




U.S. Department
of Transportation

**Federal Aviation
Administration**

Office of the Administrator

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


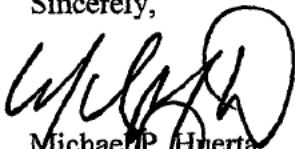
Dear Dr.  Hansman:

Thank you and the Federal Aviation Administration's Research, Engineering and Development Advisory Committee for your June 6 letter providing recommendations on the Fiscal Year 2018 Research and Development (R&D) Portfolio. The key themes and topics that you raise, including Unmanned Aircraft Systems (UAS) Integration into the National Airspace System, Big Data, and High Level Research Strategy and Plan Development, are indeed of significant interest and we will continue to address these areas. Asserting global leadership in the evolution of civil aviation is one of our strategic priorities, and we appreciate your acknowledgement of the work well done as we support International Civil Aviation Organization activities in the development of global CO₂ emission standards.

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

We will continue to incorporate the Committee's recommendations and foster increased communications 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) 2018 Research and Development (R&D) Portfolio

Subcommittee on Aircraft Safety

Findings: **UAS Leadership and Strategic Planning** - FAA still has not released to the SAS a high-level strategy and single, overarching, plan with clear objectives and milestones for dealing with UAS in an integrated manner. We believe that a roadmap is in development but this information is not readily available for review. The lack of an articulated strategy makes it very difficult for the SAS, and others, to evaluate UAS R&D plan and identify potential gaps.

The UAS safety requirements come from the UAS office in AVS; the research is carried out by the NextGen office; and the UAS CONOPS development lies in the ATO organization. The integration and connection between these elements is not apparent. It is not clear who has the ultimate UAS authority and responsibility within the Agency. To outside reviewers there is neither a method for developing comprehensive and integrated UAS research requirements, nor agreement on who has primary responsibility for this. SAS recommends that the FAA -

Recommendation (1): Distribute a coherent strategy for achieving safe and efficient UAS integration into the NAS. This should be the basis for a holistic approach to prioritized planning of UAS activities, responsibilities, and associated funding. A companion document should be developed to show how the objectives are being flowed out to ensure alignment of the research and to help identify gaps. These need to be shared with all UAS stakeholders.

FAA Response: **The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s).** The FAA is developing a detailed Unmanned Aircraft System (UAS) Implementation Plan to align all the Agency's UAS integration activities and establish activities and dependencies for increasingly integrated UAS operations. The initial Implementation Plan will be a foundational document which will evolve over time and will be a rolling plan. The UAS Roadmap will be published once it has cleared executive level review and will serve as the public facing document to report out on progress and provide high level next steps from the UAS Implementation Plan.

Recommendation (2): Implement a cohesive organizational structure for all of its UAS activities and place overall responsibility for the activities with a single person or organization.

FAA Response: **The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s).** The FAA has up-leveled the UAS Integration Office to create an executive lead for all UAS activities within the Agency. The FAA has also established a Senior Advisor on UAS Integration, a position established to focus on external outreach and education, as well as an enterprise-level approach to FAA management of UAS integration efforts. The Senior Advisor reports directly to the FAA Deputy Administrator. Also, the FAA has created a UAS Board to ensure cross-agency agreement, buy-in, and direction for its UAS activities. The Board is cross-organizational, bridging the safety perspective with airspace management challenges and other areas of integration (e.g., airports, technology development).

Finally, the FAA has established a UAS Advisory Committee, which the Agency announced in May 2016, to help disseminate and coordinate this information across the stakeholder community more transparently.

Finding: UAS CONOPS and Concept Maturation Plan - The FAA should be commended for developing a CONOPS for integrating UAS operations into the NAS, associated “operational requirements”, and a concept maturation plan for identifying research required to carry out the maturation plan. SAS found that the CONOPS was developed several years ago, based upon assumptions developed at that time, and has not been vetted with stakeholders outside FAA. Since the UAS situation is rapidly changing (e.g., increased emphasis on small UAS flying at low altitudes), and lacks broad community stakeholder input, the concept is likely incomplete.

Recommendation (3): SAS recommends that this CONOPS, the “operational requirements”, the concept maturation plan, and the prioritized research requirements be vetted with all stakeholders and updated accordingly.

FAA Response: The FAA concurs with the Committee’s recommendation and is undertaking the following actions to address its recommendation(s). The activities contained within the UAS Concept Maturation Plan are FAA priorities that may be addressed through research, procedures, policy, and/or implementation of functionality. The FAA acknowledges that input from the UAS community could influence facets of the concept maturation products and recognizes the need to engage the UAS community on its UAS concept development products and progress, including scenarios and potential requirements. The outreach has already begun with National Aeronautics and Space Administration (NASA) and industry stakeholders related to low altitude UAS operations. To address the broader UAS stakeholder community and range of potential operations, the FAA has prepared a UAS External Stakeholder Engagement Plan that lays out an approach to working with public and civil UAS entities to review FAA products. This engagement will be performed as appropriate, as products mature and evolve. It is anticipated that this effort will also be shared and coordinated through the Drone Advisory Committee.

Finding: UAS Data - SAS supports the risk-based approach for UAS requirements, certification, concepts, and policy – but all of these require data. FAA panelists identified the need for more data, for a variety of purposes (environmental assessment, UAS forecasts, UAS policy decisions, FAA adoption of industry based standards, risk based UAS requirements, etc.). The lack of data and the lack of a serious FAA initiative to collect data is a shortcoming. Beyond certain incident and accident data from COA operations, there does not appear to be an attempt to get comprehensive data to understand the risk of UAS operation, and what potential safety issues might emerge. With over 400,000 registered small UAS, 3700 section 333 exemptions, several Pathfinder programs, and many other UAS operating in the airspace there is an opportunity to expand the operational and safety data routinely collected and analyzed. This existing data can be used to inform what data collection initiatives may be required in the future.

Recommendation (4): SAS recommends that FAA begin a comprehensive effort to collect UAS operational and safety data. Data beyond just accidents and incidents is needed. Routine operational data will help establish baselines of operational use, norms, best practices, and serve as the dominator when considering mishaps rates. FAA should use this data to answer a series of questions: What sort of safety incidents are we aware of today? How many of them

are occurring? Can these events be dealt with by existing policy or rules or will research be required to develop a solution?

Resulting from the rapid and often unpredictable UAS growth a research project should be initiated to determine what UAS safety data is needed 5-10 years from now and to lay the groundwork for its creation, collection, and analysis. SAS further recommends that the Safety Oversight Management System (SOMS) project (A11H.SSM.11) be expanded to include UAS data.

FAA Response: The FAA concurs with the Committee's recommendation and with the noted exception intends to undertake the following actions to address its recommendations.

The FAA plans to conduct a data review to assess and describe relevant datasets, databases, and sources of market use for existing and forecasted UAS fleet data. This will help the FAA analyze the emerging market, including emerging safety risks, such as growing concentrations of flight activity that are creating "hot spots." Once complete, FAA will be better positioned to determine what further research projects may be required regarding UAS safety data.

The FAA non-concurs with the recommendation regarding the Safety Oversight Management System (SOMS) project (A11H.SSM.11). This system is designed as a decision support tool to support the Air Traffic Safety Oversight Service (AOV) in its role for safety oversight of the Air Traffic Organization (ATO). It is intended to use data already available from other AOV sources and is not intended to store data or information. Changes to SOMS would require extensive redesign and would delay the availability of SOMS for its intended purpose.

Finding: UAS Pathfinder Projects - SAS commends FAA for the novel industry partnership in the three Pathfinder projects. This will lead to faster implementation of UAS procedures in the three areas of UAS application. With the exception of the participants, there is limited availability of the details of the pathfinder program initiatives outside of the FAA. The SAS remains concerned that the scope of the Pathfinder effort is limited when considered against the current UAS expected operational demands.

Recommendation (5): SAS recommends that the FAA consider accelerating the Pathfinder program to include more complex types of operation with more accelerated schedules. Additionally, a process should be developed for the results from the Pathfinder projects to be made widely available.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). The FAA continuously evaluates the evolving UAS enterprise for opportunities to accelerate safe NAS integration. The UAS Focus Area Pathfinder programs are a valuable tool, and the FAA will consider this model and others for addressing additional integration challenges.

To make Pathfinder status information more widely available the UAS Integration Office is developing progress reports for its external Web site, http://www.faa.gov/uas/programs_partnerships/focus_area_pathfinder/. In addition, the FAA periodically briefs these programs externally at UAS symposiums and public gatherings, such as UAS Technical Analysis and Applications Center (TAAC), Association for Unmanned Vehicle Systems International (AUVSI), and others including the newly established Drone Advisory Committee (DAC).

Findings: UAS Center of Excellence (ASSURE) - In most of the ASSURE presentations and the poster sessions at FAA-sponsored UAS seminar in February it was not clear what the

research question/issue being addressed was and how it related to FAA research priorities. SAS was unable to get a comprehensive picture of the research being performed by ASSURE or the gaps in research needs in the eyes of the FAA team. This finding is another reflection of the lack of a disseminated overarching UAS strategy. Without knowledge of the comprehensive picture it is hard to evaluate the ASSURE research and identify gaps.

ASSURE projects have received approximately \$6M for this fiscal year but one of the six ASSURE project areas, “Air Traffic Integration”, remains unfunded. The “Airworthiness” project was impressive – the team is building on years of work in developing a finite element model of a Boeing commercial aircraft and will have this ready to begin simulations of the impact of UAS collisions on different parts of the aircraft. It was not clear that the rest of the on-going projects were on a clear path to develop a flexible framework for risk-based UAS decision making and performance-based rulemaking. It seems unlikely that ASSURE will be able to answer key integration questions at the level of fidelity needed by FAA.

It is not clear that there can be widespread engagement between ASSURE and universities unaffiliated with the COE. This is a potential shortcoming of the FAA COE approach as there may be significant capability outside the ASSURE coalition that could likely benefit FAA. SAS recommends that -

Recommendation (6): Future ASSURE projects should be consistent with FAA research needs and priorities based on the overarching FAA plan for UAS integration into the NAS. The projects should include funding for UAS integration into the NAS.

FAA Response: The FAA concurs with the Committee’s recommendation and with the noted exceptions and clarifications intends to undertake the following actions to address its recommendations. The Agency initiated a cross-agency approach to develop Strategic and Implementation plans for UAS Integration. These plans will define the shared vision, goals, priorities, decision points, activities, dependencies, and timelines. Future research including projects assigned to ASSURE will support the execution of these plans. The FAA’s Center of Excellence for Unmanned Aircraft Systems defined 11 focus areas for research and ASSURE is prepared to execute in all focus areas including Air Traffic Integration. As the FAA matures the implementation plan, ASSURE will be called upon to apply these competencies to address cross-cutting Agency needs with a high level of fidelity.

Recommendation (7): FAA should develop and implement a process for engaging capable universities and other research organizations not affiliated with ASSURE in UAS research.

FAA Response: The FAA concurs with the Committee’s recommendation and with the noted exception intends to undertake the following actions to address its recommendations. ASSURE was selected through a competitive selection process pursuant to FAA’s acquisition rules. Congress mandated the establishment of a UAS COE as the FAA’s think tank and vehicle for UAS research and appropriated funding specifically for that purpose. Recognizing that the ASSURE COE is the officially sanctioned vehicle for reaching academia for UAS research, ASSURE can propose expansion to its university team to enhance its capability to address FAA research needs and gaps. ASSURE continues to cultivate a robust cadre of partners in both academia and industry and has the ability to form new partnerships as the need arises.

In addition, the FAA is actively engaging with other organizations in the conduct of UAS research. To this end, FAA has several active cooperative research and development agreements (CRDAs) with industry partners including the four current UAS Pathfinders. It is likely that additional CRDAs will emerge over time to assist the FAA with addressing UAS research needs.

Finding: UAS Funding Impact on Other Safety Research Portfolio Items - Contract funding for UAS is contained in Budget Line Item, A11.1, under AVS. SAS observed that funding for UAS has been significantly increased over the requested amount in the final congressional appropriation for the past two years. In 2015 the amount increased from a contract request of \$7210k to \$13210k. In 2016 the enacted amount increased from \$8150k to \$16022k. Overall this resulted in an average of 33 percent reductions in funding for other safety related BLIs. Contract requests for UAS in 2017 and 2018 are \$8400k and \$7400k, respectively. SAS is concerned that a similar congressionally directed re-allocation may occur in FY17 and FY18. We also note that this re-allocation of funds within the AVS scope impacts the FAA's ability to plan and conduct research in other areas considered critical to aircraft safety including human factors (\$5.1M reduction in FY16), Aeromedical (\$1.5M reduction in FY16) and Weather (\$1.6M reduction in FY16).

Recommendation (8): SAS recommends that the FAA conduct a review that assesses the collateral impact of congressional re-allocations of budget on existing and proposed RE&D and Aviation Safety research portfolio to understand the funding changes required, and the impacts of those changes, on other aviation safety RE&D priorities. Specifically, those BLIs or RE&D tasks that are provided funding in a one year, then halted in interim year(s), and restarted may make it difficult to efficiently utilize resources and effectively complete RE&D activities. The Subcommittee recommends re-reviewing prioritization within and between BLIs for consideration of balancing funds and ensuring the most significant aviation safety priorities are addressed, particularly in light of the RE&D restrictions during Continued Resolution operations.

The FAA should also consider developing an alternate approach to incrementally funding UAS that does not result in significant reductions in research budgets for other BLIs.

FAA Response: The FAA concurs with the Committee's recommendation and with the noted clarifications intends to undertake the following actions to address its recommendations. The FAA utilizes research prioritization processes to prioritize research requirements and allocate resources based on established priorities. When funding is reduced, these priorities are used to minimize the impact. Congress provides specific guidance on the FAA's ability to reprogram funds once they have been appropriated.

Specifically, Congress requires the advance approval of the House and Senate Committees on Appropriations of any proposal to reprogram funds that:

- creates a new program;
- eliminates a program, project, or activity (PPA);
- increases funds or personnel for any PPA for which funds have been denied or restricted by Congress;
- redirects funds that were directed in such reports for a specific activity to a different purpose;
- augments an existing PPA in excess of \$5 Million or 10 percent, whichever is less; and
- reduces an existing PPA by \$5 Million or 10 percent, whichever is less;

All below threshold reprogramming's (less than 10 percent or less than \$5 Million) are reported to Congress on a quarterly basis.

The FAA has established a UAS Board to ensure cross-agency agreement, buy-in, and direction for its UAS activities and at the direction of the UAS Board; the Agency is determining resourcing needs. There is a clear understanding from executives across the Agency that UAS cannot supplant other safety critical activities.

Finding: Additive Manufacturing. SAS has been previously expressed concern that the FAA may be falling behind in evaluating technologies and certification criteria related to Additive Manufacturing and its expected increasing presence in industry. This has been a finding in the past two SAS meeting reports and was identified as one of the emerging issues. The FAA has responded to our concerns by noting that Certification Policy Memos and an Additive Manufacturing Research Roadmap are in development. There is also a tactical project plan, which is working the issue. The committee applauds these efforts and encourages their continuation on an expedited pace although we remain concerned that the pace of change is too slow to support industry. Additionally, it is noted that Additive Manufacturing research continues to fall below the funding cutoff levels in the 2017 and 2018 research plans.

Recommendation (9): Expedite efforts to provide the Additive Manufacturing Research Roadmap and Certification Policy Memos and reconsider required funding in future year plans to accomplish the required tasks in the tactical plan and Roadmap.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). By the fall subcommittee meetings, the FAA expects to have the draft Additive Manufacturing Roadmap completed and shared with industry and government agencies. In addition, the FAA has several ongoing activities related to additive manufacturing (AM) that are non R&D related that will be presented to the Subcommittee. With respect to R&D, the FAA has developed a plan to address the need for Additive Manufacturing research. In FY2016 the FAA joined two consortiums; Kansas Aviation Research & Technology (KART) and the Carnegie Mellon University (CMU) Consortium on Additive Manufacturing (AM) which are well aligned with the FAA's near-term Additive Manufacturing technical areas of interest. There is programmed funding for research in FY2017 and FY2018 and a request for funding in FY2019.

Findings: Advanced Materials Research – Supportive of SAS Emerging Issue - SAS published its Emerging Issues and Future Opportunities Tasking Report in the fall of 2014. The report included a description of an emerging issue related to the Certification of Advanced Materials and Structural Technologies. Specifically, "as aircraft and engine designs drive towards advanced performance, new material systems and structural concepts will continue to be introduced that are significantly different from the current ways of designing, building, and maintaining airframes and engines. The FAA needs to stay abreast of these changes to make certification decisions and build its knowledge to support regulations, standards, guidance materials, and training that maintain safety."

Four specific areas are recommended for additional propulsion system research in alignment with this emerging issue, Hot Corrosion in Nickel Alloys, Advanced Inspection Technology,

Cold Dwell Fatigue in Titanium and Advanced Computational Materials Methods for Microstructure Changes.

- The effect of hot corrosion on engine rotor life is an important element that needs to be matured, especially the influence of operations in severe environments. Initial results of a program to predict the formation and growth of corrosion pits during service is being incorporated into the FAA rotor life prediction design code known as DARWIN (Design Assessment of Reliability With Inspection) to quantify the degrading effects of hot corrosion on rotor life. This work should be continued.
- The engine industry continues to rely on the Fluorescent Penetrant Inspection (FPI) process whose reliability is highly dependent on human performance. With innovative non-destructive evaluation (NDE) methods, it is becoming increasingly possible to more reliably detect cracks and to also characterize microstructure for anomalies prior to crack formation and as a means to measure material properties to determine remaining life. In addition, methods to nondestructively determine grain size and bond joint integrity can be used as tools to both validate manufacturing processes and to provide finished part quality assurance. Lastly, advanced NDE used during on-line process monitoring of manufacturing processes has the ability to virtually eliminate manufacturing induced anomalies. The subcommittee notes with concern the lack of FAA resources currently allocated for the NDE of Critical Engine Components requirement. This requirement is currently programmed for zero funding in FY16, FY17, and FY18.
- The subcommittee notes that the FAA has also made significant progress in studying Dwell-Fatigue in Titanium (Ti6242). This work established some of the fundamental, physics-based reasons for the occurrence of the cold dwell phenomenon, which can lead to fatigue failures and uncontained rotor failures. The research identified titanium features that are required for the activation of the cold dwell phenomenon. Quantitative characterization of these microstructural features was initiated during this project in both metallographic and ultrasonic methods, but specific, standardized characterization tools and methods were not established or proposed. There are follow-on efforts that would be useful in establishing an industry-wide adoption of tool/methods to mitigate the incidence of cracks and fractures due to cold dwell fatigue.
- Recent and anticipated progress in computational materials science has shown that fundamental theoretical research and modeling can be used to develop an understanding of the critical physical phenomena that occur during metal processing. With this understanding microstructural changes can be anticipated and accounted for in the process. Computer experiments can be used to aid in rotor alloy designs and manufacturing process development.

Recommendations (10): The FAA should continue to prioritize funds within the Improve Aviation Safety R&D portfolio to allow further development and validation of hot corrosion models and their incorporation into the DARWIN code.

FAA Response: The FAA appreciates the Committee's recommendation on the development and validation of hot corrosion models for the DARWIN code. However, we are not able to pursue this recommendation at this time as the priority is to complete the ongoing work in support for the Advisory Circulars for the part 33 rule changes. The hot corrosion models currently in DARWIN are based on work done by AFRL. The FAA will continue to work with

AFRL and other government and industry partners to leverage their work on the hot corrosion issue along with other potential changes to DARWIN as we complete the current work.

Recommendations (11): The FAA should reinstate previous funding levels to continue the study of innovative NDE research for engine materials characterization and to assist with the transition of the most promising methods to original equipment manufacturer's (OEM) production and field overhaul facilities. Efforts should also be focused on advanced NDE to replace and improve upon Fluorescent Penetrant Inspection.

FAA Response: The FAA appreciates the Committee's recommendation on innovative NDE methods. However, we are not able to pursue this recommendation at this time as the NDE work is focused on two specific aspects of NDE: sonic infrared technology as a replacement to Fluorescent Penetrant Inspection and residual stress.

Recommendations (12): The FAA should continue to work collaboratively with industry and AFRL through the RISC and JETQC initiatives to fully understand texturing in Titanium and identify billet and forging practices needed to prevent cold dwell failures including standard definitions for characterization and certification of titanium material.

FAA Response: The FAA concurs with the Committee's recommendation and is addressing it in the following manner. In April 2016, the FAA and Air Force Research Laboratory (AFRL), proactively convened a 2-day meeting to discuss the state of the industry regarding cold dwell fatigue. During this meeting, previous FAA sponsored research was reviewed and industry and academia discussed their latest efforts and concerns. At this time, the FAA is working with industry via the Rotor Integrity Sub-Committee (RISC) and the Jet Engine Titanium Quality Committee (JETQC) and the USAF to develop a roadmap of research needs in this area. When the roadmap has been prepared, the FAA will use it as the basis to justify research as a requirement. Research anticipated from the roadmap includes activities to develop standards regarding texture, validation of possible NDE methods to detect such texture, and models that could be incorporated into the DARWIN code to quantify the risk associated with cold dwell fatigue. It is the FAA's intention to leverage industry and USAF contributions as much as possible.

Recommendations (13) The FAA should continue to work collaboratively with the USAF and other agencies to develop and incorporate similar computational methods into the DARWIN code to better enhance its life prediction accuracy.

FAA Response: The FAA concurs with the Committee's recommendation and continues to work collaboratively with our government and industry partners to advance the computational capabilities of the DARWIN code.

Finding: Research to Mitigate the effects of Ice Crystal Icing – engine test and analysis capabilities - In the spring 2016 SAS meeting, the subcommittee was presented a comprehensive review of the icing-related RE&D portfolios (A11.D (Icing), A11.K (Weather)), with a focus on proposed funding and research in FY18. Significantly differing allocations between the BLIs (in this case A11.D and K) were noted.

Recommendation (14): The near-term need for ice-crystal-icing (ICI) test and analysis tools for engines has been noted in the engine harmonization working group (EHWG) and acknowledged by the Technical Community Representative Group (TCRG). While further

weather research may be advantageous to assist in operations to avoid ICI conditions, it would not be practical to expect all operations to be able to avoid ICI. Therefore a means for engines must be designed, analyzed, and-or lab tested to predict and reduce susceptibility is crucial. The need for near-term solutions for predicting effects of ICI on specific engine design, and to allow for methods of compliance other than extensive and complex flight testing is recommended. The subcommittee recommends that RE&D funding for A11.D be prioritized at a higher level for FY18 and forward.

FAA Response: The FAA appreciates the Committee's recommendation and at the time of the meeting in March had already planned to program FY18 funds for this research. The actual funding levels will be determined by the final Congressional budget for FY18.

Subcommittee on Human Factors

Finding: The HF Subcommittee was asked to focus on UAS technology needs and research for this session. We applaud Civil Aerospace Medical Institute (CAMI) and the Human Factors (HF) staff for identifying the top 5 HF UAS research needs and their intent to produce an HF UAS tech roadmap. We also were impressed with the NASA and AFRL Detect and Avoid Display research which should be reviewed by the FAA. The addition of the UAS Tech Center efforts will complement this research. However, we believe the proposed FAA FY18 UAS HF Research Plan, as presented, is not properly prioritized, aligned and funded to meet pressing UAS users' and customers' needs in the next five years.

Recommendation (1): In view of this situation, the HF Subcommittee recommends the FAA conduct several workshops this summer with the nation's top Human Factors experts and other appropriate areas of expertise to develop UAS baseline guidelines for HF issues such as displays, control stations, etc., based on current and past research for UAS and manned systems. These guidelines should be provided to the FAA and published as appropriate. This would be a huge step forward for the FAA and serve as an initial baseline with incremental upgrades as the UAS HF research matures. Failure to do this will result in commercial systems being built without the benefit of the existing documented HF research and expertise.

FAA Response: The FAA concurs with the Committee's finding that UAS-specific guidelines are needed. However, the FAA notes the following in the actions to address its recommendations: First, the FAA already has baseline guidelines for HF issues such as displays and controls based on current and past research for manned systems, and many of these guidelines apply to UAS as well. Instead, the FAA will focus on developing UAS-specific guidelines for Human Factors for inclusion in FAA guidance material. In lieu of workshops, the FAA will consult with UAS experts at other government agencies as well as industry.

Recommendation (2): Human Factors Subcommittee recommends the FAA prioritize, align, and appropriately fund the HF UAS research using results from the summit addressed in the finding. Alignment consists of integrating the HF research with the overall UAS Research Plan which, in turn, needs to be integrated with the UAS Implementation Plan.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). The FAA has established a UAS Board to ensure cross-agency agreement, buy-in, and direction for its UAS activities. This Board is overseeing the development of a detailed UAS Implementation Plan

that aligns UAS integration activities and establishes activities and dependencies for increasingly integrated UAS operations. The initial Implementation Plan will be a foundational document that will evolve over time.

At the direction of the UAS Board, the Agency is determining resourcing needs and FAA's research prioritization process will be used to prioritize and align HF research requirements accordingly.

Finding: The committee was extremely pleased by the efforts of the Human Performance group within the ATO to create a new process for gathering Human Factors and Human Performance requirements from various program acquisition groups. Using a "Roundtable" forum that brings together various stakeholders and organizations responsible for these requirements is a significant step in prioritizing Human Factors research needs within the ATO. While it is anticipated that this process will result in a more robust and effective research portfolio, there was some concern about the timing of the roundtable meetings and how the output will impact out-year research submittals. In addition there was also a concern that the results of the roundtable process could lead to an emphasis on more reactive research proposals rather than a more strategic view of what needs to be accomplished to fulfill longer term needs and gaps.

Recommendation (3): Expand the use of the roundtable forum to discuss and prioritize Human Factors research requirements within the ATO.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). The next FAA Human Factors research requirements roundtable is planned for mid-September 2016. This meeting will aim to involve each of the ATO's Service Units, whereas, the pilot roundtable held in February 2016 only included some. The September roundtable discussion will focus on identifying 2017, 2018, and beyond Human Factors research needs and will be used as input into the FAA's research prioritization process.

Recommendation (4): Consider categorizing and prioritizing Human Factors research needs along at least two time horizons: short-term and long-term needs. This will facilitate a more strategic view of what needs to be accomplished in the longer term.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). Sources for Human Factors short-term and long-term research needs will be obtained from current Human Factors roadmaps, a strategy document currently under development in a joint effort by the Technical Center and Civil Aerospace Medical Institute, and future meetings of the ATO human performance roundtable. The longer-term research view will be captured in the FAA's National Aviation Research Plan (NARP), and in future years' budget narratives that are submitted by the U.S. Department of Transportation to the Office of Management and Budget, and reflected in the President's Budget submitted annually to the Congress.

Recommendation (5): Execute on the six month plan: identification of an executive sponsor and advocate for Human Performance within the ATO, education of ATO personnel on Human Performance areas of significance, and documentation of the scope, roles, and responsibilities of the Roundtable.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). The Human Performance Group within the ATO Office of Safety and Technical Training is continuing work

to identify an FAA executive who will sponsor and advocate for Human Performance within the ATO and educate and coordinate with ATO service units. A charter is also in the process of being drafted that identifies the scope, roles, and responsibilities for the ATO roundtable members, as well as the role of the research performer.

Finding: The committee was pleased with the flight deck/maintenance core and NextGen research presented. There was concern expressed that current training methodologies and assessment of training effectiveness to measure pilot performance may not keep up with modern learning methods and technologies. For example, there is evidence that new NAS procedures are not trained consistently by all operators. In some cases distance learning and bulletins are being used to deliver required training without determining the effectiveness of the training or adequately measuring if the pilots actually obtained the required knowledge and skills to safely fly the new procedures in the NAS. The assumption is usually made that simply by watching the distance learning or reading the bulletin that the training was effective.

Recommendation (6): The committee recommends that the FAA identify required pilot knowledge and skills for current and new flight deck systems operated in NextGen. The FAA needs research on available training methodologies and procedures to train current and future systems for NextGen that emphasizes performance-based measurements of training effectiveness. This should include what data should be collected to measure effectiveness.

The FAA should identify a process for defining the required knowledge and skills, training devices, and the training methodology for training instructors and aviation personnel for current and new NextGen systems, including how to measure effectiveness and what data should be collected to measure training effectiveness.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). The FAA has initiated a project to identify recommendations for pilot training using a problem solving/decision making approach. Additionally, the FAA has identified the research need to investigate knowledge and skill requirements for NextGen and alternative training approaches to meet those requirements.

Finding: During this review, it has been difficult for the Human Factors Subcommittee to assess the HF priorities and total FAA Human Factors research and application investment to include leveraged work done by external agencies supporting FAA. This is probably true of the other REDAC Subcommittees in their research areas.

Recommendation (7): This committee recommends the FAA provide a summary of overall FAA prioritized research needs across lines of business at a high level and how the proposed investments (both internal and external) are aligned and leveraged to satisfy these needs and identify the gaps. The Director of Research should brief all of the REDAC Subcommittees at an upcoming set of Subcommittee meetings.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). The Director of Research is engaging with FAA's Research Executive Board members to augment the Agency's annual NARP to better reflect FAA's strategic program and prioritized research needs. The target timeframe for this work is the 2018 NARP. As an outcome of this work the REDAC Subcommittees will be briefed in 2018 with a summary of FAA's prioritized research requirements, investments, and supporting partner activities. Recognizing the diverse audience that will be served by a more strategic program description in the NARP, the FAA intends to

coordinate and seek input from the R&D community as it shapes this presentation and will provide updates/briefings to the REDAC Subcommittees in 2017 as this effort progresses.

Subcommittee on Environment and Energy

Finding: The International Civil Aviation Organization (ICAO) recently adopted CO₂ emission standards for in-production and new type certificate airplanes per plan. The environmental assessment tools developed as part of the FAA E&E RE&D program were critical in the evaluation of stringency options for the CO₂ standard development. The readiness and capabilities of the tool suite enabled FAA to achieve global leadership in ICAO discussions.

Recommendation (1): The ICAO CAEP/11 work program includes the development of an nvPM standard. The subcommittee recognizes that this requires the development of a database based on engine test measurements. While some progress has been made significant work remains. The subcommittee recommends that the FAA commit the necessary resources to generate this database and associated analyses tools. This is needed to develop the standard on time and maintain FAA's global leadership in ICAO discussions.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). The FAA is focused on developing a global market based measure for international aviation CO₂ emissions and an engine standard for particulate matter emissions. The FAA has done considerable work to support the global market based measure and has made considerable investments to develop an engine particulate matter test database. We will continue to prioritize the measurements that are needed to gather particulate matter emissions data. We are also updating our Aviation Environment Design Tool (AEDT2b) based on these measurement data such that the tool is ready to support the Committee on Aviation Environmental Protection (CAEP) particulate matter standard analysis.

The FAA agrees with the Subcommittee that resources need to be allocated to ICAO CAEP activities to ensure continued U.S. leadership. Robust funding is critical to ensure U.S. influence on the ICAO CAEP process and to develop our modeling capabilities and the generation of data to support ICAO CAEP decision-making.

Finding: During the subcommittee meeting, the FAA presented progress on several tasks that clearly indicated that this RE&D program is achieving more robust results by collaborating with other FAA departments (like ATO, ANG, ARP) and other government agencies (like NASA, DOA, DOE). This collaborative approach has matured during the past several years.

Recommendation (2): The subcommittee recommends that the FAA continue to explore additional opportunities and, where feasible, develop a joint work plan to achieve even greater benefits from the collaboration.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). The FAA has numerous collaborative efforts in alternative jet fuels, noise research, and particulate matter emissions measurements. As an example, the FAA has started collaboration with NASA to conduct particulate matter emission measurements that will help NASA advance the scientific

knowledge of particulate matter emissions while helping the FAA develop a more robust database to assist the work in ICAO CAEP. The FAA will continue to keep the REDAC apprised of our progress on this front.

The FAA agrees that continued collaboration is needed to leverage activities that are being performed within the FAA, in other agencies of the Federal Government, as well as by foreign governments. Collaboration is especially important given reduced Federal funding for R&D.

Finding: FAA shared the results of the CLEEN program tasks which indicated successful technology maturation of several technologies with opportunities for insertion into products starting 2016 to beyond 2020 with significant environmental benefits. The FAA also shared the program plan for CLEEN-II. This portfolio is well balanced among noise and emissions reduction technologies and alternative jet fuel development.

Recommendation (3): The subcommittee is highly pleased with the progress here and recommends that the FAA continue their commitment to this program which produces high value especially with the greater than 1:1 cost share by industry.

FAA Response: The FAA concurs with the Committee's recommendation. During the process of setting up CLEEN II, the FAA carefully considered the make-up of the CLEEN II portfolio with a goal to achieve such a balance. The FAA appreciates the Subcommittee's view that the CLEEN II portfolio is well balanced among noise and emissions reduction technologies and alternative jet fuel development. The FAA also appreciates the Subcommittee's support of the CLEEN Program as it remains one of our top priorities.

Finding: The environmental impacts of Unmanned Aerial Systems (UAS) are going to be a growing issue. Given the recent surge in the number of UAS operation approvals, there is a need to get proactive on this issue.

Recommendation (4): The subcommittee recommends that the FAA start plans to assess and understand the noise impact of UAS. This would include the development of environmental impact assessment tools starting with evaluating the applicability of AEDT2b. We are also encouraging the FAA to explore opportunities to make noise measurement that will provide both an indication of the future challenge and a better understanding to make assessment models more relevant and practical.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). The Office of Environment and Energy (AEE) and the Office of Unmanned Aircraft Systems (AUS) are working closely within the ASSURE Center of Excellence to acquire noise measurement data for UAS. We are also leveraging opportunities with NASA and the U.S. Department of Defense to access UAS noise data. In addition to the ASSURE measurement campaign, AEE is developing a plan to address the potential environmental impacts of UAS to ensure that FAA is able to assess environmental impacts considered under the National Environmental Policy Act, develop noise certification procedures including potential risk-based noise standards for UAS, and develop environmental analysis capabilities that are unique to UAS. These efforts could require additional noise measurements and analysis to cover a growing range of vehicle types and could potentially include the creation of noise models.

The potential noise concerns regarding UAS are not well understood at this time. The FAA agrees that there is a need to be proactive regarding UAS noise given the increased sensitivity to noise produced by civil aircraft. The FAA anticipates that the noise levels of individual UAS,

along with their mission, will play a part in determining the community reaction to this new aircraft type.

Subcommittee on NAS Operations

Finding: **UAS Integration in the NAS** - The Subcommittee appreciated the opportunity to learn about the FAA's UAS plans at the recent session of the UAS Research Expo. It is clear that the FAA recognizes the need for a high level, cross-agency approach to the integration of UAS in the NAS and the subcommittee strongly concurs and finds that integration of UAS in the NAS will require a strong system engineering approach with centralized leadership that is capable of making the significant technical and procedural decisions necessary to make progress. This system engineering approach must include all aspects of integration of UAS in the NAS, including UAS certification and safety, operational procedures, and supporting technologies.

Finding: The subcommittee finds that FAA has performed significant work to develop a UAS concept of operations and a set of mid-term UAS operational scenarios. The FAA has decomposed these into a set of FAA requirements and operational shortfalls and an evolution strategy for air traffic operations. The FAA has developed a UAS Concept Maturation Plan that focuses on those activities that address existing FAA shortfalls associated with the provision of air traffic services to UAS airspace users in the mid-term and beyond. However, the FAA has not shared this work to any significant degree with the external stakeholder community. The result is that the external community cannot appreciate the specific problems that the FAA is addressing and is unaware of any substantial plan to move toward a solution. In addition, the FAA cannot benefit from the ability of the external stakeholder community to recommend innovative solutions to some of the problems (e.g., through UAS equipage or procedures). As the Subcommittee has already reported to the FAA: "Finding a common approach to addressing routine UAS access to the NAS requires that UAS community develop patience and understanding of the challenges of operating in the airspace and that the FAA develop a greater sense of urgency to allow safe and effective UAS business."

Finding: As previously noted by the subcommittee, the level of effort, as reflected by the allocation of RE&D and F&E funding that the FAA has been given in FY16 for UAS research and development, appears to be substantially focused on airframe safety and certification and not on the development of operational concepts and procedures that are necessary to close the operational and technical shortfalls identified in the UAS Concept Maturation Plan. This apparent mismatch will likely further delay the integration of UAS in the NAS.

Finding: The subcommittee finds that the UAS technology space and user demand continues to grow at an extremely rapid pace and continues to significantly outstrip the FAA's ability to plan for and conduct the research and development necessary to address the operational and technology shortfalls.

Recommendation (1): The subcommittee recommends that FAA immediately engage the broadest set of external stakeholders of the UAS community and share with them the FAA's UAS operational scenarios, requirements breakdown and UAS Concept Maturation Plan. The FAA should use this engagement to inform the user community of the technical and operational challenges it faces and revise that plan with input from the community.

FAA Response: The FAA concurs with the Committee's recommendation and with the

noted exceptions and clarifications intends to undertake the following actions to address its recommendations: The activities contained within the UAS Concept Maturation Plan are FAA priorities that may be addressed through research, procedures, policy, and/or implementation of functionality. The FAA acknowledges that input from the UAS community could influence facets of the concept maturation products and recognizes the need to engage the UAS community on its UAS concept development products and progress, including scenarios and potential requirements. The outreach has already begun with the Unmanned Traffic Management Research Transition Team through its efforts to collaboratively review FAA products with NASA and industry stakeholders related to low altitude UAS operations. An initial scenario review session occurred at NASA Ames Research Center in California during July 2016. To address the broader UAS stakeholder community and range of potential operations, the FAA ATO has prepared a UAS External Stakeholder Engagement Plan that lays out an approach to working with public and civil UAS entities to review FAA products. This engagement will be performed as appropriate, as products mature and evolve. It is anticipated that this effort will also be shared and coordinated through the Drone Advisory Committee.

Recommendation (2): The subcommittee recommends that FAA establish and maintain high level system engineering leadership, as described above, focused on UAS integration in the NAS. This leadership should be charged with prioritizing research and development across all the FAA organizations to ensure that UAS integration progresses as rapidly as possible. This leadership must be able to make the significant operational and technical decisions necessary to make this happen. The subcommittee recommends that this leadership develop an integrated research and development plan for UAS in the NAS and present a progress report on this plan at its August 2016 meeting.

FAA Response: The FAA concurs with the Committee's recommendation and with the noted clarification intends to undertake the following actions to address its recommendations. The FAA has established a UAS Board of the most senior executives, a subordinate UAS Executive Committee, and a UAS Implementation Plan Work Group. System engineering leadership is included at the committee and work group levels and are actively involved in developing a detailed UAS Implementation Plan that aligns UAS integration activities and establishes activities and dependencies for increasingly integrated UAS operations. The initial Implementation Plan will be a foundational document which will evolve over time. At the direction of the UAS Board, the Agency is determining resourcing needs and FAA's research prioritization process will be used to prioritize and align research requirements accordingly. A progress report on this activity was provided at the August 2016 meeting.

Subcommittee on Airports

Finding: The spring 2016 meeting was the first meeting at which branch projects and associated budgets/spending were grouped by research project area (RPA). As noted in the subcommittee's Fall 2015 report, the branch had proposed presenting project budgets by RPA to more clearly indicate how branch funding is and will be allocated and prioritized and provide a more logical grouping of individual research projects. The revised budget presentations based on RPAs did provide these benefits, but there was concern among committee members that budget reporting at the individual project level was lacking in the new reports. There was also continuing concern

that current budget reports do not effectively convey individual project progress (e.g., project spending to date vs. anticipated budget to complete).

Recommendation (1): The subcommittee recommends that branch staff provide more detailed budget reports that include detail at the individual projects (e.g., RPD) level that can then be rolled up to RPA subtotals. The subcommittee also recommends that branch staff provide clearer summary-level assessments of spending to date and anticipated budget to complete projects at the RPD level.

FAA Response: The FAA concurs with the Committee’s recommendation and is undertaking the following actions to address its recommendation(s). At future subcommittee meetings, in addition to presenting the Airport Technology Research (ATR) budget at the RPA level, budget reporting will also be provided and summarized at the project level including spending to date and anticipated budget.

Finding: The branch’s proposed FY17 and FY18 budgets as presented to the subcommittee included capital investments for new facilities—specifically an on-site photometric laboratory, an asphalt concrete pavement testing facility, and additional storage space. The budgets for these facilities were presented as “above the line” expenditures, defined by branch staff to mean capital projects that would require expenditure above expected FY17 and FY18 funding levels. Subcommittee members raised concerns about the long term sustainability of such above the line expenditures and suggested that barring extraordinary circumstances/justification, such expenditures should be included within the existing program budgets.

Recommendation (2): The subcommittee recommends that branch staff include capital expenditures within expected program budgets, rather than as supplemental/additional program expenditures. Such requests should be accompanied by a description of the project’s justification (e.g., critical testing functions that cannot be obtained on a timely or cost effective basis elsewhere; essential facility rehabilitation). The subcommittee also recommends that the branch consider dedicating a portion of its budget to capital improvements, including major facility maintenance/renovation, the costs of which are expected to increase as several of the branch’s facilities age.

FAA Response: The FAA concurs with the Committee’s recommendation and is undertaking the following actions to address its recommendation(s). Future budgets will be developed with special allocations dedicated to upkeep, upgrades, and renovations. In addition, these annual budgets will also consider planning and incorporating new capital expenditures. These requests will be supported by technical and business-case justifications.

Finding: Other than the aforementioned requested enhancements to budget reporting and treatment of capital projects described in Findings 1 and 2, the subcommittee was satisfied that the branch’s proposed FY2018 budget is reasonable and reflective of industry priorities for airport-related research.

Recommendation (3): The subcommittee recommends accepting the branch’s proposed FY2018 budget, but suggests that the FAA investigate options for incorporating capital expenditures within future budgets.

FAA Response: The FAA concurs with the Committee’s recommendation and is undertaking the following actions to address its recommendation(s). The FAA is looking at all possible options to incorporate capital expenditures in future budgets. This includes

dedicating a portion of its annual budgets or when possible, incorporating funds from other sources.

Finding: The subcommittee appreciates the branch's increased focus on airport planning and environmental issues and is interested in helping the branch assess research projects in these areas.

Recommendation (4): The subcommittee recommends that the FAA Office of Airports and Branch staff engage subcommittee members (or their designees) to discuss future airport planning and environmental research projects. We also recommend engaging members of the Subcommittee on the Environment and Energy in these discussions.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). As part of a new emphasis on airport planning and environmental research issues, the FAA will develop and coordinate portfolios for airport planning research, and airport environmental research. When appropriate, the FAA will also engage members from the Airports Subcommittee and the Subcommittee on Environment and Energy.

Finding: The Subcommittee supports the branch's involvement in Unmanned Aircraft System (UAS) research that facilitates integration of UAS into the National Airspace System in a manner that does not undermine the safety and security of the NAS, particularly in the vicinity of airports.

Recommendation (5): The subcommittee recommends that the branch continue its support of UAS research activities that enhance airport safety, security, and efficiency.

FAA Response: The FAA concurs with the Committee's recommendation and is undertaking the following actions to address its recommendation(s). The FAA will continue to define research requirements for future applications of UAS at airports.

Finding: Branch staff has continued to refine their airport safety database, which fuses information from the FAA's wildlife strike database as well as accident and incident reports from FAA and NASA databases. This database has been a key tool in the development of the FAA's Runway Incursion Mitigation (RIM) program, which began in the fall of 2015 and is expected to continue indefinitely. In the RIM program, the FAA is identifying specific airfield locations at specific airports that are high priorities for physical or operational mitigations to reduce the risk of runway incursions. Subcommittee members believe that airport operators should have some level of access to the airport safety database to better understand what data are being used to drive RIM activities at their airport and so that these operators can undertake mitigation activities more proactively. The subcommittee understands that providing such access may require de-identification of some of the incident and accident reports incorporated into the database (e.g., ASIAs, ATSAP).

Recommendation (6): The subcommittee reiterates its recommendation from spring 2015 and requests the FAA evaluate how it can make data from the Airport Safety Database available to airport operators so that this information can be used proactively by airport operators to enhance margins of safety at their facilities.

FAA Response: The FAA concurs in large part with the Committee's recommendation and offers the following response. The FAA is currently developing a tool within the Airports Geographic Information System for airport operators to readily access the runway incursion

information for their airport. This is the same data that the FAA has extracted from the Airport Safety Database and used to identify priority locations under the RIM program. The new tool is expected to be completed and available to the airport operators this calendar year. We have been engaging airport operators as part of the RIM program and if they have questions or issues with the data then we would be interested in talking with them further. In addition, the raw runway incursion data and most of the other information in the Airport Safety Database information is already available through the public ASIAs site.