R. John Hansman
T. Wilson Professor of Aeronautics and Astronautics
Director, International Center of Air Transportation

Massachusetts Institute of Technology
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Aeronautics and Astronautics

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November 23, 2021

The Honorable Stephen Dickson
Administrator
[redacted]

Dear Administrator Dickson:

Attached below please find the findings and recommendations from the Safety, Airports, Environment and Energy, Human Factors, NAS Operations subcommittees from the fall meetings which have been reviewed and supported by the full REDAC.

The full REDAC also made several general observations for your consideration.

Research During COVID – The REDAC noted that the FAA was generally able to make effective progress on the research agenda often in a virtual mode during the COVID restrictions. While there were some areas which were delayed due to experimental limitations the agency was effective in maintaining the research enterprise.

Environment and Energy Research Portfolio – The REDAC would like to commend the program and quality of the research in the Environment and Energy portfolio. The REDAC supports the research to increase the availability and use of Sustainable Aviation Fuels as well as the collaboration with NASA including the Sustainable Flight Demonstrator.

Protection of Aviation Spectrum – The REDAC notes the increasing challenges to the reserved aviation spectrum including current and future demands placed on spectrum allocation and utilization by both emerging/new aviation entrants as well as by non-aviation users. Research and technical analysis is going to be required to address the reallocation of spectrum usage and the potential impacts to those bands traditionally utilized or reserved for aviation use.

We appreciate the opportunity to support the FAA in promoting the safety, efficiency and sustainability of our national aviation infrastructure. I would be happy to meet to provide further insight on these observations or explore ways in which the REDAC can more effectively support you and the FAA mission.

Thanks for the opportunity to contribute.

Sincerely,

R. John Hansman
Chair, FAA Research, Engineering and Development Advisory Committee

Enclosure

Research, Engineering and Development Advisory Committee (REDAC)
Guidance on the FY 2024 Research and Development Portfolio

Subcommittee on Environment and Energy

General Observations: The Environment and Energy (E&E) Subcommittee of the FAA Research, Engineering and Development Advisory Committee (REDAC) focused on reviewing the RE&D Portfolio for Office of Environment and Energy that was developed based on the RE&D budget for FY 21 that was enacted on December 27, 2020 (RE&D received $198M). We were advised that the FY 22 budget had a request for $258.5M for RE&D. During the meeting, the staff from the Office of Environment and Energy (AEE) provided updates on all of the major research projects within the portfolio. Work on programs such as the Aviation Sustainability Center of Excellence (ASCENT); Continuous Lower Energy, Emissions and Noise (CLEEN); Commercial Aviation Alternative Fuels Initiative (CAAFI) and the Aviation Environmental Design Tool (AEDT) have been progressing. The updates highlighted accomplishments, since our last meeting, that have been realized both locally and on the international front directly linked to the ongoing research. Listing the individual accomplishments and their impacts on many of the different facets of aviation is not realistic during this presentation, but these accomplishments further validate the need for sound research when developing regulations and policies and procedures.

Despite the ongoing COVID-19 impacts, the Subcommittee continues to be very impressed with the job the leadership and staff of AEE has been doing. The presentations outlined a high level of communication between AEE staff and their partners to continue these necessary research efforts, but they also showed the challenges associated with COVID-19 restrictions and how they have impacted some projects.

As was highlighted in our March 21 briefing, there is a heightened awareness about the environmental impacts associated with the aviation industry. The current administration has made a commitment on climate change and has issued an Executive Order 14008 that outlines its goals. It has commitment towards "reducing the aviation sector's emissions in a manner consistent with the goal of net-zero emissions for our economy by 2050". The government has announced its intention to advance the development and deployment of sustainable aviation fuels and on maintaining a leadership position at the world level with organizations such as the International Civil Aviation Organization (ICAO). The establishment and funding of the new Sustainable Aviation Fuel Grand Challenge aimed at dramatically increasing the production of sustainable aviation fuels are initiatives that demonstrate U.S Leadership. We know that partnerships with other governments, other federal agencies, our Centers of Excellence and Private Corporations who are involved in the research portfolios that AEE has in place provide results and are a very effective vehicle to conduct and coordinate future research and maximize limited resources.

The Subcommittee believes that AEE is doing a good job and has once again presented a balanced portfolio. We believe that AEE has added research projects that address the priorities that the Subcommittee has previously identified. The Subcommittee believes that additional research will probably be needed within CLEEN and ASCENT to support the government's

initiatives. The Subcommittee members realize that there is still additional research required to address ongoing areas of concern.

The Subcommittee is comfortable that AEE, the ASCENT Center of Excellence, CLEEN Program, CAAFI and others efforts, as well as and their partners, including NASA, are working together to realistically address the impacts that the COVID-19 pandemic has had on continued research efforts. The long term impacts of this pandemic on the citizens of the world and the aviation industry are still not known, but we believe that AEE has a proven blueprint that can be used to address future research needs. Guided by the updates and presentations, the Subcommittee has proceeded with the following "Findings and Recommendations". The recommendations offered are all for inclusion in the REDAC report.

Finding: Sustainable Aviation Fuels (SAFs) - We know that the Sustainable Aviation Fuel (SAF) Program including efforts in the Commercial Aviation Alternative Fuels Initiative (CAAFI), Continuous Lower Energy, Emissions and Noise (CLEEN) and Aviation Sustainability Center of Excellence (ASCENT) are a critical component of the industry's global emission reduction strategy. In order to meet the federal goals of increasing the production of SAFs to at least 3 billion gallons per year by 2030; demonstrate new technologies that can achieve at least a 30% improvement in aircraft fuel efficiency, there will need to be an increase in the research projects within the ASCENT portfolio. The same can be said if we hope to develop fuels that can be blended above 50% in today's fleet of aircraft. The current research has helped with the creation of a number of companies that have the potential to benefit the rural economies of several states and the U.S. Aviation industry. In 2020, 4.6M gallons of was used by the U.S. Aviation Industry, a 190% increase over 2019, and 2021 is on pace to exceed 2020 levels. The establishment of the Sustainable Aviation Fuel Grand Challenge will insure that the U.S. Government and the private sector are working together to address aviation sector emissions. The creation of the SAF MOU between the DOE, DOT and USDA will initiate and commit resources to the necessary research, development and deployment. There are ongoing efforts to ensure that alternative jet fuels are in CORSIA through ICAO CAEP. The FAA must also use their research to address the challenges from other countries/companies that are proposing other alternative fuels as realistic or long term solutions.

Recommendation: The Subcommittee agrees with the mandate proposed by the current administration that the work on Sustainable Aviation Fuels (SAF) is a critical component for the reduction of aviation sector emissions and supports the SAF Grand Challenge. Since the maturation of the Sustainable Aviation Fuel program will be a major environmental benefit for the public, will create a new industry within the U.S. that benefits rural America, and will benefit the U.S. aviation industry, we strongly recommend that the FAA AEE continues to allocate funds for the continuation of research on SAFs. We also strongly recommend that any additional funding that AEE receives should be used to accelerate this program in order to accomplish the goal of being able to supply 100% of the aviation fuel needed in 2050. The FAA must maintain a leadership role in the development of SAFs to ensure that the rules to be considered at a global level (ICAO) will be beneficial to the U.S. industry.

Finding: Public Private Partnerships - The Subcommittee continues to acknowledge and support the fact that the Office of Environment and Energy (AEE) have proven over decades to be very good stewards of taxpayer money. The leadership team at AEE has used their budgeted amounts to conduct and coordinate the research necessary to produce informed, data driven

policies, facilitate technological advances in the aviation industry, and produced models and data that have positioned the U.S. as both a State leader at ICAO CAEP and on the global aviation stage. The execution of this research portfolio has been accomplished by working collaboratively with private industry, major universities through the ASCENT Center of Excellence, other Federal Departments and Foreign Governments. Three quarters of Environment and Energy research funds generate 100% plus cost matching from non-federal partners (CLEEN, CAAFI, and ASCENT). This leverages scarce FAA R&D funds to accomplish significant advances and improvements. In addition, we believe that government funding has been used and executed effectively to lower the risk of new and emerging technologies such that they can be adopted by industry. The benefits of these partnerships has clearly been proven over time and is very apparent in most of the current projects. The maturation of new technologies has delivered improved environmental performance and has enabled aviation system growth and associated positive economic impacts. In order to comply with Executive Order 14008 on Tackling the Climate Crisis, there will be an increased reliance on these Public Private Partnerships.

Recommendation: Whereas the Subcommittee continues to endorse Public Private Partnerships like the CLEEN, CAAFI and ASCENT programs to leverage resources, we believe that the FAA will not be able to accomplish any of the priorities set forth by the current administration without allocating robust funding for these programs. AEE should be given the flexibility to utilize any additional funding that it receives in FY22, FY23 and FY24 on projects within its portfolio that will enhance and accelerate existing research to best address the current federal mandates.

Finding: Global Leadership - It is evident that the FAA AEE currently maintains a leadership role in ICAO CAEP and has been the driving force behind the push for data driven rule making. Based on the commitments made by the current administration on Climate Change, the Subcommittee firmly believes that maintaining the U.S. global leadership position at ICAO CAEP is essential and advantageous to U.S. aviation industry and will allow the U.S. government to defend its positions based on scientific research. Previous work that has been done with ASCENT and the Volpe Center has clearly allowed the FAA to maintain a scientifically supported position at ICAO CAEP. The close collaboration with NASA at ICAO CAEP is also clearly supporting global leadership. Anything that jeopardizes ongoing research at AEE will impact the FAA/U.S. global leadership position at ICAO CAEP.

Recommendation: The Subcommittee recommends the continuing strong support of all research efforts/programs that will allow the FAA and the U.S. to maintain its current global leadership position at ICAO CAEP. It is the belief of the Subcommittee that if the FAA/U.S. does not maintain its leadership position at ICAO CAEP it will not be able to influence policy/rulemaking and this could have a significant negative impact on the U.S. aviation industry.

Finding: Noise Research - Aviation noise is and will continues to be one of the biggest environmental impact related to the aviation industry and it requires ongoing research in order to address the concerns of the citizens. The Subcommittee realizes that there is much research that is still necessary to address the ongoing topic of aviation noise. Whether there are new technologies or new procedures that can be implemented to help reduce the impacts of noise as the aviation industry rebuilds needs to be evaluated. Historically, advances in aircraft technology have been the major factor in reducing aviation's environmental impacts. But the Subcommittee understands that there is about a 7 year lag between flight testing a technology

and it's appearing in the fleet. Therefore if we want to consider any new technology being introduced into the fleet in early 2030, we need to invest in the research now. The use of government resources during the initial research stages helps mitigate technology risk and incentivize private companies to invest and develop cleaner, quieter technology. AEE has seen a number of research projects that have contributed to more fuel efficient and quieter aircraft. They have also developed new operational procedures that have reduced the noise impacts in communities in and around airports. There are a number of new research projects that have been added to address issues related to new entrants into the aviation system. There also have been significant upgrades made to the Aviation Environmental Design Tool (AEDT). AEE has established an AEDT User Review Group for ideas and feedback in order to ensure that the tool is beneficial to the actual users. FAA has also launched an initiative to partner with airports to gather more noise data resulting from noise complaints. Finally, AEE is working with industry to accelerate the development of technologies that reduce noise through the CLEEN Program.

Recommendation: The Subcommittee strongly supports the prioritization of the noise research that will support informed decision-making, the introduction of new entrants to the national air space, and enable NextGen deployment.

Subcommittee on Aircraft Safety

Finding: Transfer of NAS Related Technology from NASA to FAA - The REDAC Subcommittee on Aircraft Safety (SAS) maintains awareness that NASA periodically transfers NAS-related technology to the FAA for further maturation and deployment. The SAS notes that NASA may not have matured some of these technologies to a NASA Technology Readiness Level (TRL) 6, where it has been tested in a relevant environment. The SAS finds that some of these technologies have been placed in FAA projects funded by F&E rather than RE&D funds and, therefore, not presented to the SAS for review. In addition, NASA transfers to FAA can also have forms of other technology such as data, concepts of operations, technical manuals, etc. which helps inform future FAA decisions and technology roadmap definitions.

Recommendation: The SAS recommends that all NASA technology transfers to FAA that have not reached a NASA TRL 6 maturity level be included in future briefings to the SAS such that the Subcommittee will have adequate information upon which to base its advice on RE&D funding and prioritization to the FAA. This will further ensure sufficient relevant environment evaluation exists for successful implementation decisions.

Recommendation: It is also recommended that the SAS receive briefings on low-TRL work in progress on the non-technology knowledge transfers from NASA such as data and documentation which are used to help inform FAA decisions. This will provide SAS members a better understanding of long-term RED portfolio and direction.

Recommendation: To address the broader level of other on-going NASA research, the SAS recommends that NASA provide periodic briefings to the SAS on those topics of research that may be applicable to our scope of oversight. It is further recommended that this be addressed as a recurring agenda item at future SAS meetings with rotating topics of interest.

Finding: Electric Aircraft Research - The SAS notes that the research in the A11L Unmanned Aircraft Systems landscape is timely and appropriate. However, as technology advances a new Budget Line Item should be added for solely electric powered aircraft. Further in-depth research can aid industry to address this new and emerging technology appropriately.

Recommendation: The FAA should conduct research exclusively on electrically powered aircraft including flight planning requirements and a correlation of battery level to an emergency or minimum fuel equivalent. This research should apply to small UAS, large UAS, advanced air mobility (AAM) vehicles, and other applications of electric propulsion systems. Any inability of aircraft to not have adequate power supply and reserves can impact the users of the NAS. Included in the F&R, specific addressing of battery standards, tolerances, capabilities, crash worthiness, and effects on battery performance by the range of anticipated temperatures and altitudes, and fire hazards (including suppression) should be researched.

Finding: UAS Radio Frequency Spectrum - In the opinion of the SAS, the research in the A11L Unmanned Aircraft Systems landscape is excellent. An additional observation of the committee is that various segments of the radio frequency spectrum have recently been allocated and assigned for auction, there can be safety and interference hazards with reassigned frequencies that may be adjacent to those required by manned aviation. In certain cases, shielding may not be an appropriate measure of mitigation nor a protective "guard band" may be enough to protect, critical, often safety of life systems on manned aviation.

Recommendation: The FAA should research and test the radio frequencies that are used by low altitude UAS including those that operate Unmanned Traffic Management (UTM) systems and or Beyond Visual Line of Sight (BVLOS). Additionally, the research should examine the appropriateness of the utilization of non-aviation networks by small UAS, as well as, overall latency and integrity issues in communications.

Finding: Airframe Icing on Non-Standard Aircraft Configurations - The SAS agrees that the FAA research in A11D budget line item for Aircraft Icing is appropriate. However, a research gap exists. For example, UAS airframe icing is lacking for study. As these present unique designs are vastly different from traditional transport aircraft, and potential testing methods may also differ.

Recommendation: The FAA should expand the Research Landscape to include the non-standard configurations. This research will cover all types of UAS from small to large, as well as, Advanced Air Mobility (AAM) type aircraft. Icing studies should include airframe, engine, and rotor icing. Without adequate research, ice accretion could cause a catastrophic condition affecting users of the NAS, both in the air, and on the ground.

Finding: UAS Safety and Security Technologies - For the research being conducted in the A11L Unmanned Aircraft Systems landscape, it is critical that UAS enter the market with the appropriate safety and security technologies that include standardized operational protocols that are expected by those in manned aviation. Certain technologies that may be labeled with a safety function should be researched as a check and balance to the overall safety system.

Recommendation: The FAA should research the capabilities of all "turn-key" technologies that allow mission completion right out of the box where most often no pilot input is involved. This

includes evaluation of all technologies that would permit this capability and evaluate risks that would be posed. Additionally, safety and security features, such as "geo-fencing," "return to base," "lost link," and other safety risk mitigation technologies should be evaluated and a basis for standardization established from the data. The standardized performance of these features is needed to ensure that the safety and security protocols protect all members of the NAS.

Finding: Role of Landscapes in Prioritizing BLIs - The Subcommittee on Aircraft Safety (SAS) makes note that both industry and FAA place much effort in developing the Research Landscape for the National Airspace System 2020 - 2030 that was last updated on February 14, 2020. This Landscape document identified important areas of "research drivers" that would provide an external force or motivation that may stimulate R&D investment. From the SAS members' perspective, it has become unclear as to how the research landscape effort is currently being used in the prioritization process when developing BLI items for the research portfolio.

Recommendation: It is recommended that the FAA provide a briefing to the SAS on how the research landscape document that was developed with both industry and FAA input is being used to identify both gaps in the current R&D portfolio as well as in the prioritization of future BLI items for research.

Subcommittee on Human Factors

Finding: Training Air Traffic Controllers for Increased Automation Use - Current training for air traffic operators tend to be developed for individual capabilities, with a "knobology" (user interface) scope, and typically does not focus on operational use, nor the cognitive skills needed for increased use of automation (e.g., decision support tools) when compared to traditional "manual" skills. We acknowledge some current research is starting to be more operationally focused (e.g., on TBO), but this research does not address skill degradation (e.g., from automation or long periods away from work) nor the subtleties of cognitive skills for the full-spectrum proficiency of Controllers, Supervisors and Traffic Flow Managers. Further, proficiency in cognitive skills is currently assessed mostly by subjective judgment of instructors/examiners, whose assessments are very difficult to standardize. Likewise, the development and incorporation of post-automation proficiency in off nominal conditions does not appear to be accounted for in the plans for automation introduction.

Recommendation: The FAA should conduct research to identify ways to effectively train air traffic personnel and assess their proficiency to use tools and systems that are increasingly automated. The research should identify the associated cognitive skills and knowledge Air Traffic personnel need to use automation effectively across operational contexts, as well as methods to assess proficiency**.** For example, training should:

- Address knowledge and skills associated with tasks requiring psychomotor, perceptual and cognitive skills as well as the ability to participate effectively as a member of a team.
- Extend learning that only deals with how to accomplish specific tasks while using a tool, to include additional understanding and application of the full capability of the tool in the context of other systems during operation.
- Address the skills that a Front Line Manager should have to assess and address proficiency and skill degradation for controllers.

- Develop and maintain proficiency in the knowledge and skills necessary when operations transition from an automated environment to a potentially degraded automation environment.

These new training aspects should also consider:

- The needs for initial training as well as the needs for recurrent training.
- Address issues associated with potential skill dependency due to long term use of automation.
- Training to deal with anomalous situations.

There is an assumption that necessary skills are developed today, as a result of experience in the operational environment, however these skills may not be developed due to reliance on automation during routine operations.

Without identifying required knowledge and skills and providing appropriate training, operational personnel may not have the skills and knowledge needed to manage degraded system states. As the operational landscape increases in complexity with TBO, training content will need to keep pace with operational change to ensure the workforce remains proficient across all states of operations to maintain the safety of the system.

Finding: Update Alerting Systems Standards - The current flight deck designs and regulatory framework for flight deck alerting systems were based primarily on research that was conducted by aircraft manufacturers in the late 1970's and early 1980's. The last major collaborative efforts in improving and standardizing aircraft alerting systems by U.S. commercial transport aircraft manufacturers were from 40 years ago. The results of these studies were used as a foundation for the current aircraft certification regulation on Flight Deck Alerting 25.1322 and FAA Advisory Circular 25.1322-1 for the design approval of flight crew-alerting functions. Since then, technology has advanced significantly, and new capabilities have been implemented in modern alerting systems such as: prioritization of alerts within the categories of warnings, increased categories of alerts, grouping of alerts under "umbrella" messages, intelligent alerting based on information integration from multiple sources, etc.

Today the level of aircraft systems integration has grown exponentially, resulting in significant increases in the complexity of failure and non-normal conditions. At the same time, the proliferation of automated systems has changed some flight crew tasks to increase monitoring and assessing the outputs of automated information integration. This shift has led flight crews to place more reliance on alerting automation and has increased the need for pilots to have comprehensive understanding of aircraft systems to effectively understand the operational behaviors and outputs of the alerting systems. The combination of these factors has directly impacted human machine interaction by exposing flight crews to conditions that may not have been identified in previous guidance. These conditions may include increased susceptibility to startle effect which may directly impact cognitive performance, sensory overloading, prioritization of complex information under high workload, and swift transitions from passive monitoring to manual control tasks.

Recommendation: The FAA should conduct research that provides a current scientific and engineering basis to update alerting system standards for design and implementation of modern

flight deck alerting systems. The research should focus on human performance considerations to inform the design of alerting systems and updates to the associated regulation to enable a harmonized interpretation.

For example, the research should address:

- Cognitive performance and alerting such as the effective use of human senses according to the tasks.
- The effectiveness of current alerting methods and systems, and identify effective means to mitigate identified human performance issues such as startle, sensory overloading, prioritization of complex information, and swift transfer of control.
- Temporal characteristics of the actions the alerts trigger and improved ways to effectively delineate between categories of alerts such as advisories versus cautions.
- Ways to represent and present alerts to flight crews to effectively guide response to and understanding of the failure. The complexity of the automated systems that also hide their automated processes can be difficult to understand without extensive knowledge of the systems, and they may result in increased reliance on the automated alerting.
- Increased system integration that processes information and outputs it to the flight crew with no transparency into its processing. Flight crews must monitor and assess automated system outputs which creates new tasks and adds workload.

Technology and system integration has advanced significantly, and new capabilities have been implemented in modern alerting systems. Without updated research and assessment of the effectiveness of alerting methods on modern and future flight decks, the industry may continue using outdated knowledge, approach and methods, which do not reflect the current and future task demands of the flight crew and their operational environments. Additionally, the lack of common ground on human performance related to alerting systems contributes to divergent interpretations of the regulations.

Subcommittee on NAS Operations

General observations: Weather RE&D Funding - In the prior Winter/Spring 2021 meeting, the NAS Ops Subcommittee noted concern over significant reductions in weather-related RE&D funding and recommended that the FAA aggressively increase visibility into the importance of this line of research. At its Summer/Fall 2021 meeting, the Subcommittee was pleased to learn that FY22 weather-related RE&D funding is slated to be restored to more robust levels similar to earlier years that are more appropriate to the national need to conduct this research. The Subcommittee also appreciated receiving the presentations from the Weather RE&D and NextGen Weather Technology in the Cockpit BLIs that reviewed the broad extent of ongoing research contributing to aviation safety and efficiency.

Finding: Environmental Impact Mitigation Through Advanced NAS Operations - The Subcommittee noted the significant increase in planned FY22 RE&D funding allocated towards

environment and energy considerations. We observe that beyond the development of core technologies such as advanced fuels and reduced-emissions propulsion systems, new air traffic management procedures may enable lower-noise lower-fuel-burn operations, with earlier implementation timelines. Some of these new procedures may be implemented in the near-term without requiring new technologies. In the longer-term, it will be important for the FAA to research and develop effective decision support systems for more complex procedural concepts to enhance NAS domestic and International efficiencies. In addition, the future vehicles may have different optimum performance profiles than current generation vehicles. The air traffic management system will need to seamlessly integrate these vehicles and provide them with trajectories tailored for optimum energy performance. Adding to the complexity of these problems is the requirement to balance changes across multiple stakeholders including the FAA, adjacent Air Navigation Service Providers (ANSPs), airspace users (airlines, general aviation, small and large UAS operators, Advanced Air Mobility operators, and commercial space operators), and outside communities and neighborhoods, involving both technical and non-technical (policy) issues.

Recommendation: The Subcommittee recommends that the FAA continue to foster and strengthen linkages between new initiatives in AEE, ANG, and ATO (in particular, AJV-S) related to environmental impact mitigation through new technologies for NAS operations. Regular coordination between these organizations will help ensure that RE&D efforts are initiated in time and in a coordinated manner to support the introduction of new procedures and technologies that reduce the environmental impact of the nation's aviation system.

Three example RE&D topics at the intersection of environment and NAS operations include (1) development of new ATC tools and procedures to enable adaptive low-workload efficient and safe systematic dispersion of departures; (2) exploring enhancements to the Terminal Sequencing and Spacing (TSAS) system that may be needed to efficiently accommodate a mix of aircraft types performing delayed deceleration approaches; and (3) integration of future reduced-emissions vehicles for optimum trajectory profiles. A roadmap for RE&D activities to support the introduction of these and other aspects of environmental impact reduction while ensuring safe and efficient NAS operations should be developed and executed.

Finding: Human Factors - The Subcommittee received a briefing on the RE&D Enterprise Human Factors research activities, which highlighted a growing volume and variety of human factors research and development work compared to recent past years. The Subcommittee was particularly pleased that research activities in this budget line are introducing activities related to addressing Human Factors needs and challenges associated with strategic air traffic management concepts, including traffic flow management. This research has broadened to include a focus on the Human Factors associated with the operational integration of complex Traffic Flow Management (TFM) concepts and decision support capabilities. Examples of research focus areas include:

- The impact of Trajectory-Based Operations (TBO) on the Traffic Flow Management Unit (TMU)
- TMU regional coordination and decision making
- Effective methods for TBO training.

While the Subcommittee is encouraged by the important focus of these activities on TBO-related considerations, the Subcommittee is aware that emerging Traffic Flow Management concepts that build upon the foundation of TBO must also be examined. These emerging traffic flow management concepts will require the introduction of new decision support capabilities, new training needs, and potentially changes to the decision-making process in the strategic management of traffic. It will be important to define and pursue additional research into systems and procedures for ensuring effective multi-stakeholder collaborative decision-making using uncertain forecast information. Future concepts also depend on the use of advanced capabilities, such as machine learning/artificial intelligence, which present unique Human Factors challenges beyond those studied through TBO.

The Subcommittee considers the following focus areas as particularly urgent, due to the complexity of these future concepts and the challenges associated with the operational integration of new traffic flow management capabilities:

- Future Flow Management
- Performance Based Flow Management

These concepts, and their maturation plans, are in development but are not considered focal areas for the Enterprise Human Factors research and development until Fiscal Year 2024. The complexity of these research needs will warrant continued investment in Human Factors.

Recommendation: The Subcommittee recommends that the FAA continue to grow strategic enterprise Human Factors Research and Development funding and activities associated with longer-term strategic traffic flow management and collaborative decision making.

The Subcommittee also recommends accelerating the focus on Human Factors considerations associated with the FAA's info-centric vision for the NAS generally, and the Future Flow Management and Performance Based Flow Management concepts and plans specifically.

In addition, given the progression to highly automated systems of the future, the Subcommittee also recommends focus on human/machine teaming, and graceful degradation of automated systems for handoffs in off-nominal conditions from automation to human.

Finding: Flight Dynamics Research Related to Advanced Air Mobility - New flight vehicle concepts, such as Electric Vertical Takeoff and Landing (eVTOL) aircraft for Advanced Air Mobility (AAM), may require new technologies to enable safe and effective manual or automated flight control. The flight dynamics and physics of these new vehicles are different from prior aircraft because of the difference in electric powertrain response time constants, in particular. The outcomes from this domain of R&D are vital for understanding the effect of eVTOL flight path control capabilities on airspace procedures design and management.

At its Fall meeting, the NAS Operations Subcommittee received a briefing describing a study underway to explore issues related to flight control of eVTOL vehicles using NASA's Vertical Motion Simulator (VMS). The Subcommittee observed that the current FAA R&D activities using the VMS seem mis-matched to the potentially very different flight dynamics of future

vehicles. The specific research requirements and objectives that led to the decision to use the VMS were also not clear to the Subcommittee.

Recommendation: The Subcommittee recommends that the FAA (with NASA) articulate and evaluate the requirements for using piloted motion-based simulators (such as the NASA Ames VMS or NASA Langley Cockpit Motion Facility (CMF)) for R&D of eVTOL aircraft entering the AAM markets. If use of a motion-based flight simulator is determined to be necessary, the FAA and NASA should ensure that the selected simulator has been appropriately modified to provide a high-fidelity emulation of the flight dynamics of these new aircraft types as well as the Human-Machine-Interfaces (HMI) of these new aircraft types.

Subcommittee on Airports

Observations and Commendations - We appreciate FAA's continuing focus on time-critical research projects. These include evaluation of Alternative Aircraft Firefighting agents and assessment of Uncrewed Aircraft System (UAS) detection and mitigation systems, both of which are associated with legislative requirements in the 2018 FAA Reauthorization Act.

We are also pleased to see results of research into other areas involving new airspace entrants, including continuing work on beneficial uses of UAS at airports, the impacts of climate change on airport operational and infrastructure needs, sustainable airfield pavement research, and Vertiport design standards.

The Subcommittee was also pleased to see the alignment of the Program's research portfolio with current Administration priorities. The Subcommittee was particularly interested in how much of the Program's airport planning and pavement research is helping to enhance airport sustainability and resiliency.

The Subcommittee also remains pleased regarding the Program's efforts to modernize and enhance FAA pavement design and management tools, evaluate airfield pavement design, and assess airport resiliency.

With respect to firefighting research, the Subcommittee expressed its concern and disappointment that the FAA's evaluations of PFAS-free firefighting foams had not identified agents capable of meeting current FAA and Department of Defense (DoD) performance standards.[1] We expressed these concerns in a letter to the FAA Office of Airports that we sent in August, preceding the meeting. In the letter, included as Attachment A, the Subcommittee expressed our support for synchronizing FAA and DoD firefighting agent research efforts and statutory deadlines to provide an achievable pathway to transition to fluorine-free agents. We discussed synchronization of these research efforts at length during the meeting.

[1] Current DoD performance specifications necessitate use of firefighting foams that contain per- and polyfluoroalkyl substances (PFAS), a class of chemical compounds that is bio-accumulative, persistent, and have been linked to adverse health impacts in humans and animals.

Finding: Alternative Firefighting Agent Research - As noted in our last two Subcommittee reports, the Program's Alternative Firefighting Agent Research project has been of concern to the Subcommittee because:

- The Project's findings were needed to support FAA action regarding Section 332 of the FAA Reauthorization Act of 2018. Section 332 included a three-year deadline—ending on October 4, 2020—for FAA to "not require the use of fluorinated chemicals to meet the performance standards referenced in chapter 6 of AC No: 150/5210-6D and acceptable under 139.319(l) of title 14, Code of Federal Regulations."
- Airport operators are under considerable pressure from state and local governments and local communities to reduce or eliminate use of PFAS at airports.
- There are significant and growing concerns about the human health impacts and associated liability associated with PFAS contamination on and near airports.

Per our Spring 2021 recommendations, the Subcommittee submitted a letter on August 18, 2021, supporting FAA's request to Congress to extend the Section 332 deadline. The U.S. Congress declined to approve this extension in late September. Without the extension, U.S. airports have been left in a challenging situation with fluorinated foams being the only firefighting agents that meet current FAA and DoD requirements, but under legislative provisions that do not allow FAA to require use of such foams.

The current pathway to approval of non-fluorinated firefighting foams for use at U.S. airports relies on DoD's introduction of a new performance standard for non-fluorinated/PFAS-free foams, which the U.S. Congress has mandated by January 31, 2023.

Recommendation: Consistent with our Spring 2021 report, the Subcommittee recommends that the FAA prioritize assistance and support for DoDs research efforts regarding a new performance standard for non-fluorinated/PFAS-free foams. We also reiterate our recommendation from Spring 2021 that the FAA prioritize research associated with ARFF training, equipment requirements (including equipment cleaning), tactics, and other supporting guidance that will be needed to facilitate the transition from fluorinated to non-fluorinated foams.

Finding: Airport Sustainability and Resiliency - As noted previously, the Subcommittee appreciated the categorization of several of the Program's projects in terms of airport sustainability and resiliency. U.S. airport operators are extremely interested in ways they can enhance both sustainability and resiliency through appropriate capital investment and changes in operating and maintenance practices.

Recommendation: The Subcommittee recommends that the FAA continue to prioritize research projects that enhance airport sustainability and resiliency particularly within the advanced pavement materials, extended pavement life, airport planning & design, and environmental tools & guidance Research Program Areas (RPAs).