ServiTech
Amy Reis, Ingenicomm
Michelle Rodrigues, SRI International
Elizabeth Sheley, Ingenicomm
APPENDIX D

Presentations

1) Space Technology Research Institutes (STRI) [Falker]
2) Innovation at NASA [Terrier]
3) Update on STMD Strategic Implementation Plan [Chytka, Cirillo]
5) Entry, Descent, and Landing (EDL) Strategy and GCD Program Investments [Munk, Tate]