NASA Advisory Council (NAC)
Aeronautics Committee

November 14-15, 2016
NASA Ames Research Center, Moffett Field, Calif.

Meeting Summary

Participants:

First	Last	Organization	Role
John	Borghese	Rockwell Collins	Vice Chair
Dr. Michael	Francis	United Technologies Res. Ctr.	Member
Dr. Missy	Cummings	Duke University	Member
Dr. Lui	Sha	University of Illinois	Member
Dr. Karen	Thole	Penn State University	Member
Dr. John-Paul	Clarke	Georgia Tech	Member
Dr. David	Vos	Independent Consultant	Member
Irma	Rodriquez	Aeronautics Committee	Exec. Secretary
Robert	Pearce	ARMD OAA	DAA / Strategy
Tom	Edwards	NASA Ames Res. Center	Dep. Center Dir.
Huy	Tran	NASA Ames Res. Center	Director, Aeronautics
Jay	Dryer	ARMD AAVP	Director
Doug	Rohn	ARMD TAC Program	Director
Dr. Mujeeb	Malik	ARMD TAC Program	RCA/TTT Project
Dr. John	Cavolowsky	ARMD AOS Program	Director
Dr. Jessica	Nowinski	ARMD AOS Program	Tech Advisor
Mark	Ballin	ARMD AOS Program	Manager

Monday, November 14, 2016
The meeting was called to order at 2:02 p.m.

Introductions

Vice Chair Mr. John Borghese welcomed members and announced that both Dr. Jaiwon Shin and Ms. Marion Blakey were not able to attend.

Mr. Robert Pearce sent Dr. Shin's regrets about not being able to attend. NASA is waiting additional guidance regarding the new presidential administration. It will take time for the new administration to put together a new budget. ARMD's budget request is at the $640M level. However, there will be budget uncertainty over the next several months.

Mr. Tom Edwards, Ames Deputy Center Director welcomed the Committee members to the Ames Research Center. Ms. Huy Tran, Aeronautics Research Director, provided an overview of the Ames Aeronautics capabilities that support the ARMD strategic thrusts.

CFD Vision 2030 Implementation Plan by Dr. Majeeb Malik

Dr. Majeeb Malik briefed the Committee on the CFD Vision 2030 Implementation Plan. Mr. John Borghese commented that the project seems to be trying to do a lot of things, but it needs a lot more computational ability and asked if the project plans to develop algorithms that are more complex. Dr. Malik indicated that it's not just the hardware: it's both hardware and software so the answer is to have bigger machines, or ones that would exploit more code better.

Dr. David Vos asked about the measurable targets and milestones including specific industry needs in the medium range. Dr. Malik indicated that NASA has technical challenges that are in the five to six-year range that deliver new technology. NASA and Boeing have a pioneering effort to make sure this can be used in their design efforts. He added that NASA is also working with the U.S. Air Force Research Laboratory. NASA is interacting with all the stakeholders and they won't have to wait 15 years.

Dr. Clarke asked about the timeframe for alternative fuels work and expressed concerned about a research timeline of five to six years not aligning with a three-year alternatives fuels time horizon. Mr. Jay Dryer indicated that ARMD is working with other agencies on an alternative fuels strategy that aligns with other efforts in government. He added that it's more about understanding the models so testing and certification can be accomplished sooner in coordination with the Federal Aviation Administration's (FAA) timelines. Dr. Vos added that if there is a driving need, a decision point or some new aero propulsion interaction, driving milestones by a certain date would really inform the process here. A discussion ensued about the need to advance a good story included in which is the need to know how everything adds up across government.

Dr. Michael Francis noted that NASA has an autonomy initiative and embedded in that is AI (artificial intelligence) and machine learning. He suggested that that there's a potential marriage here. Those tools could be useful and he indicated that he hasn't seen no reference to that. It's a way to calculate the data and he felt that the project should take advantage of all those adjacent technologies to make this effort truly transformational. Use the intelligence algorithms to do it. Use the physics to help inform

the process. Dr. Malik indicated that the project doesn't have the funds to deploy the new generation of AI systems.

Mr. Doug Rohn clarified that if NASA's proposed New Aviation Horizons Program (NAH) happens, NASA will be building X-planes. It could provide designers crucial tools down the road. That's the connection: having those tools that could be used by Boeing and others.

Dr. Vos emphasized that the project needs to make it a goal, otherwise it won't happen. He added that 2-D and 3-D flow visualization is what everyone has always wanted. Maybe, based on funding, grid visualization isn't a priority. Identify the key enablers that over time will break free.

New Funding Model for NASA's Aerosciences Ground Test Facilities by Jay Dryer

Mr. Jay Dryer briefed the Committee on the NASA new funding model for NASA's Aerosciences Ground Test Facilities. In FY17 the New Funding Model will fully cover the operational cost for NASA users of a key set of critical aeroscience ground test facilities. In addition, limited funds are available for capability advancements, new test technologies, and maintenance.

Dr. Clarke stated that the project was managing all these things centrally and the biggest expense is employees. He asked about moving people between centers. Mr. Dryer indicated that this is not easy to do and added that at a given center, the project optimizes within the center boundaries, moving people between facilities.

Dr. Vos asked about consolidating facilities and what was the backlog of work. Mr. Dryer indicated that in terms of optimization, the studies have looked at critical facilities. There is a specialty need. Now the project is running at capacity.

Mr. Borghese asked if everything was treated as just an expense and where are the aero subject matter experts. Mr. Dryer answered that it was both: the Aeronautics Evaluation and Test Capabilities Project and a pull from the programs/projects side. A lot of this is driven by ARMD needs. This isn't just "I've got something to test;" it's a question of prioritization that determines the duration of the test.

Mr. Borghese asked if the investment in facilities and computer models is driven by the new ARMD initiatives in X-planes. Mr. Dryer stated that the new funding model is independent of the X-plane program. It's not just the demonstrators but increased utilization overall.

Dr. Francis offered a word of caution indicating that it's a budget-limited world. A danger is to let the facilities drive the agenda. A big concern is the balancing act between the important ones in the present and the ones coming that will put NASA in a leadership role.

Dr. Clarke and Mr. Borghese expressed appreciation for NASA's approach with the facilities new funding model and praised the project for doing a really good job.

Meeting Adjourned at 5:44 p.m.

Tuesday, November 15, 2016
The meeting was called to order at 9:57 a.m.

Vision and Strategic Planning for Advanced Aviation Operations by Robert Pearce

Mr. Robert Pearce provided a brief review to the Committee of ARMD's Strategic Thrusts included in the Strategic Implementation Plan (SIP) with a focus on the advanced aviation operations (Thrusts 1, 5 & 6).

The discussion centered on the UTM and UAS Strategy. Mr. Borghese asked how the vision and roadmap of UTM (unmanned aerial systems [UAS] traffic management) could enhance overall traffic management. Mr. Pearce indicated that NASA has spent a lot of time looking at overall UAS strategy and has started to come together over NASA's role. The overall operation of the NAS (national airspace system) is a research topic that NASA needs to get into.

Dr. Vos added that the UTM could launch an entirely new way for air traffic management. It's a new sandbox. Uncontrolled airspace could become the busiest and most congested airspace the world has ever seen. It provides an opportunity for hundreds of millions of dollars of GDP (gross domestic product). It provides the opportunity to create an entirely new airspace. So why isn't that the main focus and breeding ground for funding for new explorations for commercial airspace? In his opinion, the strategies and priorities are completely backwards and suggested that investment and progress should be taking place there.

Mr. Pearce clarified that when NASA looks at this internally, it's not a big conflict. The ideas aren't that different. He added that the FAA (Federal Aviation Administration) is the agency's customer and the goal is to make sure that the right level of resources and intellectual capital is put in place.

A discussion ensued about NASA's role in the collaborative space of UTM and Mr. Pearce emphasized that NASA has a role. Dr. Vos added that this is a phenomenal opportunity to get to the future. A highly automated, integrated airspace is needed. He recommended that NASA looks at how to get there with the least numbers of variables possible.

Mr. Pearce added that NASA is working with others on several breakthroughs that are important for the future and deploying resources to meet critical national needs. There is no resistance to the UTM assertions. NASA has played a role where industry and universities come together to innovate together while providing an environment to put intellectual capital in.

The Committee agreed that this is an opportunity for NASA to emphasize a vision and role in the UTM and UAS world and highlight that NASA is leading the way and developing a new economy. Mr. Pearce indicated that he agrees with the Committee's recommendation on the vision and added that there is a need to present a holistic portfolio that shows the priorities and goals.

Dr. Francis added that there needs to be a set of metrics to see how those priorities and goals are met taking into account the skill set. Mr. Pearce cautioned that making changes in the workforce takes years and NASA has a lot of expertise.

Dr. Clarke asserted that NASA needs to continue to think a step ahead, pushing the envelope even when supporting industry. NASA needs to show how all different things in the portfolio map to that goal. That's one recommendation: to really map the strategy for how to map core competencies to stay ahead.

Dr. Vos added that during the last two meetings the Committee has made recommendations to take more of a systems view and recommended that at the next meeting the conversation continues.

Hypersonic research was brought up as well. Dr. Thole suggested to look to the past for clues to the future. Dr. Cummings stated that hypersonic discussions are cyclical and suggested that there needs to be a re-prioritization and that NASA only needs to provide backup to the Air Force rather than stale research that keeps on recycling.

Dr. Francis indicated that as far as hypersonics goes, the Air Force is concentrating on threats, global reach and mostly with weapons with no human in the system. Hypersonics is a huge consumer of energy and has to be taken in context for all the other systems been worked on. It's much harder to see how hypersonics will play.

ARMD Strategic Thrust 5: Real-Time System-Wide Safety Roadmap Vision and Project Planning by Dr. Jessica Nowinski

Dr. Jessica Nowinski briefed the committee on the Real-time System-Wide Safety Roadmap Vision and Project Planning.

Dr. Cummings asked about the past work at Ames that dealt with uncertainty management. She added that those tools concerning separation were ignored in the past. She suggested to look at the lessons learned in the 1990s and how is this effort going to be better than the work done 20 years ago.

Dr. Vos added that there is excitement about automated ATM (air traffic management). He stated that NATCA (the National Air Traffic Controllers Association) and ATCA (the Air Traffic Control Association) are stressed because everything is being done manually.

Dr. Nowinski indicated that automation comes from the tools that NASA is developing. She agreed that lessons learned needs to be addressed. She added that the concerns that controllers have is that humans can figure it out when the algorithms don't work.

Dr. Cummings asked about the efforts being done by MITRE in DC and how similar they were to what NASA is doing. In addition she suggested that the NASA roadmap should show what's in use today and to be cautious about not replicating work. Dr. Nowinski clarified that they are doing some elements but they are not working on real-time. They may be developing some tools and integrating some data sources in data fusion. She also added that NASA is interested in collaborating with MITRE, but they are extremely

resistant to incorporating tools that are not their own. Dr. Nowinski agreed and stated that NASA would be willing to share our research with them.

Dr. Vos suggested that system-wide safety real-time would be particularly useful in the San Francisco Bay area which fogs up regularly. In his opinion, it's a fantastic place to implement these tools.

Dr. Francis expressed concern about having roadmaps that run out to 2045 which seems inconsistent with rapid pace of technological change in this area. Dr. Nowinski emphasized that one function of a roadmap is to tell a story and have stretch goals and another is specifying how to get there. Mr. Pearce added that NASA developed TCs [technical challenges) to address this concern. Some of these challenges are big enough that it's hard to see how things can be accomplished in less than six or seven years. Dr. Thole suggested that possibly the messaging needs to be different. It was suggested to set aggressive targets so that the long-term roadmap doesn't seem irrelevant in a technology environment that is fast-paced.

The committee suggested to break down the roadmap in pieces that are motivational and inspiring to gain the support of the new administration. It was emphasized that the messaging is absolutely crucial including having a deadline and a commitment. A discussion ensued about the technology barriers to make this happen. Dr. Nowinski indicated that cybersecurity is one, with a lot of uncertainty behind it. Dr. Clarke added that in the machine-learning segment there is a lot of uncertainty. Dr. Sha stated that when considering machine learning, one must consider its promises and pitfalls. When facing new and unexpected constraints, on has to change initial assumptions. The certification process will have to be changed. It's a challenge to the whole community. Dr. Nowinski indicated that NASA needs to find a way to present the vision so that it's not just one big machine-learning process.

ARMD Strategic Thrust 6: Assured Autonomy for Aviation Transformation Vision and Roadmap by Mark Ballin

Mr. Mark Ballin briefed the committee on the NASA ARMD developed roadmap to guide activities for Aeronautics Strategic Thrust 6: Assured Autonomy for Aviation Transformation. He cited the Strategic Implementation Plan (SIP) that states: The objective of Strategic Thrust 6 is to enable autonomous systems that employ highly intelligent machines to maximize the benefits of aviation to society.

Dr. Vos recommended using UTM as a test case that could expand out to the entire system. An appropriate level of safety from a terrestrial standpoint should apply to flights aloft. Mr. Ballin explained that high-level decision making is a very serious problem. Humans do certain jobs very well. Dr. Vos suggested to consider the crash landing in the Hudson River in which traditional procedures involved meant that there was no time for any alternative.

Dr. Sha suggested to look at the involvement of the FAA and certification rules. He stated that there is a difference between landing a UAS and a commercial airliner. It's a different air-worthiness task. Dr. Vos emphasized that this might be the real thing that deserves the focus even if it's hard to do. Dr. Sha agreed with this point and added that regulation change won't happen in four years.

Dr. Clarke expressed that we often think about humans supervising automation. An economic benefit could be like the fictional software agent “Jarvis” to warn and, in some cases, intervene. In the case of a three-person crew, if you could have a one-person crew, Jarvis would have to work only long enough on a long-haul flight to wake a sleeping pilot. If you could cut the crew from three to one, the economic benefits would be enormous.

A brief discussion ensued about Global Hawk: how it defines automation and autonomy judgement and reason which don’t exist in most systems presently. Autonomy of execution is different from autonomy of judgement. Mr. Ballin asserted that the discussion was about higher-level machine intelligence, not autonomy of execution. Dr. Cummings added that the industry will be there before 2025. Mr. Ballin agreed and indicated that the question is how NASA can add value in a world where billions are already being invested. There will be areas NASA won’t work and other times room for partnership opportunities.

Mr. Pearce added that NASA wants to reflect what the community is asking for. Dr. Vos indicated that there are already capabilities out there that address these outcomes to 2035. Dr. Cummings provided an example of Amazon Prime who is working on distributed control, and not necessarily in this country. It’s already in China and its likely coming quickly to the US.

Mr. Ballin agreed with the Committee assessment of the environment in this topic. He indicated that perhaps NASA should choose fewer visions and stick with one or two supported by funding where NASA can make a contribution. Dr. Clarke suggested that NASA should look at two things: 1) What will have a huge impact – economic, social and so on – and 2) What is no one else working on?

A discussion ensued about embedded systems and hacking into a UAS featuring a “secure” link. There is a pent-up value and demand measuring in the billions for presenting relatively simple solutions. The perfect shouldn’t be the enemy of the good-enough. Autonomy should include security, but focus the problem over a much smaller timeline of about four years. NASA could lead and coordinate.

Dr. Vos added that it’s deciding on the mission. How would a UAS navigate in the event of an outage? It’s a huge problem today. The robotics community has made great sides by using imagery. One of the problems is integrated management for small UAVs. He suggested setting up a community to do it. Set up the problem and identify the barriers where those barriers are so NASA can drive the solutions. UTM is a wonderful example. And it’s evolved dramatically today because of NASA’s efforts. Mr. Ballin agreed that the most important way to lead the community is to pick a problem that needs to be solved and form a community around that.

Dr. Francis added that he was in agreement with most of the discussion about autonomy considering the breadth of the subject. He indicated that in the near-term, the industry is working them. He suggested that NASA needs to understand where the state of the art is to get in touch with the cutting edge. If industry is doing it, NASA doesn’t need to do it. He asserted that NASA started working on autonomy about two years ago and recognized that it is still in the planning progress.

Committee Observations, Findings and Recommendations:

Below is a summary of the final committee deliberations for all of the topics covered during the two-day meeting. The committee agreed to submit the following observations and recommendations to the AA for ARMD.

1. Observation: CFD (Computational Fluid Dynamics) Vision

The Committee understands the importance of Computational Fluid Dynamics(CFD) has played in the development of efficient aerodynamics for airplane structures and turbine engine development. The CFD project has good project planning. Given the length of this project, the Committee suggests that the project define the current state of the art, what specific problems are being solved, gaps to solve these problems and develop clearly defined milestones on a frequent basis to measure progress throughout the project.

2. Observation: New Funding Model for Key Facilities

Wind tunnel testing continues to be an important part of air vehicle and engine development. The cost associated with extensive testing sometimes inhibits facilities use leading to insufficient testing and sometimes a lack of full usage of the tunnels. The Committee agrees with this new approach of funding the non-recurring wind tunnel costs. Given the dynamics of influencing usage using a new cost model, the committee suggests that the results of this new model be evaluated frequently and adjusted if necessary.

3. Recommendation: Assured Autonomy for Aviation Transformation Roadmap and the Autonomous Systems Project and UTM

Unmanned air vehicles (UAV) and personnel air vehicles are expected to grow from today's nascent industry to a $20B business within 20 years. The NASA UTM project has made significant strides in demonstrating how an appropriate automated air traffic management system could enable this UAV growth and make the US a leader through technology experimentation in the UTM project. In addition, automation, in particular autonomous air vehicles in a UTM like air traffic management system has the long term ability to enable the National Aerospace System to increase capacity and safety. Given the importance of this area to the US and NASA, the Committee recommends that the UTM project be expanded and accelerated. In addition, the committee recommends that the new Autonomous Systems project include a focus on autonomous air vehicles and address the gaps not being funded by industry like autonomous verification and validation.

Public Comments: None.

MEETING ADJOURNED at 3:05 p.m.