NASA Advisory Council Aeronautics Committee Meeting
November 15, 2018
Langley Research Center
Hampton, VA

Welcome

Mr. John Borghese, committee chairman, called the meeting to order and welcomed everyone. He asked everyone present in the room to introduce themselves with name and affiliation. Dr. Jaiwon Shin, NASA associate administrator for aeronautics, added his welcome and then briefed the committee on the appointment and confirmation of NASA's news Administrator, Jim Bridenstine, as well as other political appointees including Jim Mohard as deputy administrator and Jeff DeWit as chief financial officer.

Mr. Borghese reminded the committee about the difference between recommendations and deliberations. Recommendations are a course of action being proposed by the NAC for NASA's consideration. It must be actionable and requires a written response from NASA. A finding is something about which the NAC wishes to state an opinion. It doesn't require a response from NASA.

Mr. George Finelli, Langley Research Center's aeronautics research director, provided the committee with an update on the many ways in which Langley supports the research portfolio of NASA's Aeronautics Research Mission Directorate (ARMD). He noted Langley's recent centennial anniversary and provided some examples of the center's heritage contributions to both aviation and space.

Dr. Greg Hyslop asked Mr. Finelli how data gathered from the Low Boom Flight Demonstration mission, which is managed in part at Langley, would be shared and help open a new industry of commercial supersonic air travel. Mr. Finelli responded that the priority is to meet NASA's critical commitment of delivering a database that will help regulators change rules regarding noise from sonic booms. Dr. Shin offered that the actual X-59 aircraft design may not directly lead to a commercially-viable design and noted there are other challenges that must be overcome and cited; as an example landing and takeoff noise of supersonic airplanes. Jay Dryer (NASA ARMD's deputy associate administrator for programs) noted that experience in developing and using design tools for the X-59 was shared with industry and will inform the continuing evolution of those tools for designing future aircraft.

Dr. Karen Thole asked for help in understanding NASA's strategy for sharing information with the international community while at the same time ensuring the U.S. industry remains competitive, particularly as it relates to the community response data from the X-59 flights. Mr. Dryer explained that the rule changes to come from the database will be set by the International Civil Aviation Organization; but the technology in designing, building, and flying the X-59 is very much a U.S. asset intended to benefit U.S. industry.

eVTOL Noise Modeling and Technology Solutions

Ms. Susan Gorton, NASA's manager for the Revolutionary Vertical Lift Technology (RVLT) project, presented to the committee an overview of the project, its primary strategy being to enable a broad expansion of vertical lift applications. More specifically, the project is working to improve current configuration cost, speed, payload, safety, and noise; open new markets with new configurations and capability; and capitalize on the convergence of technology in electronic propulsion, autonomy, and flight controls.

Ms. Gorton noted that NASA's technology emphasis has deliberately shifted toward the lighter end of the spectrum in terms of mass, market, mission, range, overall configuration and propulsion concepts. The configurations range from one passenger to 15-passenger vehicles, each with different types of wings and propulsion systems.

Research areas being considered for each configuration include propulsion efficiency, performance, rotor-rotor interactions, rotor-wing interactions, structure and aeroelasticity, aircraft design, operational effectiveness, safety and airworthiness, and noise and annoyance. The last two areas are receiving primary focus within the RVTL project.

Discussion

Mr. Borghese asked how safety and certification issues would influence coming up with various configurations. Ms. Gorton gave some examples of how this happens and noted some of the tradeoffs that must be considered, such as reliability versus mass or giving up payload for extending range.

Mr. Anil Nanduri, following up on the previous question, asked if there was any reference data from NASA's own tradeoff deliberations that could be used as a benchmark for industry to consider as they work to develop their own standard models. Ms. Gorton replied she wished she could say yes, adding it was NASA's goal to be able to support such a sharing of data.

Several committee members contributed to a more detailed discussion concerning safety and reliability as it relates to the various types of power architectures being considered not only for the four NASA concept study vehicles, but by industry in general, and what that power architecture includes. Ms. Gorton noted that, for now, NASA's idea of what propulsion architecture includes is from the drive train to the propulsion system.

Dr. Mike Francis asked if any work is being done to look into acoustic aerodynamic interaction, where the acoustical energy could be potentially damaging to the aircraft's structure. Ms. Gorton replied yes, NASA is starting to look at that as their research tools allow. NASA also is looking at how vibration is transmitted through structure, with high cabin noise and reverberation being key concerns.

Committee members also offered comments about safety and reliability as it relates to vehicle size, focusing on tradeoffs between redundancy and reliability, and to what extent NASA is looking into these issues as the vehicles become smaller and the emphasis may be more on operations. Dr. Shin noted these questions are being considered within the various aeronautics projects and answers shared and integrated so everyone can benefit from them.

Committee members discussed the issue of when does noise become an annoyance, noting that public perception of noise can widely vary, not only from a measurable decibel level standpoint, but from intangible considerations as well. Measuring public perception of noise remains a challenge.

Dr. Hyslop suggested that NASA's artwork in depicting rotor and Urban Air Mobility (UAM) activity should not overly emphasize the presence of pilots or human passengers, as unmanned cargo vehicles will be just as active.

Dr. Thole advised that engaging K through 12 students and making sure they understand what noise is, and how it is produced, could aid in public acceptance of UAM activity. Dr. Allison added that connecting work on public perception of noise – the annoyance factor – to psychological research or human factors research would also be helpful.

Mr. Borghese noted there was a focus on noise and safety and expressed his concern that the focus was more on noise than safety. Dr. Allison agreed. Committee members suggested opportunities where safety could play a larger role as systems are refined or new systems developed. The example of the rotors, from the actuator assembly down into the power train, was given.

Findings/Recommendations

The Committee applauds the Rotary Vertical Lift Technology (RLVT) project initiative with a focus on the two most critical areas needed for acceptance of Urban Air Mobility (UAM): noise and safety. The Committee offers the following suggestions. The ability to accurately model noise generation and its mitigation is particularly important in the design development of rotors for wide range of operations. There is a significant amount of work being performed around the world including OEMs on noise modeling and design for low noise. NASA could leverage this effort. A particular area in which NASA could add differential value is in understanding and assessing public acceptance and perception of noise generated by air vehicles that will be used in UAM. For example, what is the most annoying part of the noise when there are many rotorcraft flying simultaneously in the vicinity. This topic could present an opportunity to engage K-12 students possibly as part of a NASA grand challenge.

Safety of vehicles in UAM is of critical importance and NASA could play a significant role in this area. The Committee suggests performing a Failure Mode Effects and Criticality Analysis (FMECA) including probabilities by component on several reference vehicle architectures. One project could be the analysis of the propulsion system starting with a tiltrotor and including the complete powertrain with and without cross winds. Determining the safety level that not only ensures safety but also meets the public's perception on what is required on safety would benefit the industry. The development of a model that allows analysis of various parameters like safety and noise would allow designers to test innovative designs of air vehicles for UAM.

Subsonic Technology Development Strategy

Richard Wahls, NASA's strategic technical advisor in the Advanced Air Vehicles Program (AAVP), presented an update on the agency's subsonic technology development strategy, with at least some emphasis on how AAVP ties to Urban Air Mobility (UAM) research.

He began with a global overview of aviation and how fixed wing aircraft will fit into the mix of different types of aircraft flying at different altitudes and speeds, and with different missions. That "fit" will remain the most significant part of aviation as the global backbone of air transportation into the foreseeable future. A number of current statistics regarding air travel were presented to underscore that importance.

Dr. Wahls continued his overview of the global market and its challenges to U.S. leadership in aviation by noting that intense and expanding international competition for manufacturing aircraft is growing. While Boeing and Airbus continue to form alliances with other companies, such as Bombardier or Emery Air, new alliances between Russia and China could mount a serious challenge to eroding the U.S. market share of building aircraft.

Another key challenge from the global marketplace that is guiding NASA's research investment decisions is societal demands for more environmentally friendly aircraft. New regulations requiring airlines to report carbon output are about to go into effect, adding to the list of environmental concerns the aviation community must continue working to address. The best way to do this is to find ways of getting new and more advanced aircraft into the market faster and at lower cost.

Dr. Wahls said that all four of NASA's aeronautics programs are addressing these goals in some manner. A specific technology he offered as an example of research toward these goals was advanced composites. He also called out the work being done to take emerging technologies outside the aviation community, and to find ways to take advantage of them in solving these challenges.

Dr. Wahls reviewed some of the goals NASA has set in the past for near-, mid-, and long-term goals for subsonic aircraft dealing with several variables, including fuel burn, emissions, and noise. He then described some of the technologies and aircraft configurations that were proposed as a result of the research driven by those goals. The research led to possible solutions that covered a wide range of ideas, from new aircraft shapes enabled by the use of composites to the use of additive manufacturing (3D printing) and electric propulsion.

Dr. Wahls shared a video that displayed some of the technologies NASA is working on, particularly in the area of electric propulsion. A discussion followed about hybrid-electric and all-electric propulsion, when each might be feasible for widespread use, and what are some of the technical and safety-related problems with the use of batteries, heat transfer, and heat rejection.

Discussion

Dr. Allison asked about applying research in advanced composites to the UAM market. Mr. Wahls noted the imminent conclusion of the current advanced composites project and described some ways in which results of that effort can be applied not only to the aviation market, but also to other areas. Dr. Allison noted the increasing use of composites in the automotive market and that some of that work, especially with tooling, might be helpful in the aerospace community. Several panel members discussed some of the manufacturing challenges aircraft manufacturers face in the introduction of widespread use of advanced composites.

A similar discussion followed a little later, also led by Dr. Allison, regarding the potential lessons-learned NASA might gain from studying or collaborating with the automotive industry in the use of batteries and managing an electric propulsion system, while also recognizing there are significant differences between the way the two industries would use such systems. Mr. Jon Montgomery from NASA noted the agency made a conscious decision not to pursue battery development, mostly leaving it to the battery and automotive industries to continue to invest their research dollars. Dr. Allison noted there is a gap in developing a tool for examining the integration of different battery concepts into an innovative automotive or aircraft system. He suggested NASA might have the expertise and incentive to address that gap and develop such a tool.

Dr. Francis cited some recent papers describing the potential negative effects on aviation due to the impact of climate change on atmospheric conditions. At their worst, those effects could lead to significant clear air turbulence that would make passenger comfort during flight difficult to achieve, if not completely unviable. He urged NASA to consider this potentiality in making decisions about future research goals. Mr. Wahls noted that NASA has not considered ride quality as a metric to study in the design of future aircraft, the emphasis being more on passenger safety.

Dr. Thole asked about the use of universities in solving some of these challenges related to batteries and electric propulsion. Dr. John Cavolowsky of NASA provided a brief update on the agency's University Leadership Initiative project and noted there is indeed a role for the academic community to conduct research in this area.

Findings/Recommendations

The Committee recognizes that there are thermal management opportunities where NASA can contribute as one of the biggest new challenges in designing all-electric or hybrid-electric aircraft is heating and cooling of the electric powertrain components. The Committee suggests NASA consider the innovation that currently exists in the automotive industry in terms of tools. There is a gap in tools and this an opportunity for innovation that NASA could fill. The Committee believes that this might be a good area for collaboration with universities and industry. Another important area is battery cell/pack architecture and how it connects to vehicle-level high voltage architecture to meet aviation standards. Additionally, all-electric aircraft will require innovative design work to make battery packs that are lightweight with adequate thermal management. Other methods for electric energy storage, including fuel cell technology, for example, should also be considered. Universities could be of help in the development of needed tools and models and the rapid testing of their fidelity through measurements on additive manufactured parts. Issues that could shape the future of subsonic flight, such as predicted climate change-induced atmospheric behavior should also be examined.

Autonomy Update

Jay Dryer, NASA aeronautics' deputy associate administrator for programs, presented an update on the topic of autonomy. He prefaced his talk by underscoring that while other areas of NASA's aviation research can trace its heritage going years and years back, the research area of autonomy is still very new.

Mr. Dryer reviewed that assured autonomy is one of NASA aeronautics' six strategic research thrusts. One reason is because autonomy is seen as enabling capability for moving forward with safe technology that will transform aviation and open a new era of air transportation at every level of operations. He noted that many of the finer details of NASA's role in this area are still being identified. Much will depend on finding the best balance between what NASA can do and what the rest of the autonomy community is doing and where they need help.

Mr. Dryer explained that work on autonomy is not being done for autonomy's sake, but because it will help in concert with other technologies to enable future innovations related to Urban Air Mobility (UAM), for example. In fact, NASA's work on UAM is helping to focus its research activities with autonomy. Achieving public acceptance and trust is important as well.

Mr. Dryer said another emphasis of research in autonomous systems is related to air traffic management (ATM). An important part of that is to identify the requirements for developing an ATM system that is resistant to disruption, capable of dynamically scaling to safely meet demand and complexity, and be inclusive of new entrants and use cases flying in the National Airspace System.

Discussion

Dr. Allison suggested NASA consider a different approach to autonomy by identifying specific, incremental goals related to UAM operations and then build the rest of an architecture around that. Mr. Dryer noted that NASA's approach to UAM is more from a big picture standpoint in which autonomy is just one part. Dr. Allison said he wasn't sure he completely agreed with that approach and offered some examples of how NASA might do things differently. Mr. Dryer said this is the kind of input NASA needs right now as it continues to identify what would be most beneficial to the community.

Mr. Nanduri suggested an approach to identifying the definition of different levels of autonomy, which could help standardize terminology and expectations about what is achievable at each level. For example, in a six-level scheme, level 6 might be a completely humanless operating vehicle and system. By introducing fully-understood levels of autonomy, specific research goals could then be identified and worked toward.

Dr. Allison proposed an approach in which different road maps to autonomy could be developed that are based on an incremental approach, perhaps beginning with the automotive industry and expanding in complexity and more autonomous operations from there.

Several panel members addressed a potential future in which more and more aircraft rely on fewer and fewer pilots, to the point of reaching Mr. Nanduri's level six of a humanless vehicle. Such a future remains distant, but short-term problems such as a shortage of pilots could force an increasing reliance on increasingly more sophisticated autonomous systems and quicken such an outcome. Public acceptance of a human-less system could be helped by a step-by-step increase in reliance on safe and secure autonomous systems. Dr. Hyslop suggested an autonomous aid could be introduced into the cockpit – he used R2-D2, the droid from Star Wars, as an example – to build public acceptance and confidence.

Mr. Borghese commented that NASA could help through its research and experience by generating data the FAA will need for coming up with requirements for safely certifying autonomous systems for use. Mr. Dryer commented that is a major emphasis of NASA's work on autonomy.

Dr. Thole reiterated her concerns that not enough students are following career paths that would be helpful in developing fully autonomous systems for aviation. They are being lured away by the giants of Silicon Valley, who are considered to be more innovative and quicker to react to industry needs. She offered some potential solutions that could help turn the tide, and others offered ideas related to workforce development, STEM engagement, and university partnerships as well.

Findings/Recommendations

Autonomous aircraft and related airspace operations and management enable emerging aviation capabilities in areas where the United States needs to maintain global leadership. The Committee offers the following suggestions:

- NASA can assume a fundamental role as the conduit between industry and the FAA for certification requirements and the verification and validation approach.
- Engage FAA early because autonomy is a disruptive concept to the standard DO-178C software certification process.
- Develop cyber security requirements which are not being addressed sufficiently by industry and are needed for safe operation.

The Committee expressed concern about the flow of talent from aerospace and universities to the broader tech industry. Engineers with autonomy and artificial intelligence backgrounds need to be enticed to enter and remain in the aerospace arena. The excitement generated by emerging Urban Air Mobility where NASA is working is an area that generates interest to attract and retain these engineers in aerospace.

Air Traffic Management Exploration (ATM-X)

Akbar Sultan, NASA's director of the Airspace Operations and Safety Program, presented an update on ATM-X, short for Air Traffic Management – eXploration. After describing ATM-X's place within NASA aeronautics' program structure, he emphasized a key point that NASA's investment in this area of air traffic management, which serves the Unmanned Aircraft Systems (UAS) community, does not mean the agency is abandoning traditional users of the National Airspace System (NAS). One of ATM-X's primary objectives is to examine the concept of a service-oriented architecture, which could be used by traditional and emerging users alike.

Mr. Sultan reviewed the project history and noted how early goals evolved as a greater understanding was gained about the scope of UAM operations. ATM-X's overall project goal is to enable safe, efficient airspace access for all users, vehicles, and missions by creating new airspace management concepts and technologies which leverage UAS Traffic Management (UTM) principles. This architecture must be scalable, flexible, and resilient to uncertainties, degradation and disruptions. Through collaboration, it must provide seamless access to the airspace for all users and those providing third-party air transportation management services.

Mr. Sultan described a wide range of research activities and results related to ATM-X work during the recent past. The presentation inspired a number of questions from the committee, which led to further discussion and observations covering a variety of operational scenarios.

Discussion

Mr. Sultan was asked to define more clearly exactly what is a user service-oriented architecture. He said that it's a collaborative increased use of third-party traffic management services that enables efficient use of the airspace by users for their own purposes. This is a more flexible approach to traffic management than the traditional approach in which a single, government-managed system directs users through the airspace in very specific ways based on traffic density, weather, and other variables.

Mr. Drennan asked if the Grand Challenge will be used as a "sandbox" to demonstrate and better understand some of the operational challenges associated with this.

Mr. Borghese noted that roughly 70 percent of delays in the NAS are due to weather issues and that there is no project related to improving weather predictability. Improved forecasting and 4D modeling of weather could greatly increase the amount of traffic the NAS could handle. He asked if other projects are addressing the weather problem, or if the assumption is that current capabilities will be relied upon. Mr. Sultan said the project doesn't have that kind of expertise and noted that other organizations – such as NOAA – are working on improving available weather products which could improve traffic management capabilities, whether the users are traditional airlines or users from the UAM community.

Dr. Allison asked Mr. Sultan to elaborate further on the definition of a service-oriented architecture, asking if the elements of this architecture and its operation are of the same general idea as those being developed for UTM. Mr. Sultan said it was, adding they envision a very federated system operated by many interconnected providers, instead of the current monolithic system. There was a discussion on the operational details and potential challenges of such a system. It was noted that managing/resolving overlaps or conflicts among service providers and/or users will benefit from the work being done by the Integrated Demand Management (IDM) project. Mr. Sultan then elaborated on the current status of the IDM concept.

Findings/Recommendations

The Committee applauds NASA in exploring the future of air traffic management needed to be viable for the significant increase in air travel in both conventional routes, new air mobility solutions, and unmanned air vehicles. The Committee recommends exploring the potential of federated systems operated by third party service organizations. The NASA Grand Challenge is an opportunity to test some of these ATM-X approaches. Transition from the existing, very safe air traffic management system to potential future ATM-X concepts needs to be examined as well. The Committee suggests that the design of the system take into account seamless integration into the current system. The Integrated Demand Management (IDM) project has shown promising results to the FAA and industry allowing a path to transition. IDM is the type of NASA research that is not well known outside of the aerospace sector but offers benefits to the current air traffic management system and the flying public.

List of Attendees

Committee Members
Dr. Eric Allison
Mr. John Borghese
Mr. Scott Drennan
Dr. Mike Francis
Dr. Greg Hyslop
Mr. Anil Nanduri
Dr. Tom Shih
Dr. Karen Thole

NASA
Dr. John Cavolowsky
Mr. George Finelli
Ms. Susan Gorton
Mr. Jim Heideman
Mr. Jon Montgomery
Mr. Steve Reznick
Ms. Irma Rodriguez
Dr. Jaiwon Shin
Mr. Akbar Sultan
Dr. Ed Waggoner
Mr. Rich Wahls

FedWriters (Meeting support)
Ms. Abigail Casas
Mr. Steve Spearman
Mr. Eric Stone