NASA Advisory Council (NAC)
Aeronautics Committee

December 4, 2014
NASA Ames Research Center, Moffett Field, Calif.

Summary of Meeting Minutes

Participants:

First	Last	Organization	Role
Marion	Blakey	AIA	Chair
John	Borghese	Rockwell Collins	Vice Chair
Mike	Francis	United Technologies RCenter	Member
Tommie	Wood	Bell Helicopter	Member
Mark	Anderson	Boeing [RETIRED]	Member
John-Paul	Clarke	Georgia Tech	Member
Karen	Thole	Penn State	Member
Stephen	Morfold	Pratt & Whitney	Member
Jaiwon	Shin	ARMD	NASA AA
Susan	Minor	ARMD	Exec. Secretary
Robert	Pearce	ARMD	SAA Director
William	Warmbrodt	NASA Ames	Aeromechanics Head
Tom	Edwards	NASA Ames	Aeronautics Director
Parimal	Kopardekar	NASA Ames	PM NextGen CTD
Joseph	Rios	NASA Ames	NASA Engineer
Richard	Barhydt	ARMD AvSP	Deputy Director
Sabrina	Saunders-Hodge	FAA	Manager, New Entrants
Guillaume	Brat	NASA Ames	SSAT Project Scientist

Thursday, December 4, 2014
The meeting was called to order at 9:12 a.m.

Introductions

Ms. Marion Blakey opened the meeting and welcomed members and participants. She said she was very excited to be at NASA Ames Research Center, and thanked all NASA staff who made the meeting possible. Introductions were made.

Dr. Jaiwon Shin welcomed all the Aeronautics Committee members to NASA Ames Research Center, and expressed his gratitude to the Committee for its support and sharing of its collective wisdom with NASA's Aeronautics Research Mission Directorate (ARMD). Continuity helps in this dynamic environment. Dr. Shin also said he was grateful to have been able to serve more years in his position than his predecessors. He thanked Aeronautics Committee Executive Secretary Ms. Susan Minor, and noted that Mr. Tom Edwards would be representing NASA Ames management during the meeting.

NASA Ames Overview by Dr. William Warmbrodt

Dr. Warmbrodt discussed NASA Ames history, noting the center's 75th anniversary in 2014. Ames was established thanks in part to the efforts of famed aviator Charles Lindberg. Dirigibles were once hangared at Ames. Cheap power was available for wind tunnels, there was an abundance of good flying weather for research aircraft, and a number of first-class academic institutions were nearby.

Today, NASA Ames occupies 200 acres of the original 2,000 that comprised Moffett Field. Ames remains small, eclectic and broad-based, with 2,480 staff: half civil servants, half contractors. The center's longstanding practice of collaboration and partnering continues to this day.

Ames Aeronautics Directorate Overview by Tom Edwards

In describing the Ames Aeronautics Directorate, Mr. Edwards noted that it is staffed by some 180 civil servants plus an equal number of contractors. About half of the Directorate's research is geared toward the Next Generation Air Transportation System (NextGen), with focus on unmanned aerial system (UAS) operations. Work also continues on exploration of automation in flight.

Partnerships with other entities bring capabilities to NASA Ames that it wouldn't otherwise possess. In addition, Ames hosted 800 interns this past summer.

Mr. John Borghese asked if the Exploration Technology Directorate was separate from the aeronautics organization. Mr. Edwards said that the Aeronautics Directorate matrixed researchers into various programs. Mr. Borghese then wondered how the Exploration Directorate determined what work would be done. Dr. Shin responded that ARMD has formulated six primary areas of research; any additional funding from ARMD must be focused on those research thrusts. NASA centers thus need to plan for the necessary expertise and skills sets they need to conduct the research.

Dr. Mike Francis said that, while he understood the matrix concept, would there be any value in reorganizing to take advantage of those research thrusts? Mr. Edwards replied

that such a step would occur when a stress point is reached, when decisionmakers determine that the status quo is worse than the alternative. Organization boundaries blur because talent and expertise is accessed wherever it lives. NASA Ames teams don't worry about the boundaries. Mr. Edwards doesn't believe that his organization is at a point yet where they need to reorganize.

In response to a question from Mr. Mark Anderson about two NASA Ames wind tunnels, Mr. Edwards said that the center's 11-Foot Transonic Unitary Plan Facility is a very busy tunnel, although there's a large swing about who is the primary customer. The 11-Foot diversifies the Ames customer base: "We have a large tunnel that can test subsonic at a large scale. That being said, we could be one year away from a bad situation. It's tenuous." In contrast, the 9-by 7-Foot Supersonic Wind Tunnel is ending a heyday of supersonics research. As long as there's business in the 11-Foot, Ames would be in good shape.

Mr. Anderson asked if the Aeronautics Directorate had ever examined the overall operational context in order to improve the efficiency of air traffic control. Mr. Edwards said that getting to the next paradigm would be very difficult given that the system has to operate continuously. Mr. Robert Pearce noted that it's how you get to where you want to be to get to an optimal situation. The tools ARMD is building, once integrated, would serve that. Mr. Edwards said that the research is taking a very hard look at autonomy. Mr. Anderson replied that it was all good work, but he had trouble integrating it mentally. In response, Mr. Edwards said that the Air Traffic Management (ATM) Technology Demonstration-1 effort – ATD-1 – is one domain that ARMD is addressing. There are other technical areas in the pipeline to address other issues.

Mr. Borghese said that doing research and transitioning it to usefulness is the hard part. When does ARMD determine when something is going to transition? What is the mechanism? And is there a point when the program is cut off? Mr. Edwards replied that once an initiative begins, a research transition team is established and then starts to dialog. It can be a difficult process, given that specific research is dependent on procurements, among other considerations. Work must also fit into a deployment schedule. When the Federal Aviation Administration (FAA) makes the decision to invest is when the handoff occurs. But if a specific research effort is not worth pursuing, it is concluded.

Dr. John Paul Clarke said that part of the issue is knowing how to recognize when nothing more can be done. Handoff ceremonies are good, because NASA then knows where the work will end up. But, going forward, is there a formal process in the ARMD organization for deciding when to end non-productive research? Mr. Edwards said that, yes, there is a process for knowing if the technologies are getting us to where we need to go. Mr. Pearce added that the whole research transition team process is a major change; ARMD is no longer doing an ad-hoc, one-off thing. Just having these teams is a major step forward. There's a steering committee that decides what teams to put in place. ARMD doesn't want to conduct research for 20 years with no payoff.

A discussion then ensued about timing and investments into research that will be adopted and deployed. Technology readiness levels (TRLs) and partnerships were discussed. Teams evolve over time. NASA ARMD forms a team at TRL 3 or 4. Optional "hooks" may be included in team formulation. Because the FAA is focused on NextGen, it's more on NASA to think about versatility and the future research timeline.

Dr. Shin observed that if ARMD doesn't do anything, the NASA workforce will be working on technologies that are primarily implemented in the far term. What ARMD has been trying to do in the last five years is focus on relevancy and near term progress for those ideas that will meet customer needs. Although ARMD is collectively making good progress on relevant research, individual efforts need to tie together.

Mr. Borghese said that because the projects are not additive, it's hard to come up with one number. It's a lot of moving parts; the difficulty is coming up with specific percentages. Dr. Francis said he agreed that some sort of tracking metrics would be useful. Mr. Anderson said that if this is the way the system works today, he wanted to see what's improving in each of the research activities. Ms. Blakey noted that, in her role at the FAA, and as the customer for a few years, there has developed a difference between night and day about how NASA has fit its work into the real world. It's a sea change and quite welcome.

Enabling Civilian Low-Altitude Airspace and Unmanned Aerial System (UAS) Operations by Unmanned Aerial Systems Traffic Management (UTM) by Dr. Parimal Kopardekar

In response to a query from Dr. Frances concerning airspace sharing, and existing infrastructure at low altitudes, Dr. Kopardekar said that unmanned aerial systems traffic management (UTM) must integrate with the bigger picture and be interoperable.

A discussion then ensued about the general public, its role as a stakeholder, and the difficulty of finding a representative general public. People whose homes are being surveilled comprise the affected public. Congress actually represents the general public and should be included in such a definition. Congress has expressed concerns specifically about privacy, which remains a very local, very personal issue. Local officials need to be part of the solution; it's not just on the federal level. But airspace is a national and local resource. Significant questions remain about enabling all players, public and private, to connect into a cloud-based national system that is as open and accessible as possible. What is a complementary system that NASA should be working to guarantee that geofencing – the use of the global positioning system (GPS) or radio frequency identification (RFID) to define geographical boundaries – will work when everybody will ignore it?

Mr. Borghese asked if discussions with the FAA have occurred about unmanned aerial vehicle test sites. Dr. Kopardekar said that he has talked with the agency; FAA personnel are interested in seeing how UTM can help them manage their missions. Each requirement – defined on a per-build basis – has a timeline. Dr. Francis asked if there was any requirement for security. Dr. Joseph Rios replied that, although NASA is building a prototype, no rules have yet been formalized. Dr. Francis observed that here's a great opportunity for disruption. In reply, Dr. Rios said there were mitigation strategies already under development. ARMD is partnering with Amazon and Google and will learn a lot from them in terms of information technology.

In terms of bird migration and its UAS effects, Dr. Rios said that no database had yet been compiled. ARMD could address it if there's a datasource and an eventual pressing need. Mr. Borghese said that what NASA efforts are leading to is essentially invention of a new airspace. It could become the de facto system if people use it. Are researchers

looking at a system resistant to cyber threats? Dr. Rios said that the UTM staff are trying to learn as much as possible about network attacks. Dr. Francis praised those efforts, but noted that it will be a very publicly accessible thing. Having to deal with issues along the way would be advisable. Dr. Kopardekar said that he agreed, and that it was something that needed to be addressed.

Dr. Clarke asked about the human supervisory issue. At the moment, Dr. Clarke said, it's "let things work, and if something goes bad, let the humans take over." Where is that in the builds? Dr. Rios then cited the future possibility of no human at the vehicle controls, but ground-based remote control and monitoring.

A discussion then ensued regarding safe modes, loss links, and minimal disruptions to the overall system because of incidents. Concerns over the NASA governance model were expressed. The issue of providers of airspace vs. business delivery systems and how it all is managed was also broached. Will the FAA be on the path to accept this approach? There is a growing awareness in the FAA that new perspectives are required. The idea of shared risk is dependent on the development of robust technology. Financial models also need to take assured safety into account.

Dr. Clarke wondered about those operating in a hybrid mode. Would governors be put on peak performers? Dr. Rios said in such a cases, one would be allowed to submit a trajectory, or a plan to loiter for 40 minutes. Such operational matters are the focus of the concept of operations – the CONOPS – still under development.

Discussion then occurred regarding development of a UAS Standardized Testing and Recording, or USTAR, system. What's the minimal set of ICDs (interface control documents) that have to be put in place? That's a challenge. Because every home may eventually have a drone, it's even more important to have evaluation standards. Questions remain about how to integrate operator experience, or lack thereof, into the overall evaluation. Test sites could be used to gather initial data. Performance data will be used to supplement drone choice. Airworthiness requirements should also come into play, especially as UAS vehicles age, in addition to mileage counts. As systems evolve and exhibit more automation, operator expertise may become less of a factor. The process must be responsive over time: self-improving and self-correcting.

Establishment of the FAA's UAS Center of Excellence by Sabrina Saunders-Hodge

Dr. Francis noted that there's a huge focus right now on small UAS. Transportation is not a priority for such vehicles. Ms. Saunders-Hodge said that was overarching in the legislation [establishing the UAS Center of Excellence (COE)]. Dr. Francis than asked if member universities would operate independently or collaborate. Ms. Saunders-Hodge said that such universities would collaborate on some initiatives. If there's a university that has a specific competence, the FAA would want to go directly to that university.

Mr. Borghese said that, given that the Department of Defense (DoD) gives 16% of their research budget to universities, FAA funding seems to be one, maybe two orders of magnitude too low. Can anything be accomplished research-wise with such a little bit of money? Ms. Saunders-Hodge said that she expected partners will use the Center and other research that is well-suited for academia. The trends show that once COEs get going, other funding streams start coming in. This COE is aligned with aviation safety

research in the FAA and is the prime sponsor. The Center has planned out to fiscal year 2017, although the budget will never be as large as the DoD's, or even NASA's.

A discussion then ensued regarding the relationship between the COE and the FAA's William J. Hughes Technical Center Research on human-in-the-loop simulations and black body modeling is ongoing; it's one way to reach out to a large academic pool of talent and expertise.

Verification and Validation (V&V) Research Update by Richard Barhydt

Noting Mr. Richard Barhydt's citation of the costs associated with the overall software development process, Mr. Borghese said the numbers appear to be very, very low, an order of magnitude below where they should be. Mr. Barhydt replied that several of the figures were dated, originating with a study done a few years ago. In reference to a query from Dr. Francis regarding authority and autonomy, Mr. Barhydt said that ARMD's verification and validation (V&V) research has been primarily focused on establishing unambiguous roles between each. Going forward, the focus will increase on autonomy.

Dr. Clarke asked about what aviation safety research will continue once ARMD's Aviation Safety Program is repurposed. Mr. Barhydt said that, overall, safety will remain a strong focus in the new strategic thrusts. ARMD's new Airspace Operations and Safety Program will be an evolution from the work ongoing in aviation safety, building on capabilities already under development.

In response to a question from Mr. Borghese about ARMD identifying the need for V&V research to maintain or increase safety while reducing cost, Mr. Barhydt said that as larger and more complex systems are deployed, it will become more difficult in terms of safety. NASA's V&V work is intended to reduce the time of development and associated costs. The V&V research will be focused earlier in the design process, to avoid issues going forward.

Dr Francis: "What is an example of a formal method you are using?" Mr. Barhydt: "One example would be in static analysis as an emerging technology, part of a formal-methods paradigm. It allows you to take logic and look for areas in the software code. It would be part of a software application. And looking how it could be applied in a certification context." Dr. Francis then said he didn't hear the words "mathematical guarantees" that can be trusted in the results. The work should be oriented such that there can be demonstration that the methods can be applied.

Dr. Guillaume Brat noted that, for certain classes of errors, it is possible to obtain a guarantee. Static analysis won't solve every problem. What's needed is a combination of techniques at different stages, and they'll give you different things. Mr. Borghese said that software does what its creators ask it to do. But the FAA isn't allowing any reduction in testing. Will formal analysis allow for a reduction in testing? Mr. Barhydt said that a future state may rely more on these methods. This is just one part in a far bigger system. By working together on this and exploring new capabilities, a point may be reached that could eventually reduce certification costs. It's a process. Dr. Brat observed that many errors can be traced back in the requirements and design process. Those errors can't be caught. Most of the cost is locating the error and then fixing it, albeit very late in the development process.

Mr. Borghese asked what would be the recommendations regarding the certification of hardware and software. Mr. Barhydt said that the first one will be focused on the software. Eventually, as the FAA has indicated, they want to cover the waterfront. Dr. Francis: “Intelligence comes in multiple flavors: machine and human. Have you contemplated adding in the human piece?” Mr. Barhydt: “This work has been geared toward software, but it is extendable to humans as well. They may have broader capability.”

A discussion then followed of human-machine interface, and issues of safety. Autonomous systems still have a human on the other end. ARMD will be concentrating on autonomy going forward. In terms of software development, the V&V tools NASA is working on may complete an entire-application scan in minutes, versus three weeks currently needed. Dr. Brat noted that’s a lot of the work that has to be done: “We are going to bring together a lot of different tools. There’s still a huge amount of work that needs to be done. This is going to be a huge emphasis.”

Dr. Clarke noted that when a procedure is designed, it gets approved for packing into a database and eventually gets loaded onto a compact disc for a test on an airplane – and then the airplane goes somewhere where it’s not supposed to go: “You need to verify that what you get is what you actually intended. We don’t have a high-level language that we trust enough.”

A discussion then followed about software being examined in the same way that human pilots are certified. Dr. Brat said it wasn’t a research issue, but has to be driven by industry. There is no standard agreed upon by industry, which is why the tools aren’t available. ARMD will start looking at cybersecurity, and also issues when humans have to take over for the autonomy. Dr. Francis said that it’s human-machine intelligence integration that’s the issue. It’s something that isn’t yet done very well. Formal analysis should be done on larger systems, as well as flight control systems for a transport aircraft.

Mr. Borghese said that V&V is a huge problem for industry, which is becoming non-viable because of certification costs. Even more important than cost is cyberresistance. There’s a need to reduce unplanned cost. There’s also a lack of understanding about what formal analysis is. The upfront systems architecture work determines a large part of the V&V. The countries in this world that will prosper are the ones that will be able to deal with complex systems. Dr. Brat invited Committee members to visit in person individually and share with ARMD what the real problems are.

Aviation’s Big Questions by Robert Pearce

Mr. Anderson asked Mr. Pearce if looking at research questions was imposed or a choice. Mr. Pearce said that it was something ARMD wants to do in order to not be overly fixated: “It gives people an opportunity to say ‘We have a different idea.’” Mr. Borghese said that the idea of encouraging people to think differently is very important: “You’re not going to stop the seedling process are you?” Mr. Pearce replied that ARMD wants more interdisciplinary interaction. It will be multi-center. Mr. Anderson mentioned workshops and the turbulent mixing of ideas. Will ARMD use that to populate the Transformative Aeronautics Program? Mr. Pearce said yes. Mr. Douglas Rohn said that it would be a merger of teams who come up with ideas, but driven by the questions being asked. Questions will first be bubbled up.

A discussion followed concerning large multi-disciplinary problems and how teams will address those. Seedling money will be provided to NASA centers so the process will be jump-started. Individuals can propose ideas. Small airspace designs, for example, could be one innovative approach. Crowdsourcing a DARPA-like Grand Challenge could be another approach. It could generate a lot of excitement. ARMD is doing this because of lessons learned. Small seedling investments – like $200,000 – lead to solutions to narrow problems. Larger investments of $600,000 are ongoing. It's been a constant process of learning from experience.

Dr. Shin expressed concern that NASA Aeronautics has become bureaucratic. He felt that ARMD should create opportunities and engagement for the younger workforce. In particular, he wants ARMD to think of new ways to work and innovations that are needed by the industry. As an example, Dr. Shin cited his conversation at a small regional conference in Seattle with a chief strategist who said that baggage remains a problem for the airline industry in terms of the overhead bins and carryon luggage.

Ms. Blakey said that the goal is to identify true brilliance. Dr. Clarke rhetorically wondered about area rule creator Richard Whitcomb: "Could he have survived today? He was not the kind of guy who would work on one program. I'm not sure we have a structure now that can enable that sort of thing." Dr. Shin said that ARMD hopes to provide an environment like that, but that questions remain. How does one manage workers? How can ARMD account for work giving researchers money and saying, 'Just go ahead and work on something?' We're wrestling with red tape all around us."

Discussion then ensued about handpicking people on a team to select the right projects: the innovator's dilemma. Political and social constraints will always operate. The average citizen remains bedeviled by a congested system. Mr. Anderson cited quick-turnaround design work on the B-52 bomber and how short deadlines focus creativity. Viscous forces are very strong. The Shark Tank approach may also prove valuable. Dr. Shin said that ARMD depends on the seedling investment approach. Mr. Borghese said that UTM could change airspace. Could that have happened using only the seedling approach? Dr. Shin said that no, not in this case. Mr. Borghese said that giving people a big problem to solve might be the better way to go. But the seedling approach is a good test.

Dr. Francis cited the DARPA approach: having the flexibility to capitalize on ideas as they occur. Dr. Clarke mentioned using undergraduates. But they don't know everything. Term projects might be a good alternative, as would be partnering with a company. Dr. Thole said that students are incredibly creative, even if they don't have all the skills. Mr. Borghese said engineers in companies are also creative. Giving proscribed objectives is one approach, but not the only approach. Mr. Pearce said the intent is "to get folks to think big."

Public Comments:

None.

Committee Deliberations

Ms. Blakey asked if there were any recommendations or initiatives and findings for the Committee to put forward. The value of this Committee is the interaction with staff. Dr. Clarke said that tracking the end of the Aviation Safety Program, and which activities are continuing and which are not, is something the Committee needs to do. Dr. Shin replied that ARMD does have all the materials in place. It's a matter of finding a time and place to present them.

Mr. Borghese said that UTM could be as big as ARPANET. These milestones are very important to continue. Dr. Shin said that some very different aviation could be emerging: "If we use these technologies right, it could open up some whole new areas." Dr. Thole said she would suggest a large conference whose focus would be UTM. ARMD may want to partner with companies to help set it up. Dr. Shin said UTM could be the combination of many things that have been very successful. Dr. Clarke said that the TED approach (based on the Technology, Education, Design talks) could work too, where you have two people. Dr. Thole said that she agreed.

Mr. Borghese said that he was one of the few non-aero people in the room. Certification is the largest expense for many of the companies represented in this room. It also is driving graduates from the industry, because certification is the most grueling kind of work one can do.

Dr. Warmbrodt said that he could see where UTM can take ARMD, and he cited tie-ins with both airborne and terrestrial intelligent sensors.

MEETING ADJOURNED at 3:38 p.m.