



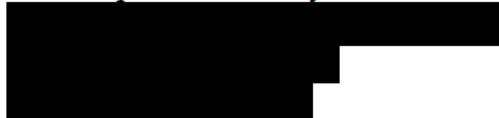
U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator



August 24, 2021

Dr. R. John Hansman, Ph.D.
Chair, Research, Engineering and
Development Advisory Committee



Dear Dr. Hansman:

Thank you and the Federal Aviation Administration's (FAA) Research, Engineering, and Development Advisory Committee (REDAC) for your June 3, 2021, letter providing recommendations on the Fiscal Year 2023 Research and Development (R&D) Portfolio. The important guidance generated during the REDAC Winter-Spring 2021 virtual meeting held on April 21, 2021, is sincerely appreciated.

Your cross-cutting observations about COVID-19 impacts, the need for research to inform system resiliency and operational continuity, and the FAA being well-positioned to contribute to the increased national focus on sustainability are appreciated and noted. The Agency has utilized effective strategies to mitigate the impact of the pandemic, and these lessons learned will be essential for the development of future protocols to mitigate other unanticipated events. Additionally, as suggested, the Agency desires a clear, strategic understanding of the functionality and acceptable uses of Machine Learning and Artificial Intelligence and their potential applications.

We have reviewed the 14 recommendations that you have offered, and the enclosed FAA Response Report reflects our proposed dispositions and action plans. I appreciate your assessment and insightful advice as well as the expertise of the REDAC professionals who continue to provide valuable guidance and support of the Agency's R&D programs.

Sincerely,

Steve Dickson
Administrator

Enclosure

**FAA Response to Research, Engineering, and Development Advisory Committee
(REDAC) Recommendations for the Fiscal Year 2023 Research and Development
Portfolio**

Subcommittee on Human Factors

Finding: **Human Factors (HF) for Aircraft Certification** - The Federal Aviation Administration (FAA) seems to be very responsive to the recent Aircraft Certification, Safety, and Accountability Act, however, it is not clear how the identified research requirements are being fulfilled and what the timing/funding would be. The Subcommittee was also pleased to hear about the FAA's plans for integration of Human Factors into policy and processes for certification and flight standards based on scientific, engineering, and operational data, but there was no clarity on the mechanisms for doing so.

Recommendation (1): The FAA should pursue the research requirements established in the Aircraft Certification, Safety, and Accountability Act and conduct research needed to support the integration of Human Factors into policy and processes for certification. This should include identifying and engaging research areas associated with the integration of Human Factors into the certification process, from identification of metrics and instruments for human performance to policy and guidance updates that account for a human system integration approach.

Consequences: Delay to harmonize the industry around appropriate methods to integrate human factors may result in multiple approaches that result in partial integration of Human Factors. The lack of research and methods to integrate Human Factors into the FAA's certification process may result in the certification of advanced aircraft flight deck and flight control systems that could have unintended safety consequences.

FAA Response: **The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation(s)** – The Human Factors aspects of the Aircraft Certification, Safety, and Accountability Act (ACSAA) were presented to the Subcommittee at the 2021 Winter/Spring meeting. The ACSAA legislation (signed on December 22, 2020) included several HF research-related provisions. Some but not all of these provisions are being addressed with funded research, such as research on transport pilot training and procedures for incorrect pilot response and response time, as well as research on pilot interactions with new flight deck technologies. The FAA will provide a status update at the 2021 Summer/Fall meeting, addressing how the identified ACSAA HF research-related provisions are being fulfilled and how the appropriate policy and processes for Aircraft Certification and Flight Standards are being updated.

Additionally, the FAA notes that the Flight Deck Human Factors research portfolios will continue their longstanding mission to support the integration of Human Factors into policy and processes for the Office of Aviation Safety Office functions, including the Aircraft Certification Service.

Finding: **Improved methods to determine individual proficiency of operational personnel** - The FAA seems engaged in research on training; however, the current research does not specifically investigate scientifically valid ways to develop, assess, and maintain full-spectrum

(psychomotor, cognitive, etc.) proficiency of operational personnel. Current evaluation methods rely on observable compliance with published procedures and performance parameters kept within clearly defined limits. Assessing cognitive skills associated with more complex cognitive processes, such as information integration, are even more difficult to observe. Proficiency in cognitive skills is currently assessed mostly by the subjective judgment of instructors/examiners, whose assessments are very difficult to standardize. Research is needed to determine how proficiency and skills are developed, trained, assessed, and maintained, including the length of time after training skill proficiency can be expected to be retained.

Recommendation (2): The FAA should pursue research to address the assessment of cognitive skills associated with more complex cognitive processes, such as information integration, that are difficult to observe and to determine the length of time after training that proficiency can be expected to be retained. This research should include the definition of proficiency, qualification standards and assessment methods, methods for maintaining and improving proficiency, and realistic proficiency retention timelines that are based on scientifically validated principles for the operational workforce. The results of this work could provide important methods for developing and measuring proficiency and may be extended to include initial definitions of proficiency needs for human interaction with autonomy and automation.

Consequences: Failure to identify proper evaluation methods may result in inadequate identification and mitigation of risks associated with developing and maintaining proficiency in operator skills. This may increase the opportunities for human error and impose additional hazards to system performance and operations.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation(s) - The FAA is currently funding two flight deck research requirements related to this recommendation: 1) cognitive skill degradation and 2) manual flight operations, including cognitive and psychomotor skills. This work was funded to provide scientific and technical data to inform the FAA's regulatory policy and guidance material, such as the draft Flight Path Management Advisory Circular (AC 120-FPM). Previously, the FAA funded research on air traffic skill degradation related to automated decision support tools to explore potential NAS efficiency impacts. At the 2021 Summer/Fall meeting, the FAA NextGen Organization, in coordination with a subset of researchers working in this area, will provide an overview of the current and prior research related to this recommendation. This will enable the Committee and the AVS sponsors to identify research gaps in this area.

Subcommittee on Airports

Observations and Commendations: The Subcommittee was pleased to see that the Program's research had resumed in the latter half of CY2020, albeit with continuing restrictions on travel and certain on-site activities at the FAA William J. Hughes Technical Center. We commend Program and Technical Center staff on their work to manage myriad issues associated with the pandemic response and their flexibility and initiative in adjusting research activities and priorities to reflect COVID-19 realities.

We appreciate FAA's continuing focus on time-critical research projects. These include

evaluation of alternative aircraft fire fighting agents and assessment of Unmanned Aircraft detection and mitigation systems, both of which are associated with legislative requirements in the 2018 FAA Reauthorization Act. With respect to the latter project, the Subcommittee was encouraged to learn during our meeting of the FAA's selection of four airports as pilot testing sites for UAS detection and mitigation systems: Huntsville International Airport, Rickenbacker International Airport, Seattle-Tacoma International Airport, and Syracuse Hancock International Airport. These four airports join Atlantic City International Airport (New Jersey) in the program, where preliminary work began in Fall 2020.

We also understand that in spite of best efforts, there will be some delay in these time-sensitive research projects. This is of greatest concern for Alternative Firefighting Agent Research, where there is a legislative deadline for research findings this year. As noted in our recommendations below, the Subcommittee recommends (and supports) the FAA requesting an extension to this deadline to ensure that data collection and analysis can be performed.

Finally, we want to acknowledge the successful conclusion of the FAA's Neighborhood Environmental Survey research effort, which culminated with the publication of survey results in January 2021 (DOT/FAA/TC-21/4). The survey effort, which began in 2014, is a critical initial step towards the refinement of U.S. aviation noise policies, noise mitigation approaches, and community outreach. The collaborative between the FAA Offices of Environment & Energy and Office of Airports and their respective research programs provides a foundation for a challenging but necessary conversation regarding aviation noise and its effects on communities.

Finding: Alternative Firefighting Agent Research Project - As we noted in our Fall 2020 report, the Subcommittee recognizes that disruptions caused by the COVID-19 pandemic have delayed time-critical research activities, including those associated with provisions in the FAA Reauthorization Act of 2018. The Program's alternative firefighting agent research project is of particular concern because:

- The Project's findings are 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, 2021—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 the use of polyfluoroalkyl substances (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.

Based on our discussions of this project during the meeting, it seems that it will be challenging to complete necessary testing and analysis this year despite best efforts on the part of Program staff to do so, principally because of COVID-19 research disruptions during the first half of 2020. The Subcommittee also recognizes the need for the FAA's efforts to be coordinated closely with complementary research efforts that have been underway within the U.S. Department of Defense (DoD).

Recommendation (1): Consistent with Recommendation 1 from our Fall 2020 report, the Subcommittee encourages the FAA to assess whether additional time will be needed to complete its alternative firefighting agent research and coordinate this research with the U.S. DoD. The Subcommittee would support FAA requests for an extension of the October 4, 2021, legislative deadline to address these issues if the FAA seeks them from Congress.

FAA Response: The FAA concurs with the Committee's findings and recommendations and is taking the following actions to address it - The FAA will continue to closely monitor the ongoing testing of potential Aqueous Film Forming Foam (AFFF) alternatives at the FAA William J. Hughes Technical Center, along with research at the DoD. FAA shares the Airports Subcommittee's concerns that FAA will likely need additional time to adequately coordinate all of the results and complementary research with DoD. We appreciate the Subcommittee's support for an extension of the October 4, 2021 legislative deadline and will continue to keep you apprised of our path forward.

Finding: Unmanned Aircraft Systems (UAS) - UAS research remains a high priority for the Subcommittee. Actions that the FAA has taken in the last six months to facilitate UAS operations (e.g., over people, beyond visual line of sight) and facilitate UAS tracking in the National Airspace System via remote identification systems coupled with increasing UAS capabilities make these aircraft very attractive for a variety of beneficial uses at airports.

Recommendation (2): We encourage the FAA to prioritize its research into beneficial UAS use cases and implementation hurdles at airports, expediting this work if possible.

FAA Response: The FAA concurs with the Committee's findings and recommendations and is taking the following actions to address it - The FAA will continue its active research efforts with beneficial UAS use cases (e.g., pavement inspection, Foreign Object Debris detection, perimeter security, wildlife mitigation, firefighting command and control), along with mapping potential implementation hurdles at airports, and will prioritize research based on ongoing assessment of testing and evaluation results.

Subcommittee on NAS Ops

General Observations: The FAA is pursuing Research, Engineering, and Development (RE&D) related to Machine Learning/Artificial Intelligence (ML/AI) technologies for Air Traffic Control (ATC), Air Traffic Management (ATM), and increasingly automated air vehicles. This work includes applying Safety Risk Management (SRM) processes to identify and assess potential safety risks from these new technologies. The Subcommittee applauds these activities and also notes that there will be a growing need to ensure that SRM tools and techniques effectively cover new certification and risk assessment challenges brought about from advanced ML/AI systems and how they interact with humans. This will likely result in the need to define and tailor research efforts focused on improving and extending the SRM and certification processes for ML/AI systems.

The NAS Operations Subcommittee was pleased to learn that the A11.i Air Traffic Control / Technical Operations program is beginning to address job task requirements and training gaps for personnel at the Air Traffic Control System Command Center (ATCSCC). The

Subcommittee feels this work is important to strengthen the capabilities and performance of these critical personnel who may not have had directly relevant training or experience with the strategic traffic management challenges addressed at the ATCSCC. The Subcommittee looks forward to hearing updates on this activity in the future.

Research Landscape Updates: The NAS Operations Subcommittee reviewed the FAA Research Landscape for the National Airspace System and provided several recommendations for extensions and enhancements based on members' understanding of the changing aerospace landscape. These included:

- There is continuing interest in mixed operations, issues handling mixed equipage, and certification of new technologies. There is a need to harmonize mixed equipage traffic within the airspace, as this is inhibiting some of the potential benefits from NextGen. One example is the challenge in extracting benefits from Required Navigation Performance (RNP) procedures when some regional jets do not carry the necessary equipage. The Landscape should ensure that mixed-equipage challenges are considered where relevant.
- Certification of new entrant concepts and operations, including Urban Air Mobility and the rapid growth in Commercial Space Transportation, is seen as a key challenge that will require a focused research and development plan to accomplish. This also includes defining future communication, navigation, and surveillance requirements for these operations – which will need to expand beyond CONUS to global coverage to enable many of these operations.
- There is increased interest in new vehicles and missions and, in particular, a move toward de-carbonization and advanced fuels and energy storage. There will be a transition to new energy sources and sustainable aviation fuels, some of which are available now but require support. In particular, it was noted that hydrogen and electric vehicles need more attention from DOE, DOT, and NASA.
- The Subcommittee noted strong environmental Research and Development (R&D) initiatives in Europe have extended beyond vehicles to include other targets to reduce environmental impact, such as the operation of nav aids or applying novel energy sources at airports.
- Autonomous vehicles at airports, including airport Ground Service Equipment (GSE), will involve a transition to hydrogen power and "carbon-aware" GSE. It was noted that there are more than 40,000 Hydrogen-powered forklifts across the U.S. which have had a great impact on improved air quality in warehouses. More than 4,000 cellphone towers have shifted from diesel to Hydrogen backup power sources. Microsoft and others are using Hydrogen for backup power. Research should continue into similar efforts at airports and other facilities.
- Risk-based decision-making research should extend not just to safety risks, as currently

covered in the Landscape document, but also to include operational decision-making from the air traffic management perspective. An example would be the use of weather forecast confidence information in making a risk-balanced traffic management decision.

- There are growing spectrum issues, especially with the existing and planned evolutions from 4G to 5G to 6G. The rapid growth in small Unmanned Aircraft Systems (sUAS) will place additional pressure on the communications spectrum. This may warrant anew research topic in the Landscape or a more detailed extension to the "Increased Connectivity by Cyber-Physical Systems (Internet of Things)" research element.

Finding: Weather-related RE&D funding - The Subcommittee received briefings on the overall Research, Engineering, and Development (RE&D) budget followed by updates from the A11.k Weather Program, A11.q NextGen – Weather Technology in the Cockpit (WTIC) program, and A11.o Wake Turbulence program.

The FY21 Enacted RE&D budgets for A11.k, A11.q, and A11.o show significant reductions from prior-year levels: down to approximately 40%, 55%, and 55% relative to their FY19 funding levels, respectively. Although major weather-related air carrier accidents are rare, they continue to be a concern, especially for general aviation and helicopter operations. Weather remains the largest single cause of air traffic delay, and it is likely that weather-related delays will become increasingly problematic as the nation returns to pre-COVID-19 traffic levels over the next few years. Research is needed to ensure that the improvements afforded by NextGen decision support capabilities are robust to weather conditions. At the same time, growing interest in small Unmanned Aircraft Systems (sUAS) and Advanced Air Mobility (AAM) concepts will require consideration of weather impacts on these new types of vehicles and missions to enable them to operate safely and effectively. These operations pose unique requirements for aviation meteorology knowledge in the Earth's boundary layer (below 1,000 feet AGL).

Also, the technologies to enable options for services are expanding rapidly, including the evolution of the Low Earth Orbit Satellite Communication (sitcom) WiFi and 5G services from companies OneWeb, Kuiper (Amazon), Starlink (SpaceX), and SpaceMobile (AST Science). Of particular concern are the needs for improved weather sensing away from traditional airports and the need to better understand, model, and forecast low-level and urban-area weather. Concerns about aircraft wake turbulence also relate to the ability to model and forecast winds, and research may need to be expanded to safely enable upper-altitude (Upper E) operations involving particularly sensitive air vehicles such as long-endurance balloons. Given these new drivers of demand and technology enablers, now would be a good time to increase funding for the FAA Weather Program, not reduce it.

Recommendation (1): The NAS Operations Subcommittee recommends that the FAA make a directed effort to improve awareness of the importance of weather-related research and the impacts that the FAA's prior weather research has had on improving the safety and efficiency of the National Airspace System.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation(s) - The FY2022 President's Budget includes an increase to both the Weather program and the Weather in the

Cockpit Program.

Recommendation (2): The Subcommittee also recommends that the weather-related RE&D programs strengthen connections with major FAA programs and strategic thrusts, including Trajectory Based Operations (TBO), Future Flow Management, Unmanned Traffic Management (UTM), Advanced Air Mobility (AAM), and NAS Integration of Transiting Operations (NITRO) to ensure that weather considerations are included and that a robust prioritized list of weather RE&D initiatives are identified to support those programs.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation(s) – The FAA will continue working with these groups, as well as other stakeholders within and outside the FAA via the established weather requirements process that was briefed to the REDAC in September 2020. In addition, a Weather Community of Interest has been established to manage weather information across the FAA and resolve mission-specific, information-sharing challenges affecting the use of weather information.

Subcommittee on Aircraft Safety

Finding: Visibility in the Source of Research, Engineering, and Development (RE&D)

Funding - The Subcommittee on Aircraft Safety (SAS) found that some FAA Research, Engineering, and Development activities are being sponsored and managed under Facilities and Equipment (F&E) funding. Furthermore, SAS learned that some research topics such as Air Traffic Management (ATM) and Communication, Navigation and Surveillance (CNS) were moved from RE&D funding to F&E funding in the late 1990s. Additionally, the SAS learned that Unmanned Aircraft Systems (UAS) Pilot Programs research is being managed with F&E funding. Some Research, Engineering, and Development being conducted under F&E funding also serve to inform FAA aviation safety policy, regulations, and rulemaking. Lack of SAS visibility into projects sponsored and managed under F&E funding leads to an incomplete SAS review of research related to aviation safety policy, regulations, and rulemaking. In addition, the potential exists for regular F&E activities, pressures, and priorities to overcome and negatively impact the prioritization and resources for mid- and long-term research.

Recommendation (1): The SAS recommends that the FAA brief the SAS on the process by which the Research, Engineering, and Development sponsored and managed within the RE&D funding and F&E funding is coordinated and ensure mid- and long-term research objectives prioritization is appropriately maintained. The SAS recommends that the FAA include F&E Research, Engineering, and Development, which inform FAA aviation safety policy, regulations, and rulemaking BLI and/or projects in future SAS briefings.

FAA Response: The FAA concurs with the Committee's recommendation and with the noted exceptions and clarifications, intends to undertake the following actions to address this recommendation - The FAA Research and Development program encompasses the following types of work in three distinct budget areas -

- Research, Engineering & Development – Applied research to develop information and tools

necessary for the FAA to develop the regulations and standards necessary to accomplish their certification and oversight role. All but the Commercial Space RE&D BLI is presented to the REDAC across the five subcommittees for Findings and Recommendations. The Commercial Space BLI is informational only for the REDAC as it is covered by a separate Commercial Space Advisory Committee.

- Facilities and Equipment, Activity 1 – Capital improvement projects necessary to accomplish FAA's mission by providing funds to establish, replace, relocate, or improve air navigation facilities and equipment and aviation safety systems. The work under this budget, except for work concerning standards and procurement activities beyond research, is presented to the REDAC NAS OPs Subcommittee for Findings and Recommendations.
- Facilities and Equipment, Activity 4 – Projects providing the FAA workforce with system engineering, integration, logistics, technical services, and transitional support for the National Airspace System. The work under this budget, except for work concerning standards and procurement activities beyond research, is presented to the REDAC NAS OPs Subcommittee for Findings and Recommendations.

The FAA will provide an informational briefing with more detail on the research-related portions of all of these budgets (i.e., not the standards and procurement work) at the next Aircraft Safety Subcommittee meeting.

Finding: Ice Crystal Icing (ICI) - The Subcommittee appreciates the FAA research in A11D budget line item for Research on Ice Crystal Icing Conditions to Address Fundamental Knowledge of High-Altitude Icing on Turbine Engine Damage and Power loss. The project is currently un-funded through the 2023 fiscal year. Further in-depth research can aid current rulemaking work to address this issue appropriately.

Prior funding was used for several flight campaigns, however, the data analysis portion requires additional funding for an additional flight test campaign evaluating the effects of atmospheric aerosol content on ice crystal concentrations at high altitude. Additionally, as many projects are put on hold during the COVID-19 pandemic, funding should be available for ongoing work, including additional testing for modeling and testing for ICI accretion behind the fan.

Recommendation (2): The FAA should consider prioritization for further Ice Crystal Icing research for Fiscal years 2021 and beyond to ensure it is adequately addressed in certification and rulemaking. The FAA should consider additional research in the following fields:

- ☐ Aerosol testing to determine the effects on high altitude ice crystal concentrations
- ☐ Continental vs. Oceanic Mesoscale Convective Systems and lapse rates and their effect on High Altitude ICI
- ☐ Basic physics studies of ice formations within turbine engine flow paths from high altitude ice crystal icing in mesoscale convective systems

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendations - The FAA agrees with all

recommended fields of research:

- Currently, the FAA is in the planning stages for preparing to perform a flight campaign in 2023 in a high aerosol atmosphere to measure the anthropomorphic aerosol effects on the formations and concentrations of high altitude ice crystal icing. A partnership with NASA, Nagoya University, Collins Aerospace, and Honeywell Aerospace has been formed. This research currently has FY21 funding.
- The FAA has initiated a study looking at Airbus flight test measurements to determine if the Airbus data is sufficient to answer the question about differences between continental vs. oceanic mesoscale convective systems during the formation of high-altitude ice crystals, which have been shown to cause aircraft engine damage and power loss, as well as, air data probe malfunction from clogging. If the Airbus data turns out to be insufficient, then additional flight studies may be required to address this rulemaking committee question.
- The FAA has partnered with the National Research Council of Canada in developing a highly innovative scaled turbomachinery compressor section, which can be highly instrumented and operated in a simulated altitude ice crystal environment, so that ice accretion formations and their mechanisms can be studied. Initial tests have shown promising results. After preliminary small-scale testing shows viability, the development of a scaled-up version is planned to start in the 2023 time frame. The large-scale rig should be fabricated, and the testing should be completed in 2026, with the final data analysis completed in 2027.

Finding: Machine Learning/Artificial Intelligence (ML/AI) - The SAS was pleased to learn about the ongoing and planned research on Machine Learning and Artificial Intelligence. Future advancements in control system technologies will depend upon an artificial learning process that has the potential to impact the basis of certification for such systems. The demands of industrial or ground-based systems differ greatly from those requirements for aircraft systems. If not fully researched and understood, the impact on aviation safety-critical systems is significant. While both industry and academia are placing a large emphasis on the development of ML/AI, more research is required to better understand the means to establish criteria to judge the confidence and validation of such systems that ultimately can lead to a basis of certification of these same systems. Furthermore, there is significant standards development work being conducted by the Radio Technical Commission for Aeronautics (RTCA), Society of Automotive Engineers (SAE), and American Society for Testing Materials (ASTM) on these technologies across the entire aviation ecosystem, both airborne and ground, addressing both manned and unmanned systems. This includes Unmanned Traffic Management (UTM) solutions.

Recommendation (3): The SAS recommends that FAA place a priority on research in ML/AI. This research will enable the FAA to work toward achieving a means of compliance by addressing the added challenge of better understanding the current and future scope of technology. On a more strategic basis, we further recommend identifying the unique attributes where those ML/AI applications can safely be used.

Recommendation (4): In addition, the SAS recommends close collaboration with industry to understand the FAA requirements and FAA to understand the technology to develop/modify

requirements based on new technology. On a more strategic basis, we further recommend identifying the unique attributes where those ML/AI applications should be used.

FAA Response: The FAA concurs with the Committee's recommendation(s) and with the noted exceptions and clarifications intends to undertake the following actions to address its recommendation(s) - The FAA has been focusing on the challenges AI/ML applications and implementations pose to the safe operations of airborne systems. This focus is supported by research on assurance challenges, gaps in the current standards and guidance, and verification alternatives. The FAA is committed to working with industry to assess new areas of innovation and to support their safe incorporation into the National Airspace System. The FAA has established a Policy and Innovation Division within the Aircraft Certification Service (AIR-600) and is engaging earlier with industry to facilitate certification of new technologies. We are actively interfacing with standards committees, industry, federal organizations, and other certification authorities.

Subcommittee on Environment and Energy

General Observations: The Subcommittee focused on reviewing the Research and Development (R&D) Portfolio for the Office of Environment and Energy (AEE) that was developed based on the Research, Engineering, and Development (RE&D) budget for FY 21 that was enacted on December 27, 2020. During the meeting, the staff from the Office of Environment and Energy (AEE) provided updates on all of the major research areas 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 (CAAIFI), 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. These accomplishments further validate the need for sound research when developing regulations and policies and procedures.

Despite the COVID-19 concerns that we had expressed in our previous report, the Subcommittee was very impressed with the job the leadership and staff of AEE has been doing. The presentations were well done and reflected impacts and or potential impacts because of COVID-19, to the research that is being done and is proposed in the future. 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 many projects, be it financial or time delays.

The overall impacts of COVID-19 on the citizens of the world are unprecedented! The aviation industry is currently going through a crisis of historic magnitude, and the road to recovery and future growth still has many uncertainties. The dramatic reduction in air travel and aviation-related activities has brought significant attention to the environmental impacts associated with the aviation industry. Members of this Subcommittee believe that the FAA and the aviation industry are at a unique point in history, and AEE and its partners are well-positioned to address the additional environmental questions that are being asked on noise and emissions. The answers to the questions can only be found through additional research and development with financial support from the U.S. government. We have already seen where other governments

have pledged support to their environmental research agenda.

The U.S.A must maintain its leadership position at the global stage in order to protect the U.S. aviation industry as we continue down the path of recovery and address new growth. This leadership position can be sustained by further expanding the Environmental and Energy R&D Portfolio using the proven blueprint that was presented to this Subcommittee. The expected results of current and future research under this portfolio will also help us address the concerns within the U.S.A as well. We know where we want to be. We need to use our partnerships with other federal agencies, universities, and businesses and our research portfolio to get there.

The Subcommittee believes that AEE is doing a good job and has once again presented a balanced portfolio. We believe that the research priorities that the Subcommittee has previously identified, growth from Commercial Subsonic traffic, Urban Air Mobility (UAM), Unmanned Aerial Systems (UAS), Supersonic Civil aircraft, and Commercial Space vehicles, do not need to be adjusted. The Subcommittee was happy with the briefings we received on a number of new research projects that have been added to address these priorities. The Subcommittee members realize that there is still additional research required to address ongoing areas of concern. There were additional discussions among the members on whether there are any research opportunities that currently exist because of the impacts that COVID 19 has had on the aviation industry.

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: Noise Research- Aviation noise is and will continue to be one of the biggest environmental impacts related to the aviation industry, and it requires ongoing research in order to address the concerns of the citizens. The overall reduction in aircraft movements as a result of the pandemic has definitely increased the focus on noise. 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. AEE has research projects that are looking at the impacts of noise on children's learning, sleep impacts, community annoyance, and cardiovascular health.

AEE is looking at the certification requirements for Supersonic aircraft, as well as Unmanned Aircraft System (UAS) and Advanced Air Mobility (AAM) vehicles. AEE is also examining how to reduce the noise from commercial aircraft and helicopters through changes in operational procedures. 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). 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 (1): The Subcommittee strongly supports and recommends the continued prioritization of noise research! Noise is a source of everlasting "headaches" for the aviation community, and despite the great improvements made by the FAA, communities have become less tolerant of noise.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address it - The FAA is committed to developing meaningful and equitable solutions to the complex and nuanced issue of aviation noise. On January 13, 2021, we published an Overview of FAA Aviation Noise Policy and Research Efforts on the Federal Register. This Federal Register Notice ("notice") contained a comprehensive overview of FAA R&D efforts on noise, and it sought input from the public on research activities to inform aircraft noise policy. We are currently in the process of reviewing the more than 4,100 submitted comments to inform the scope of additional areas of noise research. We will continue to support the R&D portfolio outlined in the notice while also looking for opportunities to expand our work, including through the inputs provided by the aforementioned comments.

The notice also contained results from the Neighborhood Environmental Survey, which quantified the annoyance of those experiencing aircraft noise in airport communities. The results show there has been a substantial increase in annoyance levels compared to surveys conducted in decades past, with roughly two-thirds of respondents to the survey reporting being highly annoyed at the level of noise used to define significance within the National Environmental Policy Act.

We are also taking steps to begin a policy review that builds on our work to advance the scientific understanding of noise impacts, as well as the development of analytical tools and technologies. This effort will build on our partnerships with academia, industry, and government to better understand, manage, and reduce the environmental impacts of aviation, including but not limited to noise. This effort will incorporate the FAA's updated understanding of aviation noise and human response so that we are able to promulgate well-reasoned, scientifically-grounded policies.

Finding: Public-Private Partnerships - The Subcommittee wishes to acknowledge and support the fact that the Office of Environment and Energy (AEE) has proven over decades to be a very good steward 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 International Civil Aviation Organization/Committee on Aviation Environmental Protection (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 have clearly been proven over time and are very apparent in most of the current projects. To date, the CLEEN and CLEEN II programs sponsored by the FAA have been responsible for the maturation of aircraft technologies responsible for significant decreases in fuel burn/CO₂, decreases in NO_x emissions, and noise reductions that would not have happened otherwise.

Recommendation (2): The Subcommittee continues to endorse Public-Private Partnerships like the Continuous Lower Energy, Emissions and Noise (CLEEN), Commercial Aviation Alternative Fuels Initiative (CAAIFI), and Aviation Sustainability Center of Excellence (ASCENT) programs to leverage resources and recommends that FAA should continue to allocate robust funding for these programs. Given the current drop in air traffic levels, now is the perfect time for Phase III of the CLEEN program to develop and mature technologies that would have an even more substantial impact on aviation environmental concerns.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address it - The FAA is maximizing the impact of taxpayer dollars by partnering with industry, academia, federal agencies, and other governments. The vast majority of the Environment and Energy R&D program has been leveraging resources from the private sector via public-private partnerships. CLEEN, CAAIFI, and ASCENT have all been successful because of their strong engagement with industry. Each of these programs have had strong partnerships with and support from, industry for over a decade. The FAA is in the process of finalizing the awards for the third phase of CLEEN, which will ensure the continuation of this model of public-private partnership on aircraft technology development through 2025. The FY2022 President's Budget includes a new Aviation Climate Research budget line item that would expand the use of public-private partnerships, such as ASCENT, CAAIFI, and CLEEN. This new effort would see the FAA invest in high-risk, accelerated research that has transformative impact potential to reduce greenhouse gas emissions from aviation in support of the 2030 and 2050 U.S. climate change goals. We are also working in partnership with the Department of Energy, the U.S. Department of Agriculture, and NASA on our research to ensure that our efforts are complementary and directed toward the Administration's goals. Finally, we are also collaborating with a number of international research institutions through the ASCENT COE and CAAIFI. We have worked diligently to develop all of these partnerships over many years and intend to continue to do so going forward.

Finding: Sustainable Aviation Fuels (SAFs) - Significant gains have been realized in the Sustainable Aviation Fuel (SAF) Program (including efforts in CAAIFI, CLEEN, and ASCENT. SAFs are a critical component of the industry's emissions reduction strategy and must be developed if industry is to get to their carbon-neutral growth goals after 2020 and their 50% emissions reduction goals in 2050. This 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 SAF were used by the U.S. Aviation Industry, a 190% increase over 2019, and this increased consumption happened in spite of the current downturn in aviation traffic.

Business aviation has also seen significant interest in SAF. Based on industry data, there should be a significant increase in production and consumption in the coming years. Recent support

from a number of agencies, including from DOE and USDA, will further support SAF production. The FAA is working through the International Civil Aviation Organization/Committee on Aviation Environmental Protection (ICAO CAEP) to ensure that a wide range of sustainable aviation fuels are included in Carbon Offsetting and Reduction System for International Aviation (CORSIA). The FAA has also been conducting research to examine whether other types of fuel besides SAF could be used in different kinds of air vehicles. This work should prove insightful for understanding how Hydrogen could be used by aviation, both in the near and longer terms.

Recommendation (3): It is still the position of this Subcommittee that the work on Sustainable Aviation Fuels (SAF) is critical to the U.S. industry, and the FAA should maintain a global leadership role in the development of SAF. 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. This includes finding ways to use SAF as blending percentages above 50% and work towards the use of 100% SAF in today's aircraft. The partnerships with the Department of Energy and the U.S. Department of Agriculture must also be reinforced.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address it - The FAA wholeheartedly agrees with the importance of Sustainable Aviation Fuels (SAF). As captured in the fact sheet from President Biden's Leaders Summit on Climate, "the United States is committed to working with other countries on a vision toward reducing the aviation sector's emissions in a manner consistent with the goal of net-zero emissions for our economy by 2050, as well as, on robust standards that integrate climate protection and safety. The United States intends to advance the development and deployment of high integrity sustainable aviation fuels and other clean technologies that meet rigorous international standards, building on existing partnerships, such as through ASCENT– the Aviation Sustainability Center – and pursue policies to increase the supply and demand of sustainable aviation fuels." SAF are the most effective near-term opportunity to reduce aviation carbon dioxide emissions and will be critical to achieving the Administration's goals for economy-wide carbon dioxide reductions. The new Aviation Climate Research budget line item will augment our longstanding efforts by supporting the development of SAF that could be used in jet engines without blending with conventional petroleum-based jet fuel and by evaluating aviation fuel supply chains to reduce the cost to produce SAF and maximize their environmental benefits. We also continue to work closely with others agencies, and in particular with the Department of Energy, the U.S. Department of Agriculture, and NASA, to work in a coordinated manner to accelerate the development and deployment of SAF.

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 rulemaking. Because of the impacts of COVID 19 on aviation globally and the continuing importance being placed on environmental issues around the globe, other governments have made commitments to their own research and environmental agenda. As a result, the Subcommittee firmly believes that maintaining the U.S. global leadership position at ICAO CAEP is not an option. It is essential and advantageous to the U.S. aviation industry. Work that has been done with ASCENT and the Volpe Center has clearly allowed the FAA to maintain a scientifically supported position at the International Civil Aviation Organization/Committee on Aviation Environmental Protection

(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 (4): The Subcommittee recommends the continuing strong support of all research efforts/programs that will allow the FAA and the U.S. to maintain its 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.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address it - The FAA appreciates the support of the Subcommittee for our ICAO CAEP activities and the importance of continued U.S. leadership therein. We concur that it is critical for FAA to have robust participation in the ICAO CAEP process, and we have allocated resources such that we can provide leadership in many of the working groups of CAEP, as FAA leadership is critical to securing overall U.S. objectives at ICAO. FAA prioritized research efforts include developing the modeling capabilities and generating the data to support the decision-making process within ICAO CAEP. Under the direction of the FAA, much of this work is being done by ASCENT COE universities and the Volpe Center, in close collaboration with NASA and industry. Over the past few years, we have been working with U.S. stakeholders and the international community to develop noise standards for supersonic aircraft with a focus on landing and takeoff noise. As AEDT is the primary tool for supporting decision-making related to noise at ICAO CAEP, this has included working with the Volpe Center to enhance its capabilities to include supersonic aircraft. In addition to this broad effort related to supersonic aircraft, FAA is also utilizing the broad research portfolio of ASCENT and expertise at NASA and DOE to ensure that the evaluation of any long-term aspirational goal is based on robust scientific analyses that quantify the economic costs and potential benefits of any specific goal. We continue to advance work in ICAO to ensure that sustainable aviation fuels from biomass and wastes, as well as lower carbon aviation fuels from fossil resources, are appropriately credited within the ICAO Carbon Offsetting and Reduction System for International Aviation (CORSIA). Finally, we are examining what additional research efforts may be needed to support efforts that could come out of the CAEP/12 meeting in February 2022.