



U.S. Department
of Transportation

**Federal Aviation
Administration**

Office of the Administrator

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

December 18, 2018

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

Dear Dr. Hansman:

John

Thank you and the Federal Aviation Administration's Research, Engineering and Development Advisory Committee (REDAC) for your May 30, 2018, letter providing recommendations on the Fiscal Year (FY) 2020 Research and Development (R&D) Portfolio. The important guidance generated during the REDAC Winter – Spring 2018 meeting is sincerely appreciated.

Key topics discussed during this meeting addressed the integration of new entrants into the National Airspace System that included Unmanned Aircraft Systems, Commercial Space Operations, and Urban Air Mobility to foster viability, sound decision-making, and U.S. competitiveness within the various industries. There was continued dialogue regarding the need for research to support certification criteria for emerging technologies pertaining to advanced avionics and automation, as well as, electric propulsion systems. REDAC also reviewed the Agency's FY 2020 research plans and budgets and addressed the Federal Aviation Administration's ability to attract and retain subject matter professionals during an era of budgetary reductions.

I have reviewed these recommendations and enclosed are the Agency 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,

Daniel K. Elwell
Acting Administrator

Enclosure

*I appreciate your
long and dedicated service
on the REDAC and your
superb leadership!*

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

Subcommittee on Human Factors

Finding: Important areas for continued Research and Development - The Subcommittee was pleased to learn the FAA FY 2020 Human Factors Core and NextGen research requirements include the areas of:

- Certification criteria for advanced avionics technologies and vision systems such as Combined Vision Systems and head worn displays.
- Evaluation of fatigue mitigation in flight operations.
- Evaluation of training effectiveness including new training paradigms such as distant learning and virtual/augmented reality, and training methods for the next generation of pilots.
- Validation of pilot training and procedures for Next Gen integration.
- Human Factors guidelines for designing advanced instrument procedures.

These areas were identified by the Subcommittee as significant areas of research in either their emerging issues list or as areas the Subcommittee believes requires continued early stage research.

Recommendation (1): The Subcommittee believes these are high priority areas that should remain consistently funded despite proposed budget reductions. The Subcommittee recognizes the FAA has many competing priorities to balance, however, the FAA should review the Human Factors areas identified above to ensure that they remain included in the research portfolio and if any of these areas are not funded the Subcommittee would like to review the rationale for those decisions and the shift in priorities.

Consequences:

- The consequences of not funding research in these areas would limit the design, development, and implementation of innovative advancements. The evaluation of new technologies, training, and procedures requires a balance between innovation and safety and without adequate evaluation and certification methods, the FAA may limit the introduction of important features, functions, and concepts and negatively impact safety and operational efficiency.
- The consequences of not funding training research would delay the evaluation of innovative training technologies, such as augmented reality/virtual reality (AR/VR), and training methods, such as distance learning, for their effectiveness. Implementation of standards to define the effectiveness of these approaches for training would also be delayed. The emerging pilot demographics are changing and research is needed to understand emerging pilot expectations, knowledge and skill needs, and whether current training will effectively prepare them.
- Human Factors guidelines are needed to design advanced instrument procedures that can be flown with old and new vehicles with variable installed technologies and performance capabilities. Without design standards and guidelines, the use of advanced procedures

will become more challenging as new types of operations (such as increased reliance on performance based navigation) are introduced.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation – We agree that the areas identified by the Subcommittee are important and we must balance the priorities of all our research programs with respect to changes in the budget and Agency needs. Additionally, research programs for the two portfolios are prioritized using different processes, and research is reviewed according to these established and approved processes. We will continue to apply scrutiny within FAA processes and additional coordination with sponsors to support the most critical research and the resources needed. As part of the process, the FAA will continue to provide the Subcommittee with status and rationale on the portfolio priorities for funded research in order to obtain feedback on areas you believe require reconsideration.

Finding: Research gaps that are not well represented in the current funded portfolio - A number of very important Human Factors research areas were identified by the Subcommittee that have not been included as part of the proposed FAA FY2020 Human Factors Core and NextGen research requirements. However, in order to provide the insights and guidance necessary to achieve the intended improvements in safety and efficiency promised by future developments in the operation of the NAS, there are a number of additional research areas that must be supported.

The following three areas are considered particularly urgent:

1. Understanding and addressing Human Factors issues associated with integration of unmanned aircraft systems (UASs) into the NAS. This includes defining standards to ensure safe and efficient integration with other air traffic and needs to encompass both small and large unmanned aerial vehicles (UAVs). Some unique challenges that such vehicles introduce include: support of situation awareness, piloting and decision making by remote pilots, coordination with visual observers, new ATC paradigms to manage rotorcraft, as well as contingency planning and interactions with the automation providing sense and avoid functions.
2. Managing increased complexity in airspace operations. This introduces a number of Human Factors issues due to the need to integrate and transition to new NextGen concepts, technologies and procedures within and across domains. This is made even more challenging by the expected variations in the performance capabilities of old and new vehicles and the introduction of new types of operations such as increased reliance on performance based navigation and the use of remote towers.
3. Supporting effective information management. Information access in the flight deck is accelerating. Some information is embedded in certified systems while other information is available through less formally controlled resources. The integration and display of these information sources makes it challenging for pilots to know the information integrity. Without Human Factors research to guide decisions regarding information automation, integration, certification, and design, unintended risk may be introduced into the system. Information overload, confusion, cumbersome and inconsistent interface

designs, stove-piped information sources (such as the use of an electronic flight bag as a source of information rather than displays integrated with the flight management system), and poorly conceived interactions with information automation are all potential barriers to achieving desired improvements.

In addition to these three broad topics, two other very important Human Factors research focus areas requiring attention were identified by the Subcommittee.

1. Increased introduction of automation and autonomous systems/subsystems. As manufacturers design and develop increased automation and more autonomous systems, the Human Factors issues associated with designing and certifying them need to be understood. Concepts for effective human-machine teaming and software mediated human-human coordination and collaboration need to be developed, evaluated, and certification criteria established. Research is needed to understand how different underlying technologies, such as machine learning, can be successfully integrated into safe and effective human-machine systems that can respond effectively to both routine and anomalous scenarios as well as provide guidance on how to assign roles and responsibilities to both humans and machine agents.
2. Transition to Trajectory Based Operations (TBO) and Performance Based Navigation (PBN). A basic assumption underlying NextGen is that the NAS will evolve into a system based on the 4-D management of aircraft trajectories. The importance of this evolution is further supported by the central role that TBO plays for the U.S. to comply with upcoming International Civil Aviation Organization (ICAO) requirements for trajectory synchronization in 2025 and beyond.

Recommendation (2): The FAA should review the Human Factors areas identified above for inclusion in its research portfolio in order to ensure that these issues will be addressed in a sufficient and timely manner. The Subcommittee further requests that the rationale for the resultant decisions and any new priorities regarding these research areas be presented to the Subcommittee at its next meeting, along with an analysis of the expected consequences if they are not supported.

Consequences:

- The consequences of not addressing these Human Factors research issues in a proactive manner will introduce barriers to achieving the goals of NextGen in a safe, timely and effective manner.
- Without this research, the planned increases in efficiency and capacity will not be achieved in a timely manner and the U.S. will not be able to comply with expectations established by International Civil Aviation Organization (ICAO).
- Experience to date with the introduction of Trajectory Based Operations into enroute operations, as well as, with the introduction of RNAV SIDs and STARs, has been mixed. Without research on Human Factors issues associated with the design, introduction, and management of advanced operations and procedures, the anticipated operational efficiencies may not be achieved.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation – Research for the flight deck and ATC human factors portfolios are prioritized using different processes, and research is reviewed according to these established and approved processes. We will continue to apply scrutiny within FAA processes and additional coordination with sponsors to support the most critical research and the resources needed. On the flight deck side, we have ongoing research involving unmanned aircraft systems and automation and autonomous systems. Research projects such as involving performance based navigation, remote towers, information management, transition to trajectory based operations, and air ground procedures are being assessed for inclusion in the respective research portfolios. On the ATC side, the FAA recognizes the important contributions of research to trajectory based operations for improving efficiency. From the ATC perspective, it will also be included as part of the Fiscal Year 2019 Air Traffic Organization Human Factors Roundtable discussion. This includes FAA leveraging industry partnerships to address research gaps in order to ensure the human performance contribution to safety and efficiency. The FAA will provide the Subcommittee with status and rationale for funded research at the Subcommittee meeting following receipt of this response.

Subcommittee on Environment and Energy

Finding: Alternative Jet Fuels - The elimination of funding for the Alternative Jet Fuel (AJF) Program including efforts in the Commercial Aviation Alternative Fuels Initiative (CAAIFI), Continuous Lower Energy, Emissions and Noise (CLEEN) and Aviation Sustainability Center (ASCENT) will have a catastrophic effect on the maturation of this fledging industry. This research has helped with the creation of a number of companies that will benefit the rural economies of some states and the U.S. Aviation industry. It is the position of this Subcommittee that the work on Alternative Jet Fuels is critical to the U.S. industry and should not be eliminated. Having the FAA maintain a leadership role in the development of AJF will also ensure that the rules that are developed internationally will benefit the U.S. industry. It is our view that these new companies and the industry that is being created will not be able to continue the work on AJF without government funding and the policies and procedures that are currently in place. Alternative fuels 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 emissions reduction goals in 2050.

Recommendation (1): Since the maturation of the Alternative Jet 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 either RE&D A13.a or A13.b budget line items have an allocation for the continuation of research on AJF.

FAA Response: The FAA appreciates the Committee's finding and recommendation; however, we are not able to pursue this recommendation at this time for the following reasons - The FAA's Research & Development (R&D) prioritization process includes a review of its complete R&D portfolio, including the area recommended by the Subcommittee. As part of this process, the FAA will continue to provide the Subcommittee with status and rationale on funded/unfunded research to obtain feedback/concerns on areas the Subcommittee believes

require reconsideration. We appreciate your feedback; however, this area was not funded in the President's Budget for FY19 as it was viewed as an area that could be supported by industry.

Finding: Public Private Partnerships - The Office of Environment and Energy (AEE) have proven over decades to be very good stewards of taxpayer money. They have used their budgeted amounts to conduct and coordinate the research necessary to produce informed 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. This has been accomplished by working collaboratively with private industry, major universities through the Partner and ASCENT Centers of Excellence, other federal departments and foreign governments. Three quarters of Environment and Energy research funds generate 100 percent plus cost matching from non-federal partners (CLEEN, CAAFI, and ASCENT). These programs leverage scarce FAA R&D funds to accomplish significant advances and improvements. In addition to the Alternative Jet fuels described in Finding 1, above, the CLEEN program has resulted in a number of technological advances that will reduce noise and emissions. For example, the GE Twin Annular Premixing Swirler (TAPS) II combustor, matured under the CLEEN program has entered into service in a CFM International engine. This engine is being used on the B-737 MAX and Airbus 320 aircraft. It reduces landing and takeoff emissions by 55 percent relative to current standards and reduces particulate matter by 90 percent relative to the current international visibility limit. In addition, government funding has been used effectively to lower the risk of new and emerging technologies such that they can be adopted by industry. The maturation of environmental technologies that deliver improved environmental performance allows aviation system growth and associated positive economic impacts.

Recommendation (2): The Subcommittee continues to endorse Public Private Partnerships like the CLEEN, CAAFI and ASCENT programs to leverage resources and recommends that FAA should continue to prioritize robust funding for these programs. The FAA should ensure that none of these programs are completely eliminated to enable the Agency to continue work on them, even if such work is at a reduced level.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation - The FAA supports the Administration's vision to maximize the impact of taxpayer dollars by improving the efficiency of federal programs through partnerships with industry and creating benefit for the American public. In Fiscal Year 2019, the FAA proposed a Research, Engineering & Development program focused on leveraging private sector innovation through partnerships with industry, academia, private sector, and other government agencies; coordinating Research & Development initiatives across federal agencies to maximize collaboration and avoid duplicate efforts; and continuing research in high priority technology and policy areas that promote innovation.

Finding: Noise Research - The Subcommittee realizes that there is much research that is still necessary to address the ongoing topic of aviation noise. There are increased noise complaints from individuals outside of the day-night noise level (DNL) of 65 dB. The increase in complaints is paired with an increase in public opposition which is resulting in growing political

pressure on the FAA as well as litigation in many areas, which is delaying NextGen Deployment. AEE has a number of 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 UAS that are larger than 55 pounds. AEE is also examining how to reduce the noise from commercial aircraft and helicopters through changes in operational procedures. Finally, AEE is working with industry to accelerate the development of technologies that reduce noise through the CLEEN Program.

Recommendation (3): The Subcommittee strongly supports the prioritization of the noise research that will support informed decision-making and enable NextGen Deployment. The FAA should therefore aggressively move forward with its research efforts to review and understand current community noise concerns and to take appropriate action when conclusions are reached.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation. - Noise is indeed a challenge for the aviation industry. We have been working for many years to better understand the issues and identify solutions that could help address it.

UAS, supersonic aircraft, and commercial space vehicles all present economic opportunities for the U.S. as well as potential concerns in terms of the environment, in particular noise. 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. 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 through continued innovation.

Finding: Global Leadership - Through the FAA's ability to influence the establishment of international standards at International Civil Aviation Organization (ICAO), the U.S. aviation industry has been able to maintain its competitiveness throughout the world. Examples of recent successes include the setting of a particulate matter standard and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Absent this leadership, there is a significant possibility that actions will be taken that are adverse to U.S. aviation interests and will place U.S. industries at a competitive disadvantage vis-à-vis their foreign counterparts. The Subcommittee therefore believes that maintaining the U.S. global leadership position at ICAO CAEP is essential. The draconian reduction in funding of approximately \$95 million (more than 50 percent) in 2019 and subsequent years drastically inhibits the FAA from being able to meet its goals and from being able to maintain current research or evaluate the impact of future entrants on the environment. Decreased funding will undoubtedly reduce the FAA's ability to respond to domestic needs, such as those regarding noise, and seriously jeopardize the U.S. global leadership position at International Civil Aviation Organization – Committee on Aviation Environmental Protection (ICAO-CAEP).

Recommendation (4): The Subcommittee recommends the prioritization of all research efforts/programs that will allow the FAA and the U.S. to maintain its current global leadership position at ICAO CAEP. It is the belief of the Subcommittee that if the FAA/U.S. does not

maintain its leadership position at ICAO CAEP, it will not be able to influence policy/rulemaking and this could have a significant negative impact on the U.S. aviation industry.

FAA Response: The FAA concurs with the Committee's finding and 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 the FAA to have robust participation in the ICAO CAEP process but also to develop modeling capabilities and the generation of data to support the decision-making process within ICAO CAEP. Efforts are also continuing in ICAO CAEP on supersonic aircraft. To be economically viable, these aircraft will need to be able to take off and land in other countries and this will require international agreements at ICAO CAEP. We have made considerable investments with the industry to develop an engine particulate matter (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.

Finding: Staffing - The Subcommittee is very supportive of the work that Office of Environment and Energy (AEE) does and believes that E&E is well managed and has a well balanced portfolio. The proposed budget cuts would require a reduction in staffing of approximately 50 percent. Staff will be required to maintain the same level of research to inform decision making and advance solutions such that the FAA can attain its goals. The loss of skilled staff could further delay the completion of critical projects. Sufficient financial and personnel resources are required.

Recommendation (5): The Subcommittee recommends the FAA place a high priority on filling staff vacancies to manage the E&E R&D portfolio and support the expanding workload within AEE.

FAA Response: The FAA appreciates the Committee's finding and recommendation: however, we are not able to pursue this recommendation at this time for the following reasons - The FAA understands the Subcommittee's concern about staff availability within the Office of Environment and Energy (AEE). We are in the process of executing a hiring plan that was developed in accordance with Administration guidance. AEE has been working with vacancies for 1/5 of their positions. 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. AEE have had good 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.

Subcommittee on Aircraft Safety

Finding: Research Prioritizations – The Subcommittee on Aircraft Safety (SAS) appreciates the FAA providing the opportunity to comment on the impacts of the proposed 2019 research budget reductions and notes the flexibility of the AVS staff to quickly provide the SAS with

requested insight into the 2019 financial planning. While it is not standard practice for SAS to comment on budget matters we did want to provide the “sense of the committee” as it relates to impacts from the FAA’s prioritization of items to be cut. We would encourage, in this limited funding environment, that the FAA consider not simply just deferring future or emerging issue research in favor of existing research but rather consider the pace of industry development in new technology and evolving areas. Overall we feel there has been a greater emphasis placed on continuing existing research versus investing in the future.

Recommendation (1): FAA should consider cancelling some of the ongoing research programs in favor of starting some focused work on the identified research priorities and emerging issues. By not investing in the future the FAA will not keep pace with industry and will be at risk of failing to serve the countries’ technology development needs.

FAA Response: The FAA concurs with the Committee’s recommendation to start some focused work on the identified research priorities and emerging issues and is undertaking the following actions to address its recommendation - The Aviation Safety portfolio development process focuses primarily on the FAA Safety outcome. The FAA is currently reviewing the process to improve it and better look forward and address emerging issues. The FAA will continue to provide the Subcommittee with status and rationale on funded/unfunded research in the portfolio to obtain feedback in identifying and detailing the emerging issues and how these are addressed in the current research projects.

Recommendation (2): In order for the SAS to be able to better provide input we recommend that FAA provide to the SAS:

- a. The programs, projects, and personnel being “deferred,” and an explanation of the process used to determine which research programs would be deferred.
- b. The impact of deferring the research and losing the personnel on aviation safety.
- c. The resulting complete waterline (or Mendoza) listing of all research programs

FAA Response: The FAA concurs with the Committee’s recommendation and is undertaking the following actions to address its recommendation(s) - Past Subcommittee meetings have included a presentation of the process for producing the Aviation Safety portfolio. Since it has been a few years, and a number of the Subcommittee members have changed, the FAA will provide a summary briefing on the process at the next meeting. The FAA will continue to provide the Subcommittee with status and rationale on deferred research in the portfolio to obtain feedback in identifying and detailing the pace of the new technology development in industry for the FAA to use in considering portfolio adjustments. The FAA does and will continue to provide the Subcommittee with the listing of the research proposals including the Mendoza Line.

Recommendation (3): The FAA is encouraged, in light of the 2019 R&D funding environment, to seek expanded opportunities for partnerships and collaboration with industry and other governmental organizations in support of certification and operation of systems incorporating emerging technologies.

FAA Response: The FAA concurs with the Committee’s recommendation and is undertaking the following actions to address its recommendation(s) - As shown in the program area document shared with the Subcommittee over the past 2 years, there are many partnerships and collaborations with industry, academia, and other governmental partners. The FAA continues to look for opportunities to leverage research from non-FAA partners in order to address the desired safety outcomes and appreciates the help of the Subcommittee members in identifying these opportunities.

Specific Comments by BLI

A.11.e – Continued Airworthiness - Proposed deferred activities include “Determine the safety of new electric aircraft”. The industry is moving forward with these products at a rapid pace supported by the convergence of technology advances in the field of electric propulsion and autonomous systems. Additionally the Research Engineering and Development Advisory Committee (REDAC), in recognition of this industry trends, has specifically tasked the SAS to stay abreast of electric aircraft technology including dispatch requirements, energy state management and battery protection schemes. The SAS is concerned that FAA may not keep pace with these developments and fall behind in their ability to support certification and regulatory efforts with these new aircraft.

A11.h – System Safety Management /Terminal Area Safety - The SAS notes that the items in this area related to Safety Oversight Management System and Integrated Domain Safety Risk Evaluation Tool are closely related to, and in support of, the SAS-identified emerging issue of Real Time System –Wide Safety Assurance. Additionally Real Time System-Wide Safety Assurance has been defined as one of NASA’s strategic thrusts. The SAS has been jointly briefed by NASA and FAA on the Research Transition Teams (RTT) related to this subject. There may be further collaboration opportunities between the FAA and NASA that will allow this important subject to proceed.

A.11.L – Unmanned Aircraft Systems Research - The 2019 budget identifies that \$73 million will be spent on UAS in the areas of Operations (\$51 million), Facilities (\$18 million), R&D (\$3.3 million) and Grant in Aid for airports (\$1 million). Any matching spending through the COE / ASSURE would be incremental to this plan. A continued lack of clarity on the overall UAS plan makes it difficult to assess if the RE&D spending will be meaningful in the context of the overall plan. Based on the stated scope of the 2019 research activities (Literature search and review in support of future regulation) it seems likely that the research activity will be overcome by the pace of “industry” development in the UAS space. At minimum, the research plan should be assessed in the broader context to assure that the research is timely and will add value to the overall effort.

A.11.J – Aeromedical Research - The SAS noted in the 2014 ‘emerging issues’ that, “Biomedical research is also needed to develop the psychological and physiological measures from the human operator that will inform the automation system,” and “... to ensure that automation on the flight deck and other safety critical applications is designed and implemented in a way to complement the strengths and weaknesses of the human operator.” Gene expression research, which feeds into biomonitoring technology, is currently deferred. Other physiological

monitoring research has not yet been planned. The SAS is concerned that the FAA will not be able to fund safety-related operator state monitoring research in the short- and long-term, leaving certification and regulatory issues lagging development in the commercial and government sectors. The projected reductions in spend and staffing at Civil Aeromedical Institute (CAMI) appear to be disproportionate and significant. Cuts of the magnitude proposed could result in the complete loss of capabilities that do not exist elsewhere. This is worthy of additional discussion within the FAA.

The SAS notes that several topics related to this “emerging issue” are cancelled in FY19 because of funding cuts; for example, a) Impact of BASICMED regulation on safety; 2) Gene expression research; and 3) Novel pharmacology research. To ensure defensible practices, FAA medical certification policies must keep pace with developments in science. The SAS is concerned that without funded aeromedical research in these areas, medical standards will fall far behind current medical practice, exposing the Agency to legal challenge and inflicting outdated medical standards on pilots.

A11.n – Commercial Space Transportation - While not a BLI responsibility area of the SAS we note that commercial space safety is a topic that we defined in 2014 as an emerging issue. We also note that there are deferred safety topics related to developing safety models to reduce overly conservative airspace restrictions for commercial aviation and developing and demonstrating innovative analysis to automatically declare aircraft hazard areas for launch/re-entry. This subject is impacting commercial aviation airspace today and with the planned growth to include many more space launch locations the impact is likely to grow. Also deferred is research into radiation hazards, which will leave unanswered questions about exposure limits for commercial space travelers. SAS believes this issue must be addressed in FAA planning, sooner rather than being deferred.

General Concerns Regarding Research Budget Cuts:

- a. Much of the deferred research is in-house labor and projects, meaning that the cuts will result in the loss of uniquely experienced FAA professionals who will be, in some cases, impossible to replace. There may be areas of research around the FAA that are extramural and much more able to pause/restart without significant disruption.
- b. CAMI and Technical Center experts are often international leaders in their field, and their loss will leave a void potentially affecting international policy and the national interest.
- c. Much of the deferred research capability is unique to the FAA, meaning that there is no alternative source for the expertise in the private sector or government. For example, the genomic research at CAMI, which is leveraged by the DOD, will be lost.
- d. It is noted that \$10M is planned to be spent on Cyber within the Office of the Secretary of Transportation. As this had been identified as an emerging issue by the SAS it would be worthwhile for the SAS to understand the extent to which this funding will be dedicated to safety related threat research.

Finding: Electric Aircraft Systems - The SAS was requested to consider electric aircraft systems to consider items such as dispatch requirements, energy state management and battery protection schemes. The SAS appreciates the presentation of a “Path to Electric and Hybrid / Electric Engine Regulation” as an initial topic in what is expected to be a much broader

conversation of electric aircraft systems. It was noted in this briefing that the FAA is currently involved in several industry committees in this regard. The current view of more electric aircraft or aircraft powered by electric or hybrid-electric propulsion systems is that there will be much more integration of these systems within the aircraft including propulsion systems providing primary flight controls in electrical virtual take-off and landing (e-VTOL) configurations. This will result in increasingly complex systems and systems of systems (ref 2014 SAS emerging issues) requiring alternate Verification and Validation (V&V) and certification compliance methods.

Recommendation (4): FAA should consider proactively developing a national plan or roadmap describing the research required in the area of electric aircraft systems safety to be better prepared for future applications of this technology.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation(s) - The aircraft industry has embraced the concept of the more electric or all electric aircraft. The greater use of electrical system is an enabling technology for more efficient combustion performance, electric propulsion, adaptive and more sensitive flight controls, and increased reliability over hydraulic and bleed air systems. The concept provides many benefits but like all new disruptive technologies comes with some risks.

This technology will require the coordination of several research teams, for example, Electrical systems, Propulsion, Flight Controls, Software Digital Systems and more. The FAA will provide a roadmap to guide and coordinate its research requirements by breaking it into 5 main research topics. The research road map will encompass:

- **Energy Generation**
 - 28VDC and 115 CF VAC are well known as established, however:
 - Higher voltages do not always have qualified components for distribution
 - Supplemental power devices (Fuel cell, Solar, Vibration)
 - One MW generators and beyond
- **Energy Storage**
 - Validation of risk and worst case (LI batteries) at the cell, module, and system level
 - Stored hydrogen and oxygen (in all forms)
 - Changes to storage and distribution using Super Capacitors charging and discharge
 - New materials
- **Electrical Power Distribution and Control**
 - Solid State moving to Primary Distribution
 - Regenerative power PWM
 - More reliance on micro controllers
 - Better maintenance data how to use it

- **Electrical Adapting Flight Controls**
 - Engines used as flight controls
 - Wireless controls
 - Learning and adapting algorithms
 - EMI for quick acting controllers
 - Control rules, man vs machine
- **Electric Propulsion & Powered Lift, Airplanes and Rotorcraft**
 - GA applications
 - UAS applications
 - Transport airplane applications
 - Air taxi implementations

Subcommittee on Airports

General Observations:

The Subcommittee felt that good progress had been made across the Program's portfolio of 19 research project areas (RPAs) as shown below.

Safety & Planning RPAs	Pavement RPAs
S1 Airport Planning & Design	P1 National Airport Pavement Testing Facility
S2 Airport Safety Data Mining	P2 National Airport Pavement Materials Research Center
S3 Aircraft Rescue & Firefighting	P3 Field Instrumentation & Testing
S4 Wildlife Hazard Mitigation	P4 Advanced Materials
S5 Visual Guidance	P5 Pavement Design & Evaluation
S6 Runway Surface Safety Technology	P6 Non-destructive Testing Technologies
S7 Airport Safety & Surveillance Sensors	P7 Software Program Development and Support
S9 Airport Research Taxiway	P8 Extended Pavement Life
S10 UAS Integration at Airports	
Airport Noise & Environmental RPAs*	New/Enhanced Facilities
N1 National Noise Survey	Fire Safety Building
N2 DNL & Metrics Evaluation	Pavement Lab Extension
N3 Sleep Disturbance	Photo Laboratory
N4 Noise Mitigation	
N5 Operations	
E1 Environmental Tools and Guidance	
* Airport noise and environmental RPAs are being co-managed by the FAA Offices of Airports and Energy & Environment.	

The Subcommittee remains supportive of the program's ongoing work and future research directions, which continue to emphasize foundational research to support (1) advisory circulars

and design guidance promulgated by the FAA Office of Airports, (2) airport infrastructure enhancements currently eligible or prospectively eligible for federal grant funding under the Airport Improvement Program, and (3) U.S leadership in areas of airport safety, planning, and infrastructure.

The Subcommittee agreed that all of its prior open recommendations from the spring and fall of 2017 can be closed presuming that the draft responses to them are approved by the FAA Acting Administrator.

The Subcommittee was alarmed by the drastic reduction in FAA Research and Development (R&D) funding that appeared in the White House's FY2019 budget. Although the Airport Technology Research Program would not be directly affected by these reductions—given that its funding is provided under the Airport Improvement Program, the drastic R&D funding cuts would have negative indirect impacts on the Airport program and significantly harm all of the FAA's other R&D programs. We are pleased that the Administration and the U.S. Congress decided followed a different course with passage of the Consolidated Appropriations Act of 2018 (Pub. L. No. 115-141), which did not include these cuts. We are hopeful for longer-term R&D funding stability via multi-year FAA reauthorization legislation.

Finding: Commercial Spaceport Standards - The Subcommittee is pleased that program staff have begun researching safety and design standards for commercial spaceports. We believe that this research should be coordinated with the recently-established and rapidly-moving commercial airspace aviation rulemaking committees (ARCs), principally the Spaceport Categorization ARC.

Recommendation (1): The Subcommittee recommends that the Airport Technology Research (ATR) Program staff coordinate with the Office of Airports to ensure that other FAA Stakeholders are aware of the ongoing ATR research project and that relevant information be shared with those stakeholders.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s) - The FAA's ATR will coordinate with the Office of Airports (ARP) to ensure awareness by other FAA stakeholders of ongoing spaceport-related research conducted by ATR. Appropriate and relevant information will be shared with other FAA stakeholders.

Finding: Future Research and Facilities Prioritizations - As was the case at our fall 2017 meeting, the Subcommittee placed a high priority on research into new categories of aeronautical vehicles--UAS and commercial space vehicles specifically--and their potential impacts on airport safety, operations, and infrastructure. Other high priority research areas are (1) pilot perception of light emitting diode (LED)-based airfield lighting systems (RPA S5), (2) aircraft rescue and firefighting (ARFF) agents (RPA S3), (3) runway incursion prevention technologies (RPA S1), and (4) noise standard development/refinement based on the Findings of ongoing noise annoyance data collection (RPAs N2-N5). In order to facilitate ARFF research and store valuable ARFF test equipment and vehicles, the Subcommittee also finds construction of the fire safety building to be a high priority.

Recommendation (2): The Subcommittee continues to recommend that the FAA Office of Airports place a high priority on research and facilities noted in Finding 2.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s) - The FAA's Office of Airports (ARP) is placing high priority on all the areas identified in Finding #2, and the FAA's Airport Technology Research Branch (ATR) initiated bidding for construction of the fire safety research facility at the Technical Center in the summer of 2018.

Finding: Collaborative Aircraft Braking Research - The Subcommittee remains pleased by the FAA's involvement of a Working Group of subject matter experts (SMEs) to reassess aircraft braking research. Given that the Working Group's efforts span multiple subcommittees' areas of expertise, it will be important to coordinate its work across relevant subcommittees.

Recommendation (3): The Subcommittee recommends that the Findings and proposed approach to future braking research developed by the Aircraft Braking Working Group be coordinated with relevant Subcommittees, namely Human Factors, Aircraft Safety, and NAS Operations. This coordination can take the form briefings to each of these Subcommittees at their Summer/Fall 2018 meetings if time permits.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s) - The FAA's ATR will coordinate with other Subcommittees to plan for in-depth briefings of the "white paper" that was developed by the Aircraft Braking Working Group in 2017-18. These in-depth briefings were presented at each requesting Subcommittee meetings, by a member of the working group, beginning in the summer of 2018.

Finding: Trapezoidal Runway Grooving - The Subcommittee understands that safety, technical, and operational issues may preclude effective testing of trapezoidal runway grooving in a worn configuration (e.g., grooving "worn" to a half-depth condition) at Atlantic City International Airport. These issues, which include challenges in getting the Tech Center's B727 aircraft braking test bed to a high enough speed to appropriately simulate landing aircraft braking performance, concerns on the part of the airport operator that half-depth grooving could compromise actual aircraft landing performance, and limited test durations driven by these concerns.

Recommendation (4): The Subcommittee recommends that the FAA reconsider ways in which the performance of worn trapezoidal grooves—both in terms of drainage and effects on aircraft braking—can be evaluated, including through cooperation with other countries' Civil Aviation Authorities where trapezoidal grooves have been installed on active runways (e.g., Singapore).

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s) - The FAA's ATR will research and propose alternate ways to study the performance of worn trapezoidal grooves to ARP. Decisions on how to proceed will be made in coordination with ARP.

Finding: National Airport Pavement Testing Facility - The National Airport Pavement Testing Facility (NAPTF) in Atlantic City, a proven national aviation asset, requires maintenance investments - specifically a roof replacement--to ensure its continuing functionality.

Recommendation (5): The Subcommittee recommends moving forward with plans to replace the roof of the NAPTF as soon as practicable.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation(s) - Over the course of two fiscal years (FY 2018 and FY 2019), the FAA's ATR will be installing a heavy duty elastomeric acrylic coating on the whole length of the National Airport Pavement Testing Facility (NAPTF) roof. This added coating, together with a new lightning protection system, will effectively permit the existing roof to function as a new roof.

Subcommittee on NAS Operations

General Observation:

During the spring 2018 NAS Operations REDAC meeting, the Subcommittee was briefed by the Office of Commercial Space Transportation (AST) on the FY 2020 proposed portfolio for Budget Line A.11N Commercial Space Transportation (CST). AST regulates the civil, military, and commercial sectors of the space program to ensure the protection of the public, property and national security and to encourage, facilitate, and promote U.S. commercial space transportation.

This R&D portfolio addresses four research areas: (1) traffic management and spaceport operations, (2) space transportation vehicles, (3) human spaceflight, and (4) industry viability.

Within the first research area, the program places an emphasis on safety to the public through effective airspace integration and spaceport interoperability, which is accomplished through the use of models and predictive capabilities, mission planning tools, regulations, and safety analysis. The research area assumes an integration of space traffic into NAS operations through the use of trajectory-based operations (TBO) automation and procedures.

Finding: Commercial Space Transportation - Today's Commercial Space Traffic (CST) operation is based primarily on airspace segregation and has significant impact to airspace use by other NAS users. The feasibility applying future trajectory based operations (TBO) automation applications as the primary way to integrate commercial space operations into the NAS is unknown and requires careful study the extension of TBO methods for CST requires an understanding of the ramification of space operations to all NAS users.

Recommendation (1): The NAS Operations Subcommittee recommends that scheduling and causal factor analysis to all NAS operations be included to the research and development portfolio. Further given the number of space ports that are under the certification process and the forecast of demand for increased number of launches, analysis is needed before an assumption that TBO will mitigate CST on the NAS.

FAA Response: The FAA concurs with the Committee's finding and is undertaking the following actions to address its recommendation - The FAA Office of Commercial Space Transportation appreciates the opportunity to respond to the findings and recommendations of

the REDAC Subcommittee on NAS Operations as detailed in the June 20, 2018, memo. Given that the Commercial Space Transportation industry is growing at an extremely rapid pace, it is an area that lends itself to insight from other parts of the aerospace community and we welcome the spirit in which the Subcommittee has assessed AST's research program. That said, we also believe the research approach for Commercial Space Transportation is somewhat unique from commercial aviation research due to (1) the relative newness of the industry, (2) the more limited sources of research expertise, and (3) the technologies being employed by the industry. For these reasons we offer the following for consideration:

With respect to the recommendation that "scheduling and causal factor analysis to all NAS operations be included to the research and development portfolio," and that "analysis is needed before an assumption that TBO will mitigate CST on the NAS," AST agrees that TBO methods, including scheduling and causal factor analyses of the impact of commercial space on NAS operations, needs to be increased. Some research in this domain has been conducted to date (e.g., the Stanford 4-D special use airspace research tasks under the supervision of Drs. Juan Alonso and Mykel Kochenderfer). AST will make efforts to increase the resources dedicated to this topic. AST particularly seeks to collaborate with ATO on this subject. AST welcomes the opportunity to discuss any of these issues directly with the Subcommittee.

General Observation:

The NAS OPS Subcommittee was briefed on the ATDP project at its March 2018 meeting. The Subcommittee has, over the past, been extremely interested in FAA work in this area and has always been of the view that this work is critically important. The Subcommittee believes that insufficient work in operational concept development and validation significantly increases the risk of operational problems after implementation. Since the budget for such work was moved from the NEXTGEN Office (ANG) to the ATO there has been an increase in concept development and validation focus on projects closer to implementation. When this shift occurred, we were told that work on concept development in earlier stages of R&D would be done by ANG portfolio managers.

Finding: ATDP - Operations Concept Development and Infrastructure (BLI 1A01C)

The ATDP presentation did not address how FAA decides which concepts will be studied with the limited ATDP budget. It was not clear what criteria are used to select and to prioritize concepts for concept development and validation.

Recommendation (2): The FAA should develop clear criteria for selecting and prioritizing concepts to be evaluated. They should identify potential implementation risks for concepts that are not selected for study or concepts that are subjected to only limited validation.

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation(s) - The Committee's finding was that the material provided along with the ensuing discussion did not address how FAA decides which concepts will be studied with the limited ATDP budget. It was not clear what criteria are used in selecting and prioritizing concepts for concept development and validation.

Over the last two years, ANG and the ATO have developed and implemented a Concepts, Validation and Requirements process that is now being used to select projects to be addressed with the limited ATDP budget. With the CVR process, NextGen develops concepts with AJV-7 validation for NextGen capabilities and AJV-7 creates concepts from the operational community not already being addressed by a NextGen capability. Through this process, the operational community can submit areas of concern and/or operational needs that may actually be pointing to operational or integration risks associated with future concepts. Those needs will be prioritized by the CVR Directors Forum and if found to be an operational priority, and if no other funding exists to address them, the activity will be funded out of the ATDP budget. AJV-7 would be happy to provide an overview of the Concepts, Validation and Requirements process at the next quarterly Committee meeting.

General Observation:

At its spring 2018 meeting, the NAS Operations Subcommittee appreciated the opportunity to review the FY2020 proposed portfolio for A11.i Air Traffic Control / Technical Operations Human Factors. This program addresses R&D needs in five focus areas: Human Factors Standards; Workforce Optimization; Improved Safety; Human Factors in NAS Technology Integration; and Human Performance Enhancement.

Maintaining an effective air traffic controller workforce is critical toward ensuring the continued safety of the NAS and enabling increased efficiencies capitalizing on NextGen investments and future concepts such as Trajectory Based Operations (TBO). The importance and challenge of workforce stewardship has also been raised recently in forums including the RTCA NextGen Advisory Committee.

The NAS Operations Subcommittee notes that in addition to tactical air traffic control functions, strategic traffic flow management (TFM) is also a critical component of NAS efficiency. Without effective TFM, traffic flows may be mismatched against available capacity, leading to significant delays, congestion, and additional workload for tactical controllers. The skills needed to perform effective TFM are different than those typically required for tactical control, with the former tending to involve longer-term strategic collaborative decision-making under significant uncertainty and without immediate feedback on the outcome of the decisions that are made. The evolution toward TBO will necessarily shift the type of TFM information, procedures, collaborations, and decisions that are required, necessitating a corresponding evolution in TFM workforce training and skills.

Finding: NextGen ATC/TechOps Human Factors - The current A11.i portfolio and proposed R&D roadmap focuses solely on tactical air traffic control and technical operations personnel. The portfolio does not include any research requirements related to strategic TFM Human Factors issues. In contrast, the NAS Operations Subcommittee finds that there are significant Human Factors R&D requirements specific to TFM involving Human Factors Standards, Workforce Optimization, NAS Technology Integration, and Human Performance Enhancement. Absent any R&D investment addressing these issues, the TFM workforce will continue to have significant challenges both in today's environment as well as when transitioning toward TBO, jeopardizing the expected benefits possible from new technologies and procedures.

Recommendation (3): The NAS Operations Subcommittee recommends that TFM workforce Human Factors considerations be directly included in future R&D portfolio planning.

Representatives from the TFM stakeholder community should be included in the ATO R&D Requirements Roundtable and research requirements specific to the TFM workforce should be identified and included in the planning process. These requirements should consider both the current Traffic Flow Management (TFM) environment as well as the planned evolution of systems including Traffic Flow Management System (TFMS), Time Based Flow Management (TBFM), Traffic Flow Data Management (TFDM) and the transition to Trajectory-Based Operations (TBO).

FAA Response: The FAA concurs with the Committee's finding and recommendation and is undertaking the following actions to address its recommendation - The FAA's Research & Development prioritization process includes reviewing its complete R&D portfolio, including the areas recommended by the Subcommittee. The FAA Human Factors Division concurs that Traffic Flow Management (TFM) is a critical workforce consideration, particularly as NAS operations shift to Trajectory-Based Operations (TBO).

The FAA has planned NextGen F&E FY 2019 and FY 2020-funded research that specifically addresses TFM Human Factors, as well as additional TBO HF research that is relevant to the TFM workforce. The FAA will present the planned research activities at the next Subcommittee meeting, as well as present any changes to the ATO Human Factors Roundtable process to ensure TFM stakeholders are represented. The FAA will continue to provide the Subcommittee with status and rationale on the portfolio priorities for funded research in order to obtain feedback on areas requiring reconsideration.