U.S. Department
of Transportation

**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., S.W.
Washington, D.C. 20591

April 10, 2018

Dr. R. John Hansman, Ph.D.
Chair, Research, Engineering and
Development Advisory Committee
Massachusetts Institute of Technology
[redacted]

Dear Dr. Hansman:

Thank you and the Federal Aviation Administration's (FAA) Research, Engineering and Development Advisory Committee (REDAC) for your November 7, 2017, letter providing recommendations on the Fiscal Year (FY) 2020 Research and Development (R&D) Portfolio. The important guidance generated during the REDAC Summer – Fall 2017 meeting is sincerely appreciated.

Key topics discussed at this meeting included the review of the Agency's FY 2020 research plans and budgets, the FAA Cybersecurity Research Plan, and the need for engaged dialogue on critical aspects of the Unmanned Aircraft Systems (UAS) Integration Research Plan. We acknowledge that the UAS plan should provide clarity pertaining to research objectives and requirements necessary to ensure viable integration into the National Airspace System.

I have reviewed these recommendations and enclosed are our responses to these recommendations.

We will continue to incorporate the Committee's recommendations as we maintain an R&D portfolio that addresses safety, efficiency, and capacity of the air transportation system in an environmentally sound manner.

Sincerely,

DK Elwell

Daniel K. Elwell
Acting Administrator

Enclosure

FAA Response to REDAC Guidance for the Fiscal Year (FY) 2020 Research and Development (R&D) Portfolio

Subcommittee on Airports

Finding: Runway Braking Friction - The Subcommittee was pleased by FAA's reassessment of the Runway Braking Friction project as well as convening a working group of subject matter experts from with a broad range of technical expertise—including aerodynamics, aircraft systems, braking systems, and human factors—to re-scope braking research plans across FAA research programs. While the Subcommittee understands that these reassessment and expert review efforts are not complete, we would like to have a general idea of how the FAA believes needed braking research should proceed.

Recommendation (1): The Subcommittee encourages the FAA to complete its reassessment of its runway braking friction research projects as soon as possible, with a focus on the objective of providing a reliable, objective method of aircraft runway friction assessment that accurately accounts for the effects of runway contaminants impacts on aircraft performance. Following this reassessment, the Subcommittee would like to receive a revised runway braking friction research plan that addresses issues identified by the aforementioned runway braking friction working group. We also recommend that the runway braking working group report back its recommendations at the next Subcommittee meeting, and possibly to the full REDAC membership, time and resource permitting.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s): The FAA's Airport Technology Research Branch will continue to lead an Aircraft Braking Friction Expert Technical Working Group. The Technical Group was formed in 2017 and has already performed a general assessment of research conducted in the Aircraft Braking Friction area by FAA and industry. The next task for the technical working group will be to develop an FAA long-term Aircraft Braking Friction Research program plan. The draft plan will be presented during the next meetings of the REDAC, both at the Subcommittee and full Committee levels.

Finding: Heated Pavement - The Subcommittee was pleased to learn that use of heated pavements to mitigate frozen contaminants in airfield pavements may be possible at lower costs than originally thought. Given the increased likelihood the economic feasibility of heated pavements, the Subcommittee believes that some consideration should be given to the potential safety and operational issues associated with such pavements, particularly those that use electrical means to heat the pavements.

Recommendation (2): The Subcommittee recommends that the FAA consider safety risks associated with electrically heated pavements as well as the potential for electromagnetic interference associated with such systems and any effects the use of ferromagnetic materials in pavement surface layers may physically have on tires, personnel, or the potential for foreign object debris.

FAA Response: **The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s):** The FAA's Airport Technology Research Branch will investigate potential safety risks associated with the incorporation of heated pavement materials and techniques on airports. Specifically, electrical and electromagnetic risks will be investigated. The potential for foreign object debris will also be addressed.

Finding: LED Lighting Research - Some Subcommittee members expressed concern during FAA presentations on light emitting diode (LED) lighting systems research that LED runway edge lights do not emit light omni-directionally in the same manner as their incandescent counterparts, potentially making airfields equipped with LED edge lights more difficult for pilots to see at night.

Recommendation (3): The Subcommittee recommends that the FAA expand evaluation of LED runway edge lights to include airfield conspicuity considerations.

FAA Response: **The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s):** The FAA's Airport Technology Research Branch will expand its evaluation of LED runway edge lights to include airfield conspicuity considerations. A plan of this proposed evaluation will be presented at the upcoming Subcommittee meeting.

Finding: Improving Awareness of Other REDAC Research Programs and Opportunities for Cross-Program Collaboration - Based in part on the discussion of research projects that involve other REDAC Subcommittees—including noise research that involves the Environmental & Energy Subcommittee, runway braking and runway incursion mitigation research that involves the Human Factors and Aircraft Safety Subcommittees, and air traffic automation research that involves the NAS Operations Subcommittee—members expressed an interest in increasing its awareness of the research within the purview of the other four Subcommittees.

Recommendation (4): The Subcommittee recommends scheduling briefings from either designated members of other Subcommittees or their FAA counterparts on research areas and/or projects that have implications for the Airport Technologies research portfolio during the Airports Subcommittee's meetings and notes that it has already been doing so successfully with the Environmental & Energy Subcommittee for the last 4 to 5 REDAC meeting cycles.

FAA Response: **The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s):** The FAA's Airport Technology Research Branch will reach out to other REDAC Subcommittees and FAA counterparts to maximize cross-program collaboration. In coordination with the Airports Subcommittee Chair, members of other Subcommittees and FAA will be invited to participate and present in the upcoming Airports Subcommittee meetings. The FAA's Airport Technology Research Branch will send representatives to participate in other Subcommittee's meetings.

Subcommittee on Aircraft Safety

General Observations: Unmanned Aircraft Systems (UAS) - The SAS greatly appreciated the initial presentation on the FAA UAS R&D Plan and commends the FAA's efforts. The plan is a comprehensive identification of research required to meet the different UAS implementation phases and the research being performed by FAA, other government agencies, industry and academia. While we have not yet had the opportunity to review the plan itself, we understand that it identifies gaps in ongoing and planned research and required funding to cover the next 5 years. The FAA is to be commended for undertaking such an ambitious planning activity. We look forward to the opportunity to review the entire plan once it is released.

Finding: UAS COE - A significant portion of the FAA's research budget is being directed to the UAS COE. From the FAA's description, it appears that the majority of UAS research is in the form of university grants (i.e. the majority of the research is conducted by the UAS COE). Grants tend to be less driven by specific outputs and thus potentially less directed towards a specific practical aim or objectives of the applied research needs identified in the FAA UAS R&D plan. The Subcommittee wonders whether the FAA is receiving full value from such research given the magnitude of the applied research identified in the plan.

Recommendation (1): The FAA should steer grants towards more goal directed research and should consider taking advantage of a contract vehicle to conduct more applied research at the UAS COE aimed at meeting the applied research objectives to identified in the FAA UAS R&D Plan.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation. The FAA UAS COE Program Manager is currently establishing a UAS COE contract, which is anticipated to be awarded in 2018. To the extent allowable under the COE program guidelines, the FAA will take advantage of either this new contract vehicle and/or grants to fund the research for UAS COE. The contract vehicle will only be utilized only when it is determined that a contract award would be the most appropriate vehicle for the required research.

Finding: UAS Ground Collision Severity Evaluation Research - The Subcommittee noted that peer-reviewed UAS Ground Collision Severity Evaluation research is not being fully leveraged by AFS-800 in granting Part 107 waivers for UAS operations over people. A clear and closed loop connection between the research performers and the consumer of the research results appears to be lacking. The Subcommittee senses that research results are not taken into sufficient consideration in UAS safety oversight, rulemaking and other actions required for achieving UAS integration into the NAS.

Recommendation (2): Through all stages of research activities, there should be tighter engagement among research performers and the FAA organization(s) that would leverage research results in safety oversight activities and rulemaking. FAA should consider how to best utilize existing structure to assure the maximum transfer of research learning.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation. The UAS Ground and Airborne Collision Severity Evaluation Research final results were peer reviewed by both internal FAA subject matter experts (including from the sponsoring organization and Chief Scientific & Technical Advisors) and external subject matter experts from Government National Aeronautics and Space Administration (NASA) U.S. Department of Defense and industry (aircraft and engine OEMs). The FAA plans to continue peer reviews for additional UAS research activities (for example, additional Phases of both the UAS Ground and Airborne Collision Severity Research) and will include the peer review team from the beginning, starting with project/test plan definition, through the review of research results. This will enable the end users of the research to provide guidance and input to the performers at the earliest stages, ensuring a useful product. The FAA will continue communicating results through various forums, including public rollout events, status reports on research on the FAA's UAS Integration Web site, and the FAA UAS Integration Research Roundtable, which represents a cross-section of FAA research stakeholders.

Finding: Research Plan Prioritizations - The plan identifies a significant amount of required research and FAA indicated that there will likely be insufficient funds to conduct all of the research identified in the necessary timeframe.

Recommendation (3): The Subcommittee recommends that FAA, together with its stakeholders, identify the minimum acceptable research results required to achieve each transition step and revise the plan accordingly. The FAA, together with its stakeholders should prioritize the research.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation. The FAA took this approach during the 1-year formulation of the Agency's first comprehensive UAS Integration Research Plan covering 2017-2022. The FAA intends to make annual updates to the UAS Integration Research Plan. The subsequent versions of the Plan will reflect changes to research priorities based on completed research, updates to the UAS integration rulemaking spectrum, and the progression of multiple FAA-industry partnerships and collaborations (including the Drone Advisory Committee, UAS Safety Team, Pathfinders, Partnerships for Safety, Integration Pilot Program, etc.). Furthermore, the FAA has defined a post-analysis phase within each transition step to assess the application of research results within the FAA and stakeholder organizations and to determine additional data and research needs to ensure timely realization of each operational capability.

Finding: UAS Research - The advanced research that is ongoing to allow UAS to safely and efficiently integrate into the NAS can, in some cases, provide safety and efficiency benefits in the manned sector. While clearly there is direct applicability to highly automated manned aviation such as with the burgeoning "on-demand mobility" concept vehicles, this research can also inform more traditional forms of manned aviation including airline transportation segments. An example of this might be allowing the crew to take advantage of see and avoid concepts that might keep the aircraft a farther distance from large birds or other airborne conflicts.

Recommendation (4): The UAS research should place added emphasis on communicating research findings which can provide parallel benefits within the unmanned and manned aviation sectors.

FAA Response: **The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation.** The FAA will continue communicating results through various forums, including public rollout events, status reports on research on the FAA's UAS Integration Web site, and the FAA UAS Integration Research Roundtable, which represents a cross-section of FAA research stakeholders.

Finding: Fatigue Mitigation - The Committee received a follow-on briefing on the FAA's overall fatigue research program. The Committee feels that this report described the existence of a wide-ranging fatigue research program within the FAA, and a strong interest in building follow-up research documenting the effectiveness of the Fatigue Risk Management System/Fatigue Risk Management Plan (FRMS/FRMP). The report identified an effective plan for moving forward which involved among other things, identifying research initiatives from around the industry, gaps in knowledge, and the establishment of fatigue working group with members from industry, research, and regulators to continue the necessary follow-up work needed to ensure required research is performed. The report stated that this working group will need a sponsor from the regulatory community to provide guidance and tasking for the working group.

Recommendation (5): The FAA establish a Fatigue Working group, identify an FAA working group lead who will best represent fatigue across the agency, execute the FAA plan that was presented as the path forward for identifying and addressing fatigue research issues, and properly implementing the research results. Follow-up studies of the effectiveness, utility, and potentially necessary enhancements of the FRMS/FRMP should be funded and implemented as soon as possible.

FAA Response: **The FAA concurs with the Committee's recommendation and is undertaking the following actions to address the recommendation.** A meeting of Human Fatigue experts from across the FAA is scheduled for the spring 2018 to discuss establishing a Fatigue Working Group and to discuss the plans going forward. The results from this meeting will be incorporated in the Human Factors Strategic Research Plan that is being drafted to be presented in the spring meeting.

Subcommittee on Human Factors

General Observation: After reviewing the 2017 portfolio projects, tasks, and their status and outcomes the Subcommittee supports the ongoing flight deck research being conducted and scheduled. However, the Subcommittee identified several important gaps in the planned Human Factors (HF) research which the Subcommittee deems high priority areas of research and recommends they be reprioritized for FY18 and funded in subsequent years. The two main areas of concern are information management and pilot training effectiveness which are presented in Findings 1 and 2.

Finding: Information Management - One gap in the Human Factors NextGen portfolio concerns Information Management. An important example of this is the impact of information overload on pilot workload and its consequences for distraction. Standards are needed to define what information may be pushed to or pulled by the pilot and when. Increasing information management demands for pilots, controllers, dispatchers, and traffic managers in NextGen operations will create human factors risks and vulnerabilities such as high workload, distraction, longer task time, and increase errors.

Recommendation (1): The FAA should review its HF portfolio for 2018 and 2019 to include information management as a research focus area and ask planned projects as appropriate to address information management issues as part of their current project tasking. Specific areas to address include: integration of different standards of information flow (volume of information and formats), acquisition of information from different sources, integrating it with other information in the flight deck, managing distractions, and managing the workload these tasks introduce. The 2020 research portfolio should include information management as a specific research focus area.

Consequences if not funded:

Modern flight decks and the control stations for controllers, dispatchers, and traffic managers are rich information landscapes that demand user's process and manage information by acquiring, filtering, interpreting, and integrating relevant information, into a coherent understanding. If the information sources are difficult to monitor and verify or if appropriate information is not shared among collaborators in the same format in a timely fashion, several human factors issues may result. Users may over rely and trust automated systems because they don't have the capacity to interpret and verify outputs. Performing information management tasks such as organizing, filtering, and prioritizing information may distract from primary tasks (such as flight path management). Communication may break down and result in both errors and inefficiencies because collaborators don't have the same information or don't interpret the information similarly because it is in different forms or formats. Primary tasks may take longer because additional information management tasks add task time but not direct value. If this research priority is not addressed, the significant changes in the information environment related to NextGen and beyond will likely increase existing human performance issues and introduce new ones that could reduce safety and efficiency thereby negating the expected benefits of NextGen.

FAA Response: **The FAA concurs with the Committee's recommendation** and will review its flight deck HF portfolio for 2018 and 2019 and specifically evaluate the research focus on information management issues, including information flow, volume, sources, and integration.

Finding: Pilot Training - A major gap in the Human Factors portfolio related to Pilot Training. There are a number of important areas related to training for NextGen that include human factors issues that are not being investigated nor are they currently planned. These areas include distance learning, training methods, training effectiveness assessment, instructor/evaluator training, and situations with no checklist.

Recommendation (2): The FAA AVS should review and reprioritize the overall safety portfolio for 2018 and 2019 to include research on pilot training effectiveness to improve safety and to

evaluate the effectiveness of training for both current and new training methods that are introduced. The 2020 research portfolio should include training as a specific research focus area. For example, concerns about distance learning and training methodologies are already in the requirements but have not been funded and are high priority issues to the Subcommittee. Training methods, such as competency based training and other methods need to be assessed and updated to meet current and future needs. What skills and knowledge do pilots need and how do we train instructors to ensure they are developed in pilots? We expect skills and knowledge to transfer, but how do we measure the effectiveness of training? Because we cannot train for everything how do we build resilience into the human component of the system, controllers and pilots, and into the system itself so that the humans are equipped to effectively manage the unexpected?

Consequences if not funded:

Distance learning is already being used extensively by operators to replace other proven training methodologies without research being conducted to determine empirically if the distance learning method is effective. Safety and training data suggest that pilot knowledge and skills required for current and NextGen requirements is increasing and current training methodologies used to develop knowledge and skills may not be as effective to meet NextGen system needs. The FAA currently provides guidance that allows for 100% of some knowledge based training to be done via distance learning using methods which some studies found to be only 10-20% effective. Research is needed to define realistic guidance on what types of distance learning delivery methods are effective for different types of knowledge and skills, how to assess effectiveness of distance learning after training completion, and the proper mix of distance learning with classroom and other methodologies. The International Civil Aviation Organization (ICAO) is supporting competency-based training and the U.S. has not funded the research to understand competency-based training and other proposed training methodologies. The FAA is participating in the ICAO working group with little or no research to back up their position. The working group work is scheduled to be completed by 2020, so the research needs to be started now.

FAA Response: **The FAA concurs with the Committee's recommendation** and will review and reprioritize the overall safety portfolio for 2018 and 2019. The FAA is aware that currently no core funding is slated to address pilot training qualifications for 2018 or 2019. The FAA is in the process of funding two research programs to evaluate the effectiveness of new technological approaches for training the emerging pilot workforce. Methodologies to be investigated include those deployable as distance learning, including virtual reality. A current research program is investigating effective methods for developing pilots' skills to manage unexpected events.

Finding: Research to Reality - Next Gen applications such as, Trajectory-Based Operations and Dynamic RNP aim to enable both greater flexibility and efficiency. For such programs to realize the expected benefits, human factors principles and findings need to be included into the design of flight crew and air traffic displays, procedures, and other details of the complex operations. While significant human factors work has been conducted that relate to these applications and supporting technologies, such as Data Comm, a continual emphasis on the correct application of past research and human factors principles is needed as decisions are made on national and international procedures and guidance. While some of the relevant work had a specific program

emphasis in the past (e.g., Data Comm), the total of the work that needs to be applied to ensure realization of expected benefits is broad and cross-cutting. This includes several 'lessons learned' that need to be considered to prevent situations that have resulted in rejection of new technologies by pilots and air traffic controllers. The application of this body of knowledge is the final step in the research process and required for the realization of the benefits of the research.

Recommendation (3): A standardized process is needed to identify within the FAA lessons learned and how to enable the continual transfer of the results of both Core and Next Gen Human Factors research and the correct application of these results and human factors principles into the decision-making bodies of the standards and procedures of Next Gen operations. These include RTCA working groups, International Civil Aviation Organization (ICAO) panels and ICAO working groups which develop and refine international standards and guidance materials and work toward global harmonization of such procedures. Such a vehicle would promote and ensure effective continual involvement of human factors in all aspects of Next Gen operations from concept development through post- implementation. Post-implementation testing would assess effectiveness and identify whether refinements are needed to realize projected benefits.

FAA Response: The FAA appreciates the Committee's view on research to reality. However, we are not in agreement and cannot pursue the recommendation because (1) no single standardized process would be appropriate across the different FAA lines of business (e.g., Aviation Safety applies research differently than the Air Traffic Organization or even necessarily within the lines of business); (2) there are many lessons learned in addition to those that come from research (e.g., lessons from operational experience); and (3) while it can be useful in many cases to apply the knowledge and expertise from the research to the development of national and international standards and guidance, it may not be appropriate in all cases. We look forward to more discussion on this topic at our next Subcommittee meeting.

Subcommittee on Environment and Energy

Finding: Public/Private Partnerships - Members of the E&E Subcommittee are very aware of the budgetary constraints that exist within the Department of Transportation and the FAA. The Continuous Lower Energy, Emissions, and Noise (CLEEN) program, the Commercial Aviation Alternative Fuels Initiative (CAAFI) and the Aviation Sustainability Control (ASCENT) program are successful industry/FAA cost-share programs that leverage scarce FAA R&D funds that have accomplished significant advances and improvements for the industry.
Recommendation (1): The Subcommittee recommends that the FAA continues to prioritize robust funding for the Public Private Partnership programs like CLEEN, CAAFI and ASCENT.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation. We appreciate the Subcommittee's continued support for the FAA's efforts to accelerate the maturation of aircraft technologies to lower noise, emissions, and fuel burn via the CLEEN Program, as well as to advance the development of alternative jet fuels via CLEEN, CAAFI, and the ASCENT Center of Excellence. All three of these programs are conducted in partnership with the private sector through cost-sharing agreements and with considerable industry engagement. This engagement

is a key reason for their success. CLEEN and ASCENT account for roughly three quarters of the RE&D Environment and Energy funding. As such, three quarters of the RE&D budget is generating 100 percent cost share. CAAFI does not have a cost-share requirement so the non-government funds going toward it have not been tracked over time. However, the effort has considerable industry support – especially from the airlines – and has been successful in directing efforts across the federal government. These are also longstanding efforts of the FAA: ASCENT is the follow-on Center of Excellence to PARTNER, which was established in 2004, CAAFI was started in 2006, and CLEEN was started in 2011.

Finding: Human Resource Allocations - As has been highlighted in the past, there is serious concern over the number of vacancies that exist in the Office of Environment and Energy (AEE) and the increasing requests for answers. There are currently twelve (12) vacancies in AEE. In order for the dedicated employees within AEE to be able to properly manage the current portfolio, which we believe is well balanced, maintain the FAA's global leadership position in the International Civil Aviation Organization (ICAO), address the growth of other areas of commercial transportation and the development of smart policy, there is a need for answers. The answers to the many questions require the ongoing need for research.

Recommendation (2): In order to provide the research that is needed to properly address the increased tasking of the Office of Environment and Energy (AEE), the Subcommittee recommends that the FAA commit the resources needed to hire additionally qualified individuals to be able to properly address portfolio needs. We would ask the FAA to not take away limited resources from current work in an effort to handle new work.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation. The FAA appreciates the assessment that the Environment and Energy portfolio is well-balanced, and we understand the Subcommittee's concern about staff availability as the Office of Environment and Energy (AEE) has been operating with vacancies for one fifth of their positions. Qualified staff are needed to maintain FAA's leadership position within ICAO CAEP to continue to manage the current research portfolio, and to overcome environmental challenges that could prevent the entry of UAS, supersonic aircraft, and commercial space vehicles into the NAS. AEE have had success over the years in filling positions with highly qualified environmental professionals. This is due in part to the students and staff that have been trained as a part of PARTNER and ASCENT, the FAA Centers of Excellence for Environment and Alternative Jet Fuels. We are in the process of executing a hiring plan that was developed in accordance with administration guidance. To accommodate the evolving nature of the industry and the FAA's needs, we are seeking individuals who could cover a variety of needs to fill these openings.

Finding: Supersonic, Unmanned and Commercial Space Vehicle Impacts - During the Subcommittee meeting, the FAA presented information that indicates that there has been a dramatic increase in the level of interest in supersonic aircraft under the current Administration. There is also potential growth in unmanned aerial systems and commercial space vehicles. There is a significant amount of research that needs to be done in order to understand the environmental impacts of these new entrants. Research is the key to establishing sound policy. The FAA/AEE should ensure that its research plans will address the noise, emissions and possible health

impacts of these new entrants such that the FAA can make informed decisions in carrying out their responsibilities under various statutes.

Recommendation (3): Based on increased interest in supersonic aircraft, the growth of unmanned aerial systems and the growth of commercial space vehicles, the Subcommittee encourages the FAA to advance our understanding on the environmental impacts of these entrants.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation. UAS, supersonic aircraft, and commercial space vehicles all present economic opportunities for the United States as well as potential concerns in terms of the environment, in particular noise. As such, the FAA is devoting resources to advance our understanding of the environmental impacts of these new entrants such that effective solutions can be found to overcome potential barriers to their entry into the NAS. There is indeed an increased interest in supersonic aircraft. Industry has put forward many design concepts for supersonic aircraft. Some are low-boom designs and some would result in a full boom like the Concorde. We are working in close collaboration with NASA to evaluate low boom technologies and conduct the necessary analyses to understand the noise and emissions impacts of these new designs. Supersonic aircraft will only be economically viable if they can take off and land in other countries. That will require international agreements at ICAO CAEP. Depending on the vehicle design, UAS could lead to noise concerns. We continue to seek partners to measure the noise from these vehicles to understand the potential issues and ensure we are well placed to deal with them. Commercial space vehicles could also present noise and emissions challenges depending on their design and where they are operating. We are leveraging efforts being funded by the Airports Cooperative Research Program to ensure our modeling capabilities can capture the noise and emissions from these vehicles.

Finding: Non-Volatile Particulate Matter - The Subcommittee is very pleased with the work done by AEE on developing a non-volatile particulate matter (PM) emissions standard and in the development of the Carbon Offsetting and Reduction System for International Aviation (CORSIA). In regards to the CORSIA, it is important that proper credit be given for the use of alternative fuels. The Subcommittee is also pleased with the efforts of the FAA along with NASA to conduct and align research activities to inform the development of noise and emission standards for supersonic aircraft. The Subcommittee believes that United States leadership in the ICAO CAEP process continues to be an important priority.

Recommendation (4): The Subcommittee highly recommends that the FAA continue their commitment for all of the necessary programs to support continued U.S. leadership in ICAO CAEP. This includes the non-volatile PM emissions standard, CORSIA, alternative fuels and supersonic aircraft.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation. We appreciate the support of the Subcommittee for our ICAO CAEP activities and the importance of continued U.S. leadership therein. Robust funding is critical to not only ensuring that we have robust participation in the ICAO CAEP process but also to the development of our modeling capabilities and the generation of data to support the decision-making process within ICAO CAEP. Because of FAA leadership, the CAEP Steering Group reached an agreement in

September 2017 on the CORSIA Package. The inclusion of alternative jet fuels within CORSIA is a direct result of many years of effort by the FAA and the ASCENT Center of Excellence. We have made considerable investments with industry to develop an engine PM test database and modeling capabilities. As a result of these investments, we have a solid foundation for making decisions in ICAO CAEP on an engine PM emissions standard. Efforts are also continuing in ICAO CAEP on supersonic aircraft. This is important as these aircraft will only be economically viable if they can take off and land in other countries and this will require international agreements at ICAO CAEP.

Subcommittee on NAS Operations

Findings: Commercial Space

1) The projected dates for NAS improvements to integrate Commercial Space in the NAS are based on the current commercial space research plan. The Subcommittee believes that these implementation dates need to be moved to the left (i.e. come earlier) to deal with the significant growth in commercial space operations that the subcommittee anticipates.

2) There are a large number of R&D projects across the four pillars. The subcommittee believes that, with the available budget, many of these will not have enough funding to achieve meaningful results.

3) Some of the projects in the commercial space R&D portfolio don't appear to support commercial space operations integration into the NAS.

Recommendation (1): The Subcommittee recommends that the Commercial Space R&D be prioritized and limited to those activities that directly support early integration of Commercial Space into the NAS. Research is currently focused on four areas (pillars):

Research Area 1. Management of Space and Spaceport Operations
Research Area 2. Space Transportation Vehicles and Analysis
Research Area 3. Human Spaceflight
Research Area 4. Space Transportation Industry Viability

The most critical items (those necessary to ensure that as the number of space launches increases there will be as little impact on ATC as possible) must have sufficient investment. Lower-priority activities, such as those in pillar 4, should be stopped completely. The R&D plan should be revised to reflect this recommended prioritization, as these activities appear to be most appropriately the responsibility and obligations of the private sector.

FAA Response: The FAA Office of Commercial Space Transportation (AST) appreciates the opportunity to respond to the findings and recommendations of the REDAC Subcommittee on NAS Operations as detailed in the November 20, 2017 memo. We have reviewed them, generally concur with the findings, and have provided comments on both findings and recommendations.

As additional information, AST has undertaken a comprehensive review of its R&D program in order better align activities with guidance from the National Space Council, the DOT Strategic Plan, as well as the FAA's Strategic Plan. As a result, we have established new priorities and an agile research profile designed to meet National Space Council/DOT Strategic Objectives, and maximize operational impact/integration within the NAS. These priorities are

- Regulatory Streamlining and Innovation (21st Century Licensing)
- Deployment of Innovation: safe integration of CST into the National Aerospace System (NAS)
- Spaceport infrastructure research: airspace integration, operations, safety of population centers
- Systemic Safety: risk-based approach to human safety

Within this context, AST offers the following comments for consideration:

1. With respect to the finding that "implementation dates need to be moved to the left (i.e. come earlier) to deal with the significant growth in commercial space operations that the subcommittee anticipates" we are amenable to considering schedule changes to our research activities, and look forward to further advising the Subcommittee on this issue. It should also be noted that the FAA's capital investment program includes enabling safe and efficient integration of commercial space into the NAS.

2. With respect to the findings regarding the number of projects under the four AST research pillars, we agree that research projects need to be prioritized, and consolidated in order to achieve meaningful results. As noted above, we have established revised priorities and are in the process of aligning projects to these specific items.
   We concur that NAS integration is a significant priority. While some projects may not specifically annotate "integration into the NAS," all of the research priorities are closely connected to safe and efficient NAS integration. It may be beneficial for us to brief the Subcommittee on these priorities and how they are directly linked to integration.

3. Comments on recommendation:
   a. AST appreciates the REDAC's focus on prioritization of research activities, and we have ensured integration of CST into the NAS as a primary pillar of focus in the new research strategy shown above. We would also add that all of the research priorities are interrelated, and will be postured to support integration of CST into the NAS. For example, risk-based approaches to human safety (Priority 4), serves as an enabler to greater capacity in the NAS, in much the same way that enhanced aircraft navigation improves safety and allows for closer spacing and increased NAS capacity.
   b. AST also concurs with the REDAC's recommendation that research activities that can be accomplished by the private sector should be reduced. We believe we can engage with industry in this regard through the recently reestablished COMSTAC and will keep the Subcommittee apprised of our progress in this regard.

General Observation: Pathfinder Programs - The Subcommittee received briefings on the FAA's three Pathfinder Programs, namely CNN's Visual Line of Sight operations over people,

PrecisionHawk's Extended Visual Line of Sight operations, and BNSF's Beyond Visual Line of Sight operations.

Findings: The Pathfinder Programs represent an excellent opportunity to both provide near-term access for specific UAS operations in the NAS while also identifying and providing data for key research issues that warrant further exploration. Although the Subcommittee appreciates the complexity of integrating these UAS activities into the NAS, the pace of progress is significantly slower than required to satisfy the accelerating demand for airspace access. The processes used to approve airspace access in the current Pathfinder Programs will not scale up to meet the expected significant expansion in the scope of UAS operations that is needed. At the same time, there does not appear to be an established process for extracting research issues and linking them to other R&D efforts within the FAA so that they can be resolved. As a result, the Pathfinder Program risks falling behind the demand for access and failing to inform the FAA's UAS research roadmap.

Recommendation (2): The FAA should define a formal process for identifying and prioritizing research and development issues arising out of the Pathfinder Program and then conveying that information in a way that can be integrated into the UAS R&D plan. Each Pathfinder focus area should produce an ordered list of associated research questions that, if resolved, would validate the assumptions and constraints placed on operations and inform future UAS operational concepts. In turn, the FAA's UAS research roadmap should facilitate ingesting inputs from the Pathfinder Program and ensuring they are resolved through its ongoing research programs. The REDAC looks forward to reviewing these research issues and priorities at its spring 2018 meeting.

FAA Response: **The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation.** The FAA has an established engagement team led by a program manager for each of the three Pathfinder Focus areas, with teams comprised of subject matter experts from across the FAA. These teams meet regularly and the program managers meet weekly to report progress and to leverage lessons learned across the Focus areas. Through partnership with FAA, the Pathfinder industry partners have reached targeted goals for success during 2017, providing data to inform research and rulemaking. UAS Pathfinders have a dedicated section within the UAS Integration Research Plan. Subsequent versions of the plan will include updates on completed Pathfinder work as well as work underway and still needed. Research questions resulting from UAS Pathfinders have been and will continue to be included within the appropriate UAS activity timeline(s) associated with UAS operational capabilities.

General Observation: NextGen ATC/TechOps Human Factors - The Subcommittee received briefings on the FAA's NextGen ATC/TechOps Human Factors research, BLI number 1A07A0/1A08A0, that focuses on documenting and transitioning Human Factors lessons learned from concept exploration and early implementation activities.

Findings: The NextGen ATC/TechOps Human Factors research is performing valuable work related to best practices, performance metrics, and standards in the early phases of the Acquisition Management System (AMS) process. While the Subcommittee understands the difficulty of integrating new technology and processes with an existing ATC, ATM, and TechOps workforce, the segmented nature of research is obscuring aggregate and collateral

human factors issues. The process of small, segmented studies and outcomes does not capture recent human factors changes and insights as context for near term plans. There does not appear to be an adequate process linking collective impacts and outcomes to the Human-Systems Integration Roadmap. As a result, the Human Factors research risks overlooking aggregate impacts or not fully capturing opportunities to align workforce development with technology for NextGen.

Recommendation (3): The FAA should define a broad scope assessment process for aligning segmented Human Factors research activities with an aggregate roadmap that is aligned with anticipated changes in workforce structure and function in NextGen. The Subcommittee is interested in understanding how the workforce will change and, as determined through HF research, how the current structure may need to transform in order to sustain significant technological and process change. The REDAC looks forward to reviewing these research issues and priorities at its spring 2018 meeting.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation. Specifically, the FAA concurs that the segmented nature of research obscures the aggregate and collateral human factors issues, or does not fully capture opportunities to align workforce development with technology for NextGen. The FAA is addressing the Committee's recommendation to define a broad scope assessment process for aligning segmented Human Factors research activities with an aggregate roadmap that is aligned with anticipated changes in workforce structure and function in NextGen.

The Human Factors Division is proposing a NextGen activity to identify shortfalls in the workforce development strategy relative to introduction of trajectory based operations. Following prior work that examined effects on tasks and training needs for the controller and Technical Operations workforces in the mid-term, this proposed work will pivot to TBO-related effects on the workforce and aggregate integration of NextGen capabilities.

At the spring 2018 meeting, the NextGen ATC/TechOps Human Factors research program manager will brief the REDAC NAS OPS Subcommittee on the past and ongoing research to identify aggregate human factors issues and priorities on this topic.