



NASA Advisory Council (NAC) Aeronautics Committee

November 12, 2015
NASA Headquarters, Washington, D.C.

Summary of Meeting Minutes

Participants:

First	Last	Organization	Role
Dr. Dava	Newman	NASA	Deputy Administrator
Marion	Blakey	Rolls Royce North America	Chair
John	Borghese	Rockwell Collins	Vice Chair
Dr. Michael	Francis	United Technologies Center	Member
Dr. Missy	Cummings	Duke University	Member
Dr. Lui	Sha	University of Illinois	Member
Dr. John-Paul	Clarke	Georgia Tech	Member
Tom	Wood	Bell Helicopter	Member
Mark	Anderson	Independent Consultant	Member
Stephen	Morford	Pratt & Whitney	Member
Dr. Karen	Thole	Penn State University	Member
Brenda	Mulac	Aeronautics Committee	Exec. Secretary
Jay	Dryer	ARMD AAV Program	Director
Susan	Gorton	ARMD RVLT Project	Manager
Doug	Rohn	ARMD TAC Program	Director
Akbar	Sultan	ARMD AOS Program	Dep. Prog. Director
Richard	Barhydt	ARMD TAC Program	Dep. Prog. Director
Robert	Pearce	ARMD OAA	DAA / Strategy
Dr. John	Cavolowsky	ARMD AOS Program	Director
Irma	Rodriguez	ARMD	Exec. Secretary [To Be]
Jon	Montgomery	ARMD OAA	DAA / Management
Dr. Edgar	Waggoner	ARMD IAS Program	Director
Parimal	Kopardekar	ARMD SASO Project	Manager
Dr. Jessica	Nowinski	ARMD SMART-NAS Project	Research Scientist

Thursday, November 12, 2015

The meeting was called to order at 9:31 a.m.

Introductions

Dr. Jaiwon Shin, NASA Associate Administrator for the Aeronautics Research Mission Directorate (ARMD), welcomed members and announced that because Ms. Brenda Mulac has accepted another assignment within NASA, Ms. Irma Rodriguez will be the Committee's new executive secretary. NASA deputy administrator Dr. Dava Newman joined the meeting and thanked the Committee for serving. Dr. Newman said she was a big fan of Dr. Shin's strategy, and thinks the upcoming year will be a good one. She hoped outstanding budget issues will be resolved. After Committee self-introductions, Dr. Newman mentioned NASA's Mars-related research, and technology innovation efforts, and education and outreach. She said she was on board 100% with the President's science, technology, engineering and math (STEM) initiative, especially as it relates to young women, and welcomed questions. Dr. Newman said that she knew that ARMD had worked hard on hypersonics, an initiative that will continue with the involvement of the White House and the Defense Advanced Research Projects Agency (DARPA); such investments are critical. And what will be done in terms of the next-generation workforce? Such skills are essential, and must be built up in the years to come. Dr. Newman is learning much regarding ARMD's work with unmanned aerial systems (UAS) and unmanned aerial systems traffic management (UTM).

Ms. Blakey said the things Dr. Newman are tracking are highly aligned with the Committee's work, adding that the ARMD strategic plan is excellent. The Committee's work on UTM and small UAS has progressed. But: how to come up with a system that truly works? Vertical lift is on the agenda for this meeting.

In response to Dr. Newman's observations, Mr. Mark Anderson said that he really appreciated her comments about supersonics, hypersonics, UTM and green aviation. Each of those areas is a great chance for NASA to get out in front of the new generations; electric propulsion and biofuels are also important. Dr. Newman mentioned the Boeing ecoDemonstrator, a flight-test program to accelerate new technologies that could reduce emissions and noise, improve airlines' gate-to-gate efficiency and help meet other environmental goals. Students are interested in tying technology to energy and the environment.

Dr. Michael Francis said that the unmentioned elephant that enables UAS is machine intelligence. It's not your father's machine intelligence; rather, it affects everything one does, moving across all boundaries: "I make a plea to the higher levels [to consider that]." A brief discussion ensued about autonomy and autonomous systems. Dr. Newman wondered where the gaps are. Dr. Francis said that the machine and intelligence must be married. Dr. Newman said that humans are always in the loop. It's definitely a capability that NASA is tracking. Hard decisions will have to be made in terms of funding and where the research is done. Capabilities must also be mapped to see where things are going.

Committee Vice Chair Mr. John Borghese said that it was heartening to witness Dr. Newman's mention of collaboration with other government agencies. There is an explosion of activity as regards new technologies for near-space missions 20 to 100 miles up. Dr. Newman said that NASA wants to get international partners to sign on for

International Space Station (ISS) commitments through 2024. There should also be new partnerships with industry. How will industry lead and transition?

In terms of center-research realignment, Dr. John-Paul Clarke wondered where the researchers will go. Dr. Shin responded by saying that ARMD is not trying to physically move people, but coordinate so each center's capabilities are known. Dr. Newman said it would be a more focused approach, involving devoted teams and close coordination and coordinated intellectual focus. Dr. Shin added that three to four years ago, ARMD leadership teams really stepped up. There is an effort underway to trim down excessive capabilities. That will be a big challenge.

Dr. Clarke asked that, as the core competencies are prioritized, if the results will be made public. Dr. Newman answered that NASA would need to accomplish that in the current [2016] fiscal year, so that everything is firmly in place as a new administration comes into office.

Dr. Karen Thole wondered what Dr. Newman's thoughts were about technology innovation. What are the new ideas? Dr. Newman said that, at government agency gatherings, NASA tends to be the star agency. Other agencies want to know about NASA best practices. Most are interested in human capital approaches, such as senior engineers mentoring junior engineers. NASA is now mapping capabilities in terms of innovation, in the process "melting the permafrost" in terms of middle management. NASA management sees great things happening at its research centers. What can be scaled up? There is no charge code for innovation: it must be part of the culture.

Dr. Lui Sha said that innovation and human capital are really important. There's no longer as much excitement among university graduate students. There is a need to reach out more. Dr. Newman said she would push back on that a bit. Intern interest remains high, as evidenced by attendance at All Hands meetings. But NASA does need to involve them in a career track. NASA does need more funding, of course, to send out more university grants, especially in aeronautics. Dr. Shin praised Dr. Newman, saying that Committee members should know from day one she has been very supportive of aeronautics. Dr. Newman said that aeronautics is her love; she is an aerospace engineer.

Dr. Shin said that the ARMD reorganization was approved at the end of September.

Vertical Lift Project by Susan Gorton

Dr. Francis wondered why Ms. Gorton's slides were all oriented toward rotorcraft; no turboprop engine was included. Ms. Gorton replied that the project's partner programs do such studies. Mr. Borghese said he knew NASA is not in the business of defining new markets, but if vertical lift vehicles could be freed from airports, center city hubs could become quite significant players that, in turn, could drive additional NASA innovations. Ms. Gorton said that ARMD has looked into that model, but moved away from it because it showed reduced passenger availability. The events of 9/11 and associated security concerns accelerated that movement. Mr. Wood agreed, saying that, for now, center-city approaches are not seen as feasible when compared to airports.

Dr. Sha made a distinction between vertical lift versus vertical landing. The newest jets can do a very short takeoff. Why aren't such jets being considered in the 2030 timeframe? Ms. Gorton said that the project's definition of vertical lift is a vehicle capable of sustained hover. And, added Mr. Wood, that definition includes landing on an unprepared surface, as well as a strong acoustic signature, which is a challenge in the center city.

Dr. Francis asked if Ms. Gorton's project is looking at other means of lift. Unmanned provides new opportunities to reconfigure. Ms. Gorton said two questions must first be answered: is it within scope and within budget? Those aren't necessarily the same thing. One needs to make new friends while keeping the old. The project is using its investment in the Small Business Innovation Research (SBIR) Program to look at new ideas and vectoring to be more inclusive.

Mr. Borghese referred to questions of safety, comfort and accessibility detailed on Ms. Gorton's presentation slides. Safety has to be a primary concern especially when looking at vertical lift in urban centers. Ms Gorton replied that safety is a barrier item for these vehicles: not just the large ones, but the small ones as well, especially if there are millions airborne.

Dr. Clarke asked if Ms. Gorton had seen the heavy lift study produced by the U.S. Army. Ms. Gorton replied that she had yet to see the final brief, but imagined there would be a significant technology cross included.

Mr. Borghese asked about the difference between the project's tech challenges and its research areas? Ms. Gorton said that the technical challenges are where the project has the most investment and is short term: three to five years. The research prepares the project for possible future tech challenges. Mr. Jay Dryer, director of ARMD's Advanced Air Vehicles Program (AAVP), said the research has to do with seedling areas and is more exploratory. Dr. Francis said he saw a lot of overlap with work done by the Department of Defense. Ms. Gorton said the project is leveraging under contract with the Army, with industry contributing 60%. The project is very collaborative with the Army; NASA has 50 years' worth of working together.

Mr. Anderson: "I always appreciate the good work you and your team are doing. You and ARMD don't get the funding you need and deserve. [Although there are] various interests of the defense community, the nation needs to fund vertical lift research. We need something to change the technology front. Considering Amazon, they will deliver things to your front porch. I would guess the thing that concerns them is noise; it's a critical-barrier issue. You should work on that today. And there's point-to-point transport." Ms. Gorton said some of that work is being conducted by the Transformative Aeronautics Concepts Program, overseen by its director, Doug Rohn. Mr. Dryer said that such efforts allow ARMD to illuminate certain areas and how they should be moved forward. ARMD is soliciting feedback from industry about what they need.

In response to a question from Mr. Borghese about rotor modeling versus building a model, Mr. Dryer said that simulation – not currently in the AAVP budget – could eventually lead to a demonstration. Ms. Gorton said the project will have to have contracts and partnerships, especially with people who build rotors. Mr. Dryer, in referencing non-tilt rotor research, said that he defines leverage with the Department of Defense as learning and doing, but not duplicating.

Mr. Borghese said the Committee is now seeing things that make sense: a lot of collaboration with DARPA and other agencies. Has something changed to make that possible? Dr. Shin said that the Office of Management and Budget has been sending a strong message to NASA and across government: If you don't have a clear mission, you won't be allowed to spend money on a specific area. ARMD can be a supporting player, but the Defense Department should work primarily on areas like rotorcraft. Ms. Gorton has done an outstanding job of balancing what can be done with a little bit of money, and playing a critical role. That's one answer to the question. ARMD has also been improving its working relationship with DARPA. Dr. Francis said that, having spent a decade at two different times working with DARPA, it tends to be volatile in terms of projects. ARMD can add stability and be complementary.

Mr. Anderson said the Committee is well aware of the political pressures on NASA. ARMD has handled it phenomenally well. In citing the X-15 program, he said it's not in the nation's interests to have ARMD disengage in these areas: "To me it's worrisome. It's probably a miracle you've managed to preserve \$20 million in this area." Ms. Gorton said that project's work was made possible because of the advocacy of Dr. Shin.

Convergent Aeronautics Solutions Project Update by Doug Rohn

In response to a question from Mr. Borghese about the difference between an ARMD project and a program, and their respective definitions, Mr. Rohn said that a program is the highest level of organized activity in ARMD. There are four, each with a director. There are 13 or 14 projects; within each is a subproject. In terms of what the Transformative Aeronautics Concepts Program (TACP) is doing, Mr. Rohn's definitions are less formal and are not stated in terms of technical challenges but activities. The time horizons vary; typically the activities are longer-term.

In response to a question from Dr. Francis about how an activity is defined as feasible, Mr. Rohn said that if an activity proves feasible, it may become an entirely new activity. Or, if it's clear what it might take to work, that activity could be turned over to another ARMD program. TACP prioritizes weighted assessments for activities. Ideas are developed in-house. At NASA's four aeronautics research centers, with the support of the project managers, there is flexibility. Funding can be made available for as little as two weeks of an initial experiment. In response to a question from Stephen Morford about how the success of a transition is measured, Mr. Rohn said first, answer the feasibility question and then, if feasible, where does the activity go? Where does it transition? In the end, the path is defined so the handoff happens. Incubation is funded through the centers. Mr. Borghese said that approach is very good. Generally the most innovative people are the busiest. Mr. Rohn said that if someone is really good, that's their primary job.

A brief discussion about electric propulsion and range ensued. Electric propulsion is a long ways away at the moment. Five-times efficiency is based on wing design, battery and propulsion design. There needs to be more efficient power conversion. The \$4.5 million TACP has committed will be a modest investment. Mr. Rohn replied in the affirmative when Mr. Morford asked if the concept can be scaled across multiple platforms and sizes.

Regarding the Scalable Convergent Electric Propulsion Technology Operations Research Project (SCEPTOR), Mr. Anderson asked if Phase 1 was funded. Mr. Rohn said yes, that this is a first-generation validation of the high-lift system. Significant computational fluid dynamics (CFD) analysis has been done. Phase 2 is to fabricate the wing and ground-test the battery, electric motors and instrumentation. If the effort reaches Phase 3, then the research will have achieved its original goal. Mr. Borghese said that if a hybrid system was adopted and scaled up, carbon emissions could be significantly reduced. In response to a question from Dr. Thole whether off-the-shelf equipment could be used, Mr. Rohn said that no, almost everything requires some work. A question from Mr. Wood about the potential for folded props and possible drag thereupon was answered by Mr. Rohn when he said researchers won't worry about a folding mechanism at the current stage.

A discussion then ensued about the potential five-times efficiency savings. The cost of the entire three-phase SCEPTOR project amounts to about \$12 million. Dr. Francis praised the effort: "You're doing great things here." There is significant outside involvement in SCEPTOR. Dr. Francis expressed concern that the research doesn't get to the right entrepreneur. Mr. Anderson said that the project would always be at a disadvantage when it comes to hardware. Dr. Thole wondered if some components could be 3-D printed; Mr. Rohn said yes, that was a possibility.

In response to mention of a future ARMD X-plane effort, Mr. Borghese said that it was a great idea. Earlier discussions have concerned a supersonic X-plane, which would be very costly. Because NASA has pioneered unmanned vehicles, perhaps an unmanned plane should be considered. There is a huge difference in costs, especially as regards certification. Dr. Francis said that if risks are taken, "of course it will cost you a ton of money." Mr. Anderson said that if an X-plane effort is undertaken, \$100 million is half of what the conventional [engineering] houses will estimate, and that the project will take four years: "So please ask the guys in the garage. You should involve people who will explore both sides of the equation."

In regards to a previous presentation to the Committee on low-boom research, Dr. Shin said that ARMD decided to have a manned supersonic X-plane because it will be flying over populated areas. It won't be flown over a range. Dr. Francis said that there would be ways to attack the problem without spending a huge amount of money. Dr. Shin said that public response is needed; that is the key element. The risk factor goes way up if ARMD makes it unmanned. This is a special case; if only cost is considered, then yes, unmanned is the best choice. Ultimately, though, it comes down to people's perception of noise.

A discussion then followed about Mach cutoff and flying over the water to measure a sonic boom's impact. Tests could start with low cost over a test range and build to something that captures interest over the longer term. Risks can be taken with unmanned vehicles that could never happen with manned, at least initially. Will the physics models work? Can the noise annoyance be reduced or eliminated? But the objective should be made clear, especially if the X-plane isn't a low-boom supersonic demonstrator.

Dr. Francis cited contingency management. Beyond the initial descriptions, one has to delve into the issues themselves, especially before a great deal of money is spent. Mr. Borghese agreed that it was a very good point. Before any rule change can be

implemented, there has to be a different approach to Federal Aviation Administration (FAA) certification. Dr. Francis said that autonomy versus human control is where the rubber meets the road. No one is yet ready to define an autonomy control system. Moving past adaptive control, one has to confront certification. Dr. Sha mentioned next-generation control systems and cited tests of adaptive control systems. Even though such systems haven't yet crossed the operational threshold, they need to be considered. Mr. John Cavolowsky, director of the Airspace Operations and Safety Program (AOSP) said that ARMD is considering how best to provide solutions in that space.

A discussion followed about how to certify judgement. The area of autonomy contains many questions that need thought and consideration, including how to apply machine learning so that it leads to appropriate outcomes. Spending time is a concept feasibility study and not engineering feasibility. But time and the right staff are both required. The operating systems for the unmanned Little Bird light attack/reconnaissance helicopter demonstrator that first flew in September 2004 might be a basis for these studies, since it's resistant to hacking. Unmanned aerial systems (UAS) are the future. The best thing to do is conduct studies and determine what factors are fundamental to UAS success. Intelligent software will have to have a different set of attributes.

Regarding the concept known as Digital Twin – a computer model that accurately simulates and predicts how an aircraft and its individual components are affected by aging and ongoing operations – Mr. Anderson asked if the idea was to develop a computational model that provides more insight. Mr. Rohn replied that the purpose is to narrow the probability bands, track aircraft in real time, and be proactive in terms of predicting flight performance.

In terms of high voltage hybrid electric propulsion (HVHEP), Mr. Borghese said that it was a really good thing to test. But how will researchers be able to effectively control 2,000 volts efficiently? Mr. Rohn said he would make a note of that concern and make sure it is covered.

In terms of the Learn to Fly initiative, wherein the use of computer tools may safely enable new airplane designs to be more rapidly flown by skipping ground-based testing, Dr. Clarke wondered if a totally novice approach could be taken. What are the calibrating parameters? Mr. Rohn said that it wasn't a totally novice approach, and that some testing was being conducted at the centers. Dr. Sha wondered whether that could entail a new fail situation. Mr. Rohn said that wasn't it, but that the paradigm is changing to a new design with adaptive controls and real-time modelling. Dr. Sha: "Can we learn to fly aircraft that are fundamentally flawed? If you take away the entire design phase, what are we learning?" Mr. Anderson joined the conversation: "Can we fly aircraft with no wind tunnel testing? What we need to do is to have a robust design that will be okay when it flies." In reply, Mr. Rohn said that it was only for new configurations and new aircraft. Dr. Francis cited the example of the Environmental Research Aircraft and Sensor Technology (ERAST) project, some of the component technologies never saw the inside of a wind tunnel. How far can such an effort go that involves entire aircraft?

Regarding the TACP initiative entitled Mission Adaptive Digital Composite Aerostructure Technologies (MADCAT) that involves research into aircraft structures made from advanced materials that can adapt to changing flight conditions by changing shapes, Mr. Rohn said studies are ongoing. Ms. Blakey praised TACP for originating so many

innovative ideas in such a short time, and commended Mr. Rohn for the program's progress to date since the last briefing before the Committee.

Summary of Request for Information (RFI) Response to ARMD's University-Led Strategic Aviation Research by Richard Barhydt

Mr. Borghese commented that some professors had not heard about ARMD's recent request for information. No member of the Committee had received the notice. Ms. Blakey asked about the demographics: Are the same universities being targeted? Mr. Barhydt replied that not all the information was in, but some universities, including some of the traditional partners with which ARMD normally works, were included. He believed there was reasonable coverage from the response that they received. There is continued ARMD interest in opening future requests to the full range of universities. There remains the need to get feedback on how to get the word out. Dr. Thole suggested one vehicle could be conferences, during which announcements are made and briefings conducted.

Dr. Francis said that as far as the autonomy topic was concerned, not many are doing it. There needs to be an effort to reach out to non-traditional partners. NASA can be a catalyst to start that conversation. Dr. Sha suggested a multi-conference collaboration with communities, after which an assessment can be made during a dedicated cyber-physical conference. NASA-instigated broad agency announcements (BAAs) are another possibility. Mr. Barhydt replied that currently such activity goes through the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES), but ARMD is looking at a broader dissemination. Time will be needed to help universities understand what ARMD is looking for. Dr. Sha said that it would be good if such outreach could become routine, perhaps on an annual basis. Mr. Barhydt replied that there is yet no specific time-frame identified, but recognized that Dr. Sha had made a good suggestion.

Mr. Anderson asked if ARMD thought a meaningful response was received from the universities. Mr. Barhydt said ARMD had received good responses but would like to get more. Mr. Pearce said that although the request went out quickly, he thought the response was good. In the past, ARMD had done RFIs, but this is different. The responses received were very positive, but not the depth of response that would be more beneficial. There is a need to launch a more substantial communication campaign so that when the solicitation comes out universities will be prepared to make a submission. Dr. Cummings said that although the response was better than expected, NSPIRES is a terrible system. She suggested using NASA centers to engage the local community, with a NASA day held at each center with the universities to establish better communication.

In response to a question from Dr. Clarke about the intention of the RFIs, Mr. Barhydt said that it was to identify a well-thought out problem that can be explored, with identification of specific technical challenges that then can move to a real outcome. Dr. Francis said there should be a good contact list created in order to let universities know that such requests are upcoming. There should be multiple ways of communicating to give advance notice so that the universities are prepared to respond on time. Dr. Thole suggested direct contact with the vice presidents of research at each institution so that the word gets out.

Dr. Clarke asked about ARMD thoughts about the number of proposals. In reply, Mr. Barhydt said that universities lay out a specific plan to achieve technical challenges. Research activities are conducted to get to a real outcome. Dr. Clarke suggested the potential establishment of a different kind of center of excellence. Dr. Francis said that there is a need to attack different levels of management at universities, emphasizing that there need to be multiple ways to communicate. Dr. Thole repeated that the vice president for research at universities is the person to contact so as to get the word out. Dr. Clarke said that ARMD could be inundated with a lot of proposals if everybody comes back with a response.

Mr. Anderson cited the breadth of recurring research themes, noting the amount of variation. Dr. Shin said that ARMD's motivation was not to augment its technical work: "I wanted U.S. universities to take leadership. We don't have time, folks. Are we really harnessing university capabilities and intellectual power?"

A discussion then ensued about researchers and requests for qualification: Come with a key question and how to answer that question. Is the question a key question? Will it really advance national and NASA priorities? ARMD isn't sure yet about what responses will be received. Although not every proposal will be funded, NASA can be showing the way, and can solicit a broad selection of inputs. Reaching out to the broad aeronautics community is critical. There is a need to specifically iterate what's critical. The overall budget for this effort is \$5 million, with each award size to be determined.

Mr. Borghese cited a previous meeting during which there was a question on giving specific proposal direction. Dr. Thole said that question led the Committee to talk about the white paper concept and the downselect process. Mr. Barhydt said that ARMD does cull down from [initial proposals]. Dr. Cummings said that Dr. Thole's idea of reaching out to vice presidents is the best idea.

ARMD Research Data Access Approach by Irma Rodriguez

Mr. Borghese complimented ARMD's data access approach, saying it was very important. But it's also necessary to have a mechanism to make the data easily searchable. [Incoming] Committee Secretary Ms. Irma Rodriguez said that ARMD will be working on implementation and exploring different search engines. Dr. Francis suggested that technical publisher Wiley might be a resource.

Regarding publication and copyright, Dr. Thole said that material that has already been published has likely had the copyright signed over to the publisher. Ms. Rodriguez said the date would not be proprietary but public. A discussion then ensued about the kinds of data that may eventually be released. Because ARMD is moving away from an ad hoc process, there is a need to work through several issues. Mr. Borghese said that a common system was needed. Mr. Morford said it was really about access to information. It's not important exactly where the information is, only that it can be accessed. ARMD Deputy Associate Administrator for Management Jon Montgomery said that ARMD doesn't yet have a full budget to fund a centralized data center. Dr. Francis said that ARMD does need a long-term commitment.

Alternative Fuel Research Data Access Pilot Project by Jay Dryer

As regards storing data on the cloud, Mr. Borghese asked who has the responsibility for making the decision for data dissemination. Mr. Dryer cited leveraging other established NASA systems. ARMD is learning about how the information gets there. It's not ARMD doing its own thing; the process is at the very beginning.

A discussion then followed about future funding. It could be cheaper to outsource, and that's being explored. There is not a user-tracking requirement as of yet. Endorsing the data that's being released shouldn't be an issue because it's research that's already been conducted. NASA will have a dedicated site that will point to the data repositories at each Mission Directorate.

Vision and Strategy for Thrust Real-time System-wide Safety Assurance by Dr. Jessica Nowinski

Mr. Borghese asked why requirements would come later. Also, since the effort is long-term, it would be prudent to include what the national airspace system will look like in 2030 and 2040. Dr. Jessica Nowinski said that requirements are included at the beginning. A discussion then followed concerning the role of increasingly more capable aircraft working in a more automated system: specifically, the role of automation in the Next Generation Air Transportation System, or NextGen. It's a challenge for migration to, and integration of, very advanced aircraft.

As regards to weather issues, Mr. Borghese wondered about the processes taking that and future states into account. Dr. Nowinski said her project is attempting to understand what the safety margins are. What is the safety case, and when should one worry about safety standards in dense operations? The more data available, the better the situation can be monitored. Studies are also underway to understand how best to push automation and humans interacting with same, for pilots as well as controllers. Director of ARMD's Airspace Operations and Safety Program (AOSP) Dr. John Cavolowksy said that AOSP is looking at this broadly across the entire system. Research will take a lot of work and a lot of thinking: it's far more than air traffic management and air traffic control. It also involves flight decks and flight crews.

Mr. Morford asked how big data will get to safety. Dr. Nowinski said her project has work ongoing concerning anomaly detection. Mr. Morford said it was a perfect example. If the causal relationship isn't understood, it's really hard to infer. But: does the modeling get to the causal relations? Dr. Nowinski replied that the more data researchers have, the closer they can get. It may always be an issue.

Mr. Borghese wondered if the project was looking at monitoring human performance directly. Such an effort would convey an immense amount of information. Dr. Nowinski said that yes, the project is studying fatigue monitoring, working with two airlines allowing human performance to be paired with aircraft performance. Flights with more pilot fatigue had more incidents. The project can collect both objective and subjective data, and is also work on attentional tunneling.

Citing two crashes and a near miss involving software overdependence, Dr. Sha said there's the possibility of software causing more problems than it solves. Dr. Nowinski said that ongoing studies are addressing such issues. Dr. Sha said he knew the project can't do everything. But as more and more responsibility is assigned to software, the software grows increasingly complex, and becomes prone to unanticipated and

unwanted interactions. Software used to mitigate potential accidents demands a cost-benefits analysis. Keep adding things, and one seeming small change could be the crucial straw that broke the camel's back.

Mr. Borghese said this area of research has been incredibly valuable to the general public, and is going to be extremely important for the future. It's very good work. Human team/automation work is very important; done wrong it makes the situation less safe. The wrong type of automation is one that's distracting but intends to be supportive, like constant alarms going off.

Dr. Sha suggested reviewing a National Academy of Sciences study and its constituent recommendations. Reduce and controlling complexity is essential; otherwise, it's a recipe for disaster. Complexity management is not being discussed at all. Consider the history of computing: complexity of automation can backfire. There is sometimes too much of a good thing. Dr. Sha wants to hear what can be taken out, not just putting more and more things in. Mr. Borghese suggested taking a look at chaotic attractors. Dr. Nowinski thanked the Committee for their comments and observations.

UTM Convention Summary of July 28-30, 2015 by John Cavolowsky

Dr. Cavolowsky reported that five hundred feet and below in altitude was the focus of the unmanned aerial systems traffic management (UTM) convention held at NASA Ames Research Center in late July. However, the UTM construct can be built so it has value for larger airspace management; for the moment, this remains only an area of research.

Director of ARMD's Integrated Aviation Systems Program (IASP) Dr. Edgar Waggoner said the program, working with the Federal Aviation Administration (FAA), has research ongoing to develop minimum Class E and Class A airspace standards. The first six years of work will be concluded in 2016. The effort is being annually funded at \$30 million; ARMD will be advocating for more such research. Dr. Cavolowsky said that work was occurring across a broader range. The highest market value is in this lower airspace of 500 feet and below.

In response to a question from Dr. Francis about the focus being either operator-intensive or automated, Dr. Cavolowsky said the assumption is that there is an operator when the missions are being flown. Dr. Thole wondered about the timescale in terms of submitting a flight plan and whether an app might be available. Dr. Cavolowsky said a proposed app would be very narrowly designed, within visual sight. UTM can't bring them down, but can say "You are out of range." This doesn't help with rogue operators, but the FAA doesn't have that capability either.

Ms. Blakey wondered about vehicle system failure. Dr. Cavolowsky said that there are a variety of ways these systems can be tracked. But there also has to be communication with the operator. Dr. Francis noted that such unmanned aircraft are the smallest machines going into a nasty [congested airspace] environment.

There were 1,190 registered attendees at the UTM convention. A brief discussion ensued about Google's involvement in UAS and UTM, and Google's Project Wing. There are a number of individuals concerned about policy, and noise continues to be a primary issue. Both lawyers and underwriters were in attendance. Mr. Anderson said

that the conference underscored that a traditional airspace with a sedentary pace is clashing with Silicon Valley culture that waits for nobody. What's going to happen? Dr. Cavolowsky replied that the Googles and the Amazons appreciate that this is the market they need. They won't do anything to keep them out of the market as bad actors. So now they're going overseas [where regulations aren't as stringent as in the United States]: they have other options and they can go to other places. He added that ARMD is "trying to keep the gasoline away from the bonfire. We're trying to inform people that this is not as easy as you think it is. We're trying to work with a single government voice with the FAA."

Dr. Shin said that, a year ago, his concern was to bring the community together, build excitement and educate. He thinks ARMD has wildly surpassed building the excitement part, but didn't do as good a job educating. He wants to show a united front with the FAA. It wasn't as strong a connection as it could have been. There has been a bit of a backlash from industry in that they see NASA as the good cop and the FAA as the bad cop. ARMD is not going there, for industry to put a wedge between NASA and the FAA. Industry thinks NASA is going to build a system in a year or two, whereas NASA has never said that and is not going to. A second concern is that ARMD doesn't want to develop a system for Amazon and Google only, but wants to develop a system for everybody. That's getting more and more difficult. A primary concern is that companies are going out of the country. UTM won't be done in two years. A big part is education.

Dr. Francis said that the education part is a work in progress. Dr. Shin said ARMD may not have all the answers, but does need to say the government is united. All kinds of things are happening. Anything the committee members can do would be appreciated. Dr. Sha said he shared Dr. Shin's concerns: "If I were a company, I would go to a lightly regulated country. If you don't cooperate with the companies, they will go away. If you do, you get the other problems."

A discussion followed about collaboration and ways to avoid conflicts. For future meetings, there needs to be more clarity on global environment for UTM. Parimal Kopardekar, manager of ARMD's Safe Autonomous Systems Operations (SASO) Project, said other countries think that what NASA has proposed is definitely worth considering. In other countries, their specific models aren't scalable. People are realizing that unless one undertakes a systematic approach, the technologies will not scale. The boundary between commercial vehicles and UAS is getting smaller by the day. Dr. Francis cited the commercial potential that interests other countries. There is the potential to establish international partnerships, thereby creating and sharing more knowledge. Dr. Cavolowsky said that ARMD is beginning to engage more broadly.

Dr. Thole asked if ARMD is going to continue the UTM convention every year. She thought the American Society of Mechanical Engineers (ASME) would love to take over something like this: "When you hook exhibits to it, it's a real moneymaker." It's would also be possible to seek the sponsorship of the American Institute of Aeronautics and Astronautics (AIAA) and the Institute of Electrical Electronics Engineers (IEEE). A brief discussion about trade shows ensued. A professional organization that's independent would be a good idea. Dr. Cavolowsky said that ARMD hadn't yet made a decision about 2016.

Mr. Borghese complimented ARMD on the convention: "This is really great what has happened. It's good that there's a lot of focus, but this is one area of many in which

NASA is active.” Dr. Francis mentioned six UAS test sites put in play by the FAA. There’s an infrastructure in play ARMD could leverage. Dr. Cavolowsky agreed, saying that ARMD has already reached out.

Committee Discussion

Dr. Shin said he really appreciated members’ very lively discussion. A lot of topics were on the agenda. The conversation and feedback were really excellent. Ms. Blakey asked that any thoughts expressed to the full NASA Advisory Council (NAC) be conveyed as recommendations. Dr. Sha said that safety is a very important issue, and cited the National Academy statement on simplicity [in computer system design]. Dr. Sha would like to see a complexity-reduction recommendation made and the Academy statement considered. It’s a safety and software concern that should be taken seriously.

In response to a question posed by Ms. Blakey about the complexity-reduction recommendation, Dr. Nowinski said that her project’s human automation team is taking a look at it. Ms. Blakey added that the Committee has wrestled with issues related to verification and validation. A discussion continued regarding complexity. Being aware of negative interactions is extremely important. Systems must be testable and verifiable. However, the higher-level brief presented to the Committee doesn’t drill down into the details of what the project and subprojects are doing.

Mr. Anderson said he would like to offer commendations: “I saw three things today that I thought were spectacular: the activities being done by ARMD’s (Convergent Aeronautics Solutions) CAS Project, the university-led strategic initiative, and UTM; it was the single best briefing we’ve ever had. All three are outstanding, given the limited resources. It makes me feel very good to be associated with NASA.” Mr. Borghese said he agreed, and wanted to add one more: vertical lift. That project is taking a limited budget and doing exactly what needs to be done. Mr. Wood concurred, saying the project could boast of a really balanced portfolio, between the old relationships and the new.

Dr. Francis said that there are interesting things that can be done with these smaller [UAS] platforms. Dr. Sha said he was really impressed with the CAS presentation. He very much agrees with the approach. Ms. Blakey said she was very much affirming of what Mr. Anderson said. Affirming what ARMD is doing is certainly not a recommendation, but it certainly could be a finding; formalizing that is doable.

Mr. Borghese said that it’s very hard to get this kind of visibility for NASA [re UTM]: “NASA is leading the world now. It’s tremendous.” ARMD’s UTM research may raise to the level of a finding. Dr. Thole said the Committee could use the word innovation. Dr. Francis said it was more than that: it’s invention.

Dr. Thole said that communicating with universities should also be mentioned as a recommendation. These briefings were the best things she’s seen since she’s been on the Committee. A brief discussion followed about the hows of engagement with the university community.

Mr. Morford said that CAS has wildly exceeded his expectations: “I didn’t expect to see such innovation that could lead to a quick demonstration. That is really critical for innovation. I’d like to commend ARMD on that; it’s excellent. And it ties into affordability,

especially as budgets are tight. Great job.” Dr. Shin said ARMD leadership was elated that its internal workforce responded with so many good [CAS-related] proposals. ARMD would like to bring that same excitement externally.

Ms. Blakey expressed the desire for one recommendation that would reach out to the universities, not just communicating but expressing expectations. As the meeting concluded, she asked that a future brief concerning software complexity be delivered.

Public Comments:

None.

MEETING ADJOURNED at 5:24 p.m.
