U.S. Department
of Transportation

**Federal Aviation
Administration**

Office of the Administrator

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

November 6, 2015

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 Research, Engineering and Development Advisory Committee for your May 28 letter providing recommendations on the Fiscal Year 2017 Research and Development (R&D) portfolio.

I have reviewed your recommendations and enclosed are the responses to the various Subcommittee recommendations.

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

Sincerely,

Michael P. Huerta
Administrator

Enclosure

FAA Response to REDAC Recommendations for the Fiscal Year (FY) 2017 Research and Development (R&D) Portfolio

Subcommittee on Environment and Energy

Finding: Noise Complaints Increasing - Noise continues to be the number one source of environmental complaints for the Federal Aviation Administration (FAA). Complaints about helicopter noise in North Shore (NYC) and Los Angeles have been challenges. Airport neighborhoods around Chicago O'Hare have also seen an increase in the number of noise complaints.

Recommendation (1): FAA Office of Environment and Energy (AEE) is encouraged to continue with data-driven decisions in responding to these complaints. The subcommittee recommends the FAA both complete the development of the noise research roadmap and implement elements that would generate the data needed to support these decisions. This includes evaluations to see if changes are warranted to the definition of noise significance.

FAA Response: The FAA is grateful for the subcommittee's continued support of our Noise Research Roadmap as it will provide data for future noise policy considerations. We are using funds, within our resources constraints, and leveraging resources from across the Agency and other U.S. Government agencies to ensure it is successful. The national community noise survey, being done in collaboration with our Airports Office, is a central component of this effort, and we look forward to starting the data collection now that we have the Office of Management and Budget approval. In addition, we continue to advance our understanding on the impacts of noise on sleep, health, and children's learning as these data will complement the knowledge gained from the national community noise survey.

Finding: Noise Challenges with PBN Implementation - More recently, the number of noise complaints increased significantly at Phoenix airport after the implementation of Performance Based Navigation (PBN) operational procedures that improve efficiency and capacity. Noise is becoming a challenge in the successful implementation of these efficient operational procedures which are a critical element of NextGen.

Recommendation (2): The subcommittee recommends that the FAA support studies to determine if there are appropriate supplemental noise metrics that are a better predictor of community reaction in neighborhoods that have not previously experienced noise and are now experiencing noise from PBN. FAA Office of Environment and Energy (AEE) and FAA Air Traffic Organization (ATO) should work together, share lessons learned from PBN implementations and determine what near-term research actions (including ways to examine

community outreach and airport engagement) may increase the success of future PBN implementations.

FAA Response: The FAA agrees that we should examine supplemental metrics, and we are currently researching the implementation of PBN around three airports with varied community reactions. AEE and ATO will continue to work together, share lessons learned, and collaborate on near-term research to increase the success of future PBN implementations. Airports, AEE and Office of NextGen (ANG) are collaborating to develop research projects using FY 2016 funds that could also increase the success of future PBN implementations. AEE, ATO, and others within the Agency are working together on multiple efforts to address community concerns and share lessons learned.

Finding: FAA-AEE and FAA-ATO Working Together - FAA has been very responsive to the requests of the Subcommittee for briefings on specific topics. A manager from FAA-ATO participated in this Subcommittee meeting and shared the metroplex procedures development process for improved operational efficiency and how environmental assessment is included in the process.

Recommendation (3): The Subcommittee recommends continued cooperation between FAA-AEE and FAA-ATO including integration of environmental assessment tools to enable early and rapid assessments of new operational procedures. The Subcommittee also requests that FAA-ATO continue participation in future Environment and Energy Subcommittee meetings.

FAA Response: AEE, ANG, and ATO are working together to develop an Aviation Environment Design Tool (AEDT2b) plug-in for the Terminal Area Route Generation and Traffic Simulation (TARGETS) tool, which is used for the design, analysis, and operational assessment of procedures and airspace. This new plug-in would replace the existing AEDT2a plug-in that is currently in place in TARGETS for procedure design. As requested, ATO will continue to participate in the Environment and Energy Subcommittee meetings.

Finding: F&E Funding Reductions Impacting Plans - Funding reductions in FY15 and FY16 is impacting operational procedures research and development, AEDT2b deployment, NextGen Environmental Management System deployment, alternative jet fuel testing and analysis, Continuous Lower Energy, Emissions and Noise (CLEEN) technology maturation, and climate research. The Subcommittee is pleased to see that the CLEEN-I program is delivering technologies with high readiness level that are ready for entry into service. With the National Aeronautics and Space Administration (NASA) Environmentally Responsible Aviation (ERA) program ending this year, CLEEN is the primary program to mature environmental technologies in the United States.

Recommendations (4): The Subcommittee emphasizes that several of these tasks (like operational procedures research and development and AEDT2b) have significant near term benefit and recommends restoring the necessary funds to make these tasks successful. The

Subcommittee recommends that FAA continue support of the Continuous Lower Energy, Emissions and Noise (CLEEN) program leveraged by industry cost sharing. We support above target funding request for the CLEEN program and alternative jet fuel testing and analysis. The need to better assess the impact of aviation emissions on climate should also be considered in the research planning process.

FAA Response: The FAA agrees that the improvements in operational procedures and the development of aviation environmental tools, such as AEDT2b provide significant benefits. The reduction in the Facilities and Equipment (F&E) budget has slowed the pace of NextGen implementation and with that the emphasis and pace of pre-implementation activities.

The Agency appreciates the Subcommittee's support of the CLEEN program. The FAA is very pleased that industry has exceeded the 100 percent cost share requirement for the CLEEN program. We continue to prepare for a second round of CLEEN and anticipate that awards will be announced in 2015. The CLEEN program continues to be one of our top priorities as is our work to advance alternative jet fuels, which happens through CLEEN, the Commercial Aviation Alternative Fuels Initiative and the Aviation Sustainability Center (ASCENT), the FAA Center of Excellence for Alternative Jet Fuel and Environment. As recommended by the Subcommittee, we are pursuing the FY 2017 above target request for the CLEEN program through the budgetary process.

Finding: Aviation Sustainability Center of Excellence (ASCENT) Functioning Efficiently - The Subcommittee recognizes that FAA-AEE has set up the Aviation Sustainability Center of Excellence (ASCENT) projects (including those related to alternate fuels development) with rapid yet smooth transition from the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) Center of Excellence.

Recommendation (5): The Subcommittee encourages FAA to continue to define ASCENT Center of Excellence tasks based on needs and gaps in the FAA environmental research roadmaps.

FAA Response: The FAA appreciates the Subcommittee's recognition that the transition from PARTNER to ASCENT has been smooth. The FAA intends to continue to leverage the capabilities of ASCENT to advance our understanding of the impacts of aviation on the environment and to support our efforts to develop sustainable alternative jet fuels for the aviation industry.

Finding: U.S Leadership in International Civil Aviation Organization/Committee on Aviation Environmental Protection (ICAO / CAEP) Is Essential - United States leadership in the ICAO / CAEP process continues to be an important priority.

Recommendation (6): In order to maintain leadership in the CAEP process, the Subcommittee recommends that FAA continue to prioritize the development / enhancement of tools and data needed to guide the development of policy and standards. We also endorse the inclusion of a Global Market Based Measure (GMBM) as one option in a basket of options for improved environmental performance and encourage the FAA to support analysis to inform the design of the GMBM.

FAA Response: The FAA agrees that continued development of our modeling capabilities and the generation of data to support the decisionmaking process are required for the United States to maintain its leadership in ICAO/CAEP. Robust funding is also required to ensure that we effectively engage in the ICAO/CAEP process. The progress on the CO_2 emissions and Particulate Matter standards are the direct result of many years of investment. The FAA continues to devote substantial resources to inform the design of the Global Market Based Measure as it has the potential to act as a "gap-filler" to complement CO_2 emissions reductions achieved from the development of new technology, operational improvements, and the development and deployment of sustainable alternative fuels.

Finding: ICAO CO_2 Standard Development is Progressing Well - The ICAO/CAEP CO_2 standard development effort is going well (with the FAA Environment & Energy R&D program providing the necessary analysis tools) and it is expected that a standard will be established at the CAEP Steering Group meeting in February 2016. For the United States to adopt this standard as a regulation, the EPA and the FAA will need to work together.

Recommendation (7): FAA should invite the Environmental Protection Agency (EPA) to the next Research, Engineering and Development Advisory Committee (REDAC) E&E Subcommittee meeting in August 2015 and participate in the discussion on the CO_2 standard progress and plans.

FAA Response: The FAA has invited EPA to participate in the August 2015 E&E Subcommittee meeting, however, representatives were unable to attend. The FAA will continue to request EPA participation at future meetings.

Subcommittee on NAS Operations

Background: The Subcommittee is pleased to observe that the briefings it received on the FAA research program had a stronger focus on how research objectives are related to the delivery of benefits to the National Airspace System (NAS). Two specific examples were noted by the Subcommittee: Data Visualization Analysis and Reporting System (DVARS) and NextGen Wake Turbulence/Wake Re-Categorization (Re-Cat).

DVARS provides a data processing capability that adds significant value to the analysis required for the development of 4D trajectory-based operations, in particular, for the verification and validation of trajectory models. The DVARS data architecture concept is well aligned with the global transition toward net-centric technologies. Because of this, the system provides a foundation for scalability for example, for "the rest of the airspace" (that is, for airspace and airports not currently provided with FAA surveillance). As the Subcommittee and the full REDAC has previously noted, the expansion of the quantity and quality of data from systems like DVARS exemplify the need for FAA to vigorously pursue an efficient governance process to make this data available to qualified users.

In recent years, the FAA has focused its wake turbulence research on the development and validation of new procedures and separation standards that have delivered substantial benefit to airspace users. The Subcommittee is pleased that the FAA has responded to its recommendation to continue the implementation of Re-Cat Phase I and notes that its plans for Phase II and III appear sound and well-focused on the delivery of operational benefits and international harmonization.

For several years, the REDAC has urged the FAA to develop a more strategic view of its R&D and use it to identify and prioritize research areas. In 2013, the Subcommittee observed some willingness on the part of FAA to do this as reflected in its stated commitment: "to develop a more strategic, forward looking process, so that there will be an integrated Agency-wide view of R&D." During its August 2014 meeting, in response to the FAA's request, the Subcommittee devoted significant time to the identification of research opportunities and issues as a first step in this process. It is not clear to the Subcommittee, however, how or if the FAA will make use of this input or whether it will make significant progress toward its stated commitment. The Subcommittee continues to stand ready to assist.

Finding: 4D Trajectory Based Operations (4D TBO) - The FAA provided a briefing on its recently-published TBO Concept of Operations during the Subcommittee's March 2015 meeting. The Subcommittee notes that, from the perspective of NAS operations, the development and validation of 4D TBO in all NAS domains is of critical importance to delivering benefits to airspace users. There are a number of significant research questions that must be answered in order to achieve the benefits of 4D TBO, among them:

- What is the transition path from near-term NextGen capabilities to the 4D TBO operations envisioned in the Concept of Operations?

- What is the system design required to achieve resilience of operations, including failure detection and recovery?

- What is the allocation of responsibility between flight deck and ground personnel during nominal and off-nominal operations?

- What is the role of humans and automation on the ground and on the flight deck during nominal and off-nominal operations?

- How will 4D TBO operations be optimized to ensure fairness across airspace users while meeting user objectives?

- How will Unmanned Aircraft Systems (UAS) and General Aviation airspace users be accommodated in 4D TBO operations?

Recommendation (1): 4D Trajectory Based Operations (4D TBO)

The Subcommittee recommends that the FAA expand upon its TBO Concept of Operations to define the transition path (at the conceptual level) and the associated research objectives as a first step toward defining a coherent research program to refine and validate the TBO concepts. The Subcommittee recommends that the FAA provide an update on this process during its August 2015 meeting so that it can provide recommendations for a strategic research agenda for TBO implementation in 2025 and beyond.

FAA Response: The FAA presented an updated briefing on 4D TBO Concept of Operations at the Subcommittee meeting in August 2015. Although the FAA agrees in principle with the Subcommittee's recommendation and findings, we believe that current FAA documents support the transition path for the 4D TBO concept.

FAA plans to deliver operations that are consistent with the 4D TBO Concept of Operations. The operations will also align with investments and capabilities specified in the FAA Enterprise Architecture and NAS Segment Implementation Plan and will outline the path to implementation. Additional concepts such as Aircraft Access to SWIM and Optimize Route Coordinator will compliment 4D TBO operations and enhance the ability for operators and air traffic to strategically plan and coordinate changes of 4D trajectories.

The FAA's current concept does not change allocations of responsibility between flight deck and ground personnel. Those functions will continue to operate as they currently do. However, the FAA's concept is fully supportive of new entrants and evolving General Aviation technology.

We hope that the briefing we provided in August answered your questions and clearly outline our plan for research and delivery of 4D TBO operations in the NAS.

Subcommittee on Airports

Finding: Airport Planning (RPD 132) - The Subcommittee generally accepts and supports the Airport Technologies Program's FY 2017 budget. However, research needs identified by FAA staff in the field of Airport Planning (RPD 132) appear to exceed the amount allocated to this research project area. These identified needs include modernizing the FAA's Runway Exit Design Interactive Model (REDIM), research to support improved FAA guidance regarding critical design aircraft designations, and developing training and guidance materials to support the FAA's new runway simulator model.

Recommendation (1): The Subcommittee recommends that the FAA review the RPD 132 budget and determine if sufficient funding exists to meet FY 2017 needs as well as if ongoing planning projects need to be reprioritized in light of new planning research needs.

FAA Response: The FAA concurs with the recommendation. Work performed under RPD 132 will be reviewed and integrated with other Airport Planning work conducted under RPD 139. These two RPDs and the associated funding will be combined under the header of an "Airport Planning" Research program area. This new RPA will be the primary vehicle to conduct airport planning research. Prior to FY 2017, the FAA's Airport Technology Research Branch will work closely with the FAA's Airports Planning Office to review and if needed, reprioritize the various planning research projects.

Finding: Airport Technologies Research Program (RPD 157) - Although the Subcommittee supports many of the proposals for new environmental research projects that will be funded within the Airport Technologies Research Program (RPD 157), we note that both safety and capacity must be considered included when assessing new types of noise mitigation techniques that can be applied to flight procedures, particularly higher glide slope approaches, delayed deceleration approaches, and the use of displaced arrival thresholds for noise abatement. Safety and operational risk assessments should be integral to the assessment of all of these techniques. Such assessments should involve subject matter experts from the pilot, air traffic, flight standards, and airport operator perspectives.

Recommendation (2): The Subcommittee recommends that the FAA take steps to incorporate safety and capacity assessments into the RPD 157 research program as well as better define how the aforementioned perspectives from the pilot, air traffic, flight standards and airport operator communities will be incorporated into its research plan.

FAA Response: The FAA concurs with this recommendation and will take the necessary steps to consider safety and capacity when conducting environmental research. The goal of the noise mitigation research is to find balance between noise and efficiency. Representatives from the applicable offices will be involved throughout the research phases. The research will entail working with other FAA lines of business and subjects matter experts to conduct safety and

operational risk assessments for each operation identified to be preferable for community noise purposes, while maintaining flight procedure efficiency. A second layer of safety and capacity assessments will also be performed by the Airport Planning Research Area.

Finding: Low Cost Ground Surveillance Systems (LCGSS) - The Subcommittee appreciates that the proof of concept work associated with the Low Cost Ground Surveillance Systems (LCGSS), particularly the optical surveillance system that has been pilot tested at Seattle-Tacoma International Airport. However, given the ongoing development of alternative surface surveillance systems, continuing reductions in the costs associated with Automated Dependent Surveillance-Broadcast (ADS-B) transponders, and the oncoming 2020 ADS-B equipage deadline, the Subcommittee is interested in understanding the role LCGSS are likely to play at airports if and when they are available for implementation before significant additional research into these systems is conducted.

Recommendation (3): The subcommittee recommends that branch staff develop a concept of operations that defines the roles and applications of the LCGSS in the National Air Transportation System given other surface surveillance programs and technology deployments that are underway, particularly surface surveillance systems that rely on ADS-B technology. The concept of operations should consider what unique capabilities or deployment opportunities would exist for LCGSS as well as those capabilities that are likely be duplicated by ADS-B based surface surveillance systems.

FAA Response: The FAA concurs with the recommendation. A Concept of Operations document for LCGSS will be prepared that will provide a description of LCGSS systems and their detailed role in enabling enhancements to the safety, operations, and surveillance capacity of airports. The description of the role of LCGSS will take into account the heterogeneous and evolving situation with respect to available surface surveillance technologies, the coincidence with Automatic Dependent Surveillance –Broadcast (ADS-B) systems, and interface with legacy surveillance systems. LCGSS will be considered as an independent system, for small to mid-sized airports and as a complementary system to existing surveillance systems at larger airports.

Finding: Aircraft Braking Friction (RPD 147) - The Subcommittee continues to be pleased by the progress branch staff is making to manage risks and reduce uncertainties associated with RPD 147, Aircraft Braking Friction. These efforts include addressing safety issues associated with the test aircraft, enhancing the test aircraft's braking systems to better represent those currently in use, and securing the services of a highly qualified test pilot. Branch staff have responded positively to the Subcommittee concerns about the project and the Subcommittee believes the branch to be in a good position to collect high quality data in early FY 2016.

Subcommittee on Human Factors

Background: The Subcommittee met February 24-26, at Wright-Patterson AFB in Dayton, Ohio. The group received updates on Human Factors (HF) and Engineering, Human Factors Research Processes, ANG Human Factors Action Items, and reviewed progress on past Findings, Recommendations, and Action Items. The primary thrust of this meeting was to review and assess the FY 17 FAA Human Factors budget. In addition, the Subcommittee toured the Air Force Research Laboratory in specific areas of autonomy and neuroscience efforts. Specific Findings and Recommendations are below.

Finding: Unmanned Aircraft Systems (UAS) Human Factors Research - The HF Subcommittee is concerned that HF research is not receiving the appropriate priority in UAS research programs. Even though there is current and planned research on UAS ground station design, we are concerned that it is insufficient and will result in being late to address future regulatory and standardization needs.

Recommendation (1): The FAA should review the HF activities within its UAS research portfolio to ensure it is sufficient and timely to address appropriate research for operator stations and terminal operations.

FAA Response: The FAA recognizes the importance of HF research to promote the safe integration of UAS in the NAS. Quarterly program reviews include an evaluation of the HF research being conducted in coordination with the UAS Integration Office (AFS-80), the UAS Airworthiness Section (AFS-86), the UAS Research and Development Section (AFS-88), and Unmanned Aircraft Systems R&D Portfolio Branch (ANG-C21). In addition the FAA has appointed an Air Traffic Organization UAS Lead who also reviews the HF activities.

Finding: Air Traffic Control (ATC) Tech Ops Core Program - The Subcommittee identified a significant risk area within the 2017 ATC/Tech Ops Core program research portfolio due to a lack of sustained research efforts past 2016 in some specific areas of training and safety. The Subcommittee observed that there is a lack of required research to provide guidance and new capabilities to: 1) implement practical Human Systems Integration (HSI) within the FAA Air Traffic Control (ATC) acquisition process; 2) implement efficient and effective safety analysis from a human performance perspective; 3) and continue development of tools that support the identification, classification and detection of ATC risks and associated mitigation strategies. This builds increased risk into the system as the training burden is increased for poorly implemented systems where the hardware (H/W) and software (S/W) components are emphasized with insufficient consideration for Human Systems Integration (HSI). Time and again, significant savings in system implementation and training, as well as enhanced safety, has been demonstrated where HSI was incorporated into the design, implementation process, and

adequate human performance safety assessments. With little or no research in this area, the FAA is creating unnecessary risk in Air Traffic Control (ATC) operations.

Recommendation (2): Create a research portfolio under ATC/Tech Ops Core program that achieves the following:

- Generation and incremental revisions of training requirements and standards,
- Development of an ATC critical incident analysis capability,
- Development of an early warning tool for consideration of human performance in ATC related safety reports,
- Development of a safety tool to augment the Risk Analysis Process developed jointly by ATO/EUROCONTROL—the objective of this safety tool would be to consider human performance in the risk analysis events process.

FAA Response: The FAA agrees that additional Research, Engineering and Development (RE&D) investment is needed to support the development of guidance and integration of human factors within the FAA ATC system acquisition process. Using in-house resources, our current efforts involve briefing new program managers on the role of human factors in the Acquisition Management System Lifecycle and introduce them to the key HSI artifacts that are expected to be developed. We also continue to provide human factors oversight of system acquisition programs through the mandatory In-Service Review Checklist items. Beginning in FY 2016, we plan to continue to leverage in-house human factors expertise at the Civil Aerospace Medical Institute (CAMI) and the William J. Hughes Technical Center (WJHTC) to support extension of our existing job/task database to support improved training requirements and standards. Ongoing safety-related research is harmonizing current ATC and Technical Operations human error taxonomies with those of EUROCONTROL and enhancing training that is given to investigators who will apply these taxonomies to determine root causes, trends, and develop recommended mitigations. Future work in this area (beyond FY 2016) may be curtailed due to the anticipated reduced level of program funding, although we are working to maintain core competencies in the areas of human error taxonomy development and risk assessment methods.

Finding: TRACON Developmental Training - The Subcommittee was pleased to learn that the HF ATC group was called upon to help solve the low through-put of controller candidates being trained at the New York TRACON. The Human Factors (HF) team has proposed a solution that will create more effective and efficient training methods, including training standards for the New York TRACON, which promise to increase the training through-put and increase the number of qualified controllers. The amount of resources required to achieve this goal is at a critical level and hence the outcome may be at risk. There also needs to be sufficient data

collection once implemented to ensure that the new methods and standards are efficient and effective.

Recommendation (3): Ensure adequate research is performed to measure the effectiveness of the new methods and tools at the New York TRACON. Then, once the tools and methods have been proven at the New York TRACON, conduct the needed Research, Engineering and Development (RE&D) to ensure that these can be successfully employed at other high density TRACONs.

FAA Response: ANG-C1 is currently working with N90 to determine the best method for getting the training standards validated and the On the Job Training Instructors, Front Line Managers, and trainees trained on the implementation of the standards. ANG-C1 is also exploring the best method for measuring the effectiveness of the overall effort, including numerous workshops, training sessions, and standards development. The FAA recognizes that we must have sufficient RE&D to demonstrate the success of the program at N90 to support any future discussions about broader use of the program and the provable benefits

Finding: Operational Concepts and Design - Significant improvements in throughput, operational efficiency, and overall system performance while maintaining the highest level of safety, are expected from the implementation of NextGen operational concepts. In order to be successfully implemented, it is critical to consider human factors issues throughout the concept exploration, design and implementation process. One such area is the focus on the operational concepts and designs associated with Performance Based Navigation (PBN) and advanced techniques for separation assurance.

In support of the implementation of these operational concepts and designs, important HF work has been conducted focusing on the design, presentation, and implementation of associated new flight deck procedures, providing significant insights into the factors that affect procedure complexity and the effective use of automated flight-path management systems to deal with the precise speed, altitude, and lateral path constraints fundamental to the application of PBN.

Continuation of HF work focusing on the design and implementation of effective flight deck procedures for PBN is necessary to help ensure that the safety and efficiency goals of PBN are achieved. This flight deck research needs to be complemented with human factors work focusing on the successful design, adoption, implementation and evaluation of PBN in the performance of Air Traffic Control (ATC), Traffic Flow Management (TFM) and Flight Operations Control (dispatch) tasks. This coverage is important in order to ensure an effective overall human-centered approach to system integration.

Recommendation (4):

- Continue to pursue Human Factors (HF) work focusing on the design and implementation of effective flight deck procedures for PBN, and on the associated implications for the design of automated flight-path management systems,
- Complement this flight deck focused work with studies concerned with the HF issues that impact the successful design, adoption, implementation and evaluation of PBN in the performance of ATC, Traffic Flow Management (TFM) and Flight Operations Control (dispatch) tasks,
- Ensure that this work is completed in a cohesive collaborative manner that provides guidelines grounded on an integrated systems perspective,
- Provide a status briefing to the REDAC Human Factors Subcommittee on plans to accomplish this work.

FAA Response: The FAA concurs that PBN human factors work is a critical element of successful implementation of these new procedures. Human factors work continues in the investigation of the factors that contribute to perceived PBN procedure complexity and identifying areas for enhancing the design of PBN procedures to reduce and mitigate the potential for confusion and Flight Management System programming challenges. Additional human factors research is evaluating the potential benefit of adding a "briefing strip" to Area Navigation (RNAV) arrivals and departures to facilitate flightcrew coordination and situation awareness during execution of the procedure.

ANG-C1 will complement the Flight Deck research and analyses work around PBN procedures complexity in focusing on human factors aspects associated with the performance of the Air Traffic Controllers, Traffic Flow Managers, Facility Managers, and Airline Operations Centers by analyzing PBN operational data collected during the design and evaluation phases, and also after the deployment of such procedures. Work is being planned to collect lessons learned and to measure the impact on workload, efficiency, and safety with a focus on ATC operations. Coordination is underway with the NextGen PBN portfolio to develop a plan to gather that data through interviews and develop analyses supporting an increase in safety and efficiency. This work is to be performed by the Human Factors Division and will inform the PBN community about shared experiences which will impact future RNAV and Required Navigation Performance procedures design and development.

Finding: Air Traffic Control (ATC) Strategic Planning Resource Allocation - A recent finding of the Subcommittee (spring 2014) applauded the efforts of ATC/Tech Ops Core program to initiate a more strategic planning effort for their area of research. However, the Subcommittee observed at this meeting that the ATC/Tech Ops Core program is no longer pursuing a strategic research planning effort due to a lack of resources. The Subcommittee had previously found that the strategic research planning effort being initiated within ATC/Tech Ops

Core program was of high value, as it would help the FAA uncover emerging risks as well as position itself for doing the appropriate research in a timely manner. Without this strategic research component, there is once again risk being built into the ATC system for both current operations as well as for NextGen implementations.

Recommendation (5): Reconsider the prioritization of this work and look to allocate necessary resources to re-start this important strategic research planning effort including resources to execute the projects in the strategic plan.

FAA Response: FAA concurs that an ATC/Tech Ops strategic Research and Development (R&D) Plan would be of value. However, as a result of the lack of funding, there is a limited set of activities and areas of R&D that can be addressed, using in-house human factors expertise and resources at CAMI and WJHTC. In addition, without a solid funding base for R&D efforts, we are unable to commit to the multiyear efforts necessary to support the research needs identified by various technical sponsors in the Air Traffic Organization. As a result, we are aligning R&D efforts to the near-term technical sponsor requirements that can be achieved using in-house resources on an ad-hoc, year-to-year basis. We are working to maintain core competencies at CAMI through appropriate tasking in such areas as development and application of controller and technical operations job task analysis and training data, human error taxonomies, human engineering standards for ATC and Tech Ops systems, and safety assessments. As the funding outlook improves, we will undertake important safety and efficiency related human factors R&D initiatives that would enable us to take a more strategic approach as we seek to develop research and development products that meet longer-term technical sponsor needs.

Subcommittee on Aircraft Safety

Finding: Unmanned Aircraft Systems (UAS) Safety Research - The Subcommittee was fully briefed on the UAS safety research plan. We are encouraged by the progress made in the past year regarding organization and networking of different stakeholders. We encourage the continuation of this integrated research planning. There appears to be a focus on real problems and growing consideration of evolving issues.

Recommendation (1): We recommend building flexibility into the FY 2017 Unmanned Aircraft Systems (UAS) budget that can address emerging issues that may not be understood currently. We also recognize the focus on Beyond Line of Sight (BLOS) operations but recommend consideration of other emerging "long term" issues such as complete autonomous operations. We also recommend that UAS National Airspace System (NAS) integration R&D focus on sense and avoid technology vs aircraft robustness in case of impending collision.

FAA Response: The FAA concurs with the recommendation and desire for flexibility. Flexibility has always been a part of our goal to enable the ability to address unforeseen issues and challenges. The FAA recognizes the dynamic nature of rapid advancements of UAS technology and increasing demands of different UAS operations scenarios. The current process for developing research requirements and performing research requires the integrated body of stakeholders to jointly establish research execution plans with specifics deliverables, milestones, and schedules in the budget execution year. Outputs from the research support regulatory activities, development of policy and guidance, and the safety oversight. The FAA Aviation Safety Research, Engineering and Development portfolio is updated as required through this process.

Operating UAS beyond line of sight and sense and avoid technology are essential elements to achieve complete autonomous operations of UAS. The level of maturities of various technologies associated with these operational requirements will dictate the UAS autonomy levels with potential impacts to the NAS. The on-going and planned FAA UAS R&D initiatives are integral part of the FAA effort to address those challenges with incremental steps toward the full-integration of UAS in the NAS. The FAA will continue working with the UAS community toward this goal.

Finding: Strategic Research Planning and Roadmaps - There has been visible progress in terms of developing a process to prioritize research based on priorities and need. Review of the 2017 strategic guidance, quad charts, and list of emerging issues highlighted a need to provide greater linkage between the proposed and funded research and the FAA's strategic plan. The strategic plan should not be a static document; it will require regular updates to address the changing needs of the FAA and the NAS and to ensure that the research is appropriately targeted.

Recommendation (2): Aircraft Safety (SAS) understands and recognizes the ongoing need for research focused on operational safety of the current fleet. Notwithstanding, focused research must be conducted to address emerging issues. The FAA should develop and implement a process to produce five to ten year research roadmaps to guide sponsors in the development of research requirements and to assist in prioritizing and focusing research on strategically significant elements. The roadmaps should define the FAA's vision for the future, quantify success measures to the greatest extent possible, and identify the research areas necessary to support the roadmap vision. It is further recommended that the FAA make available and use the roadmaps as the basis for its comprehensive strategic research plan, research needs, program initiatives, and intended outcomes for aviation safety.

FAA Response: The FAA concurs with the recommendation. While the focus in the Aviation Safety (AVS) organization is on continued operational safety (COS) of the existing fleet, there is a need to look ahead for emerging issues that could impact safety. As these areas are identified,

resources will be applied to scope and develop the appropriate plans to address potential safety hazards. One example is the Seven Year National Composite Plan published in 2014 and updated yearly. This plan includes research focusing on composite COS, Certification Efficiency, and Workforce Education. Currently AVS is in the process of developing a roadmap to address the introduction of additive manufacturing technologies, and provided Aircraft Safety (SAS) with an update on this activity in September 2015 during the Fall SAS meeting. Other roadmaps to address emerging issues are also under consideration.

These individual roadmaps collectively will make our aviation system smarter and raise the bar on safety. The FAA Strategic Initiatives and the AVS Strategic Framework identify the high level priorities and a set of initiatives that link to overall FAA Agency goals and outcome-based performance measures to track timeliness and accomplishment of aviation safety outcomes. AVS also uses Chief Scientific and Technical Advisors (CSTAs) and Senior Technical Specialists (STSs), to provide technical guidance on emerging issues, industry trends, technical demands, and research needs. Input from the FAA CSTAs is considered an essential element to understand emerging issues and to determine FAA needs and plans. The AVS Framework and the guidance from the CSTAs and STSs will assist in prioritizing and focusing research on strategically significant elements. These roadmaps will be available to the FAA Research, Engineering and Development program team to help formulate the aviation safety R&D portfolio with clearly defined research needs and desired deliverables.

Finding: **Additive Manufacturing Technologies** - There have been significant developments in additive manufacturing technologies and capabilities that are expected to rapidly proliferate in aviation applications due to many potential benefits including reduction in material cost, fewer part details, and enabling of more complex designs. However, additive manufacturing technologies have a number of technical risk factors that could have significant impact on design, production, and maintenance. The FAA must be prepared to address these factors in order to ensure appropriate airworthiness and certification standards and methods of compliance. The Subcommittee received a briefing from the FAA fatigue and damage tolerance Chief Scientific and Technical Advisor (CSTA) on the establishment of an FAA Additive Manufacturing Steering Group to address these issues. Aircraft Safety (SAS) strongly supports the high level of coordination with other government and industry initiatives and development of a detailed roadmap identifying near-term and strategic areas that focus FAA's activities on the safe implementation of these technologies. Current planning is to develop the additive manufacturing roadmap over the next eighteen to twenty-four months. This roadmap will inform regulatory, policy, and Research and Development (R&D) program needs. The Subcommittee also noted and strongly endorsed the addition of additive manufacturing materials into the Metallic Materials Properties Development and Standardization (MMPDS) process and handbook (under research requirement A11E.SIM.4) to provide standardized and acceptable design and compliance data and tools.

Recommendation (3): There is significant activity across all major aviation industry sectors in the application of additive manufacturing technologies affecting current production systems and new product designs. The Subcommittee recommends that the FAA accelerate the development of the additive manufacturing roadmap over the next twelve months in order to inform FAA's existing regulatory, policy, and R&D program needs. In addition, the Subcommittee recommends that the FY 17 and FY 18 R&D portfolio includes consideration of proactive research necessary to ensure an understanding of key properties/characteristics of additive manufacturing to identify hazards and mitigations necessary to establish the appropriate standards and methods of compliance necessary to enable safe implementation of these technologies.

FAA Response: The FAA concurs with the recommendation. The FAA recognizes the technical challenges of Additive Manufacturing (AM) technologies and the potential impact on design, certification, and production. As presented at the Subcommittee on Aircraft Safety (SAS) 2015 spring meeting, the FAA is in the process of developing an additive manufacturing roadmap that considers and leverages the substantial resources being directed towards this area by other U.S. government agencies such as DoD, NASA, NIST, DoE, etc. Development of a comprehensive roadmap for new "disruptive" technology such as Additive Manufacturing is a major undertaking, as evidenced by experience with developing a similar roadmap for Composites. The FAA AM team will target development of a draft roadmap within the next twelve months and will solicit feedback from industry and other government agencies during the 2016 CSTA AM Workshop tentatively scheduled for September 2016. This feedback will be incorporated in the final roadmap as appropriate and submitted to senior FAA management. Furthermore, in order to accelerate the process, FAA considers formation of the industry working group focused on qualification/certification issues for AM and started initial discussions with Aerospace Industry Association, General Aviation Manufacturers Association, and others.

We are taking positive steps to integrate proactive additive manufacturing research activities with our firmly established Metallic Materials Property Development and Standardization (MMPDS) development/update process. The MMPDS handbook is a globally recognized source of statistically-based design properties for metallic materials and fasteners. We are also expanding our in-house R&D expertise to meet the technical challenges of additive manufacturing. We believe this strategy will enhance our ability to establish the appropriate standards and methods of compliance necessary to enable safe implementation of these technologies.

We will update the SAS with status of the additive manufacturing roadmap, corresponding R&D requirements, and planned/anticipated research initiatives at the next SAS meeting in the fall of 2015.