**FAA Research Issues and Opportunities**

**Input from REDAC NASOPS Subcommittee**

**Research Issues that the FAA should “get ahead of”**

Issue: Integration of UAS into the NAS

There has been an unprecedented demand by the UAS community for access to the NAS. While the FAA has devoted significant effort to this issue over the past few years, it is clearly not ahead of it. Small UAS operations represent the majority of the user community demand in the relatively near term, principally because of their low cost of operation and significant economic potential. While some progress has been made in the integration of small UAS operating within line-of-sight of the operator, the concepts for broader integration of small UAS are not well understood and research is urgently needed to define and validate these concepts. This research must be well-focused and oriented to ensure that timely solutions can be introduced that are safe, while minimizing impact to current NAS operations.

It is clear that in the near term, small UAS will operate in airspace that is largely segregated from manned aircraft. However, the demand will likely drive the UAS operational density to levels much higher than can be managed using manual ATC methods, particularly as small UAS operations extend beyond operator line-of-sight and become more autonomous. The proposed FAA rule for small UAS, while helpful, will satisfy only a fraction of proposed small UAS operations.  The more general FAA UAS concept of operations specifies IFR operation, which is not a good fit for small UAS due to a lack of pilot training to operate IFR, difficulty of compliance with IFR visual operations, and the sheer volume of expected operations.

NASA is developing new concepts for autonomous airspace operations and there is an opportunity for FAA to collaborate with NASA and use the small UAS flight regime as a first step toward a more autonomous airspace system (see the associated research opportunity below). Because these lower altitude airspace regimes are likely to initially be segregated, they offer an opportunity for the FAA to be more agile in the development and implementation of new concepts.

An overall research strategy for UAS is needed that captures the range of operations and timeframes for UAS operations. This strategy needs to capture the role of both FAA and other organizations (NASA, DoD, academia, etc) in solving key challenges to safe and efficient UAS operations in the NAS.

Issue: General Aviation Safety

The Administrator has designated the improvement of General Aviation safety as one of FAA’s top priorities. However, the FAA is not “getting ahead” of this problem. GA accounts for 96% of all aviation accidents and 97% of all fatal aviation accidents.[[1]](#footnote-1) It has been estimated that the average annual cost of GA accidents in the United States is $1.64B.[[2]](#footnote-2) While the accident rate of Part 135 and corporate aviation has improved over the past decade, the accident rate of personal aircraft has not.

The FAA should focus its GA safety initiative on developing a fundamental understanding the underlying sources of the GA safety problem, and based on this understanding, develop and validate the system-level approach most likely to produce a significant impact on GA safety. To the extent that improved access to information is a factor in GA decision-making, the subcommittee notes that there are many new sources of information and decision support applications available to GA pilots. While there appears to be some penetration of these applications into modern GA cockpits, it will be important for the FAA’s research to determine why they have not yet had a significant impact on overall GA safety statistics.

Issue: Data Integrity

There has been an exponential growth in the volume of data associated with aviation operations. This data is generated, processed, and stored in highly distributed systems which include air traffic management automation, airline automation, aircraft avionics, and a variety of commercial vendors. These distributed systems are interconnected via a variety of air and ground networks. Ensuring the integrity of this diverse data set from unintentional errors, accidental corruption, and deliberate spoofing is important to ensure the reliability of aviation operations. At the same this data represents a significant resource to the broader R&D and operational community and the data must be made available to the maximum extent possible while maintaining appropriate levels of privacy and security. The FAA must “get ahead” of this issue by establishing appropriate policies for data collection, processing, storage, protection, and dissemination that keep pace with the exponential growth of data generation and increasing demand for the data to support operations, research, and development. A clear approach for developing and implementing robust cyber-security practices, in particular, is needed to address the increasing threats to US systems. These policies must appropriately balance the cost of collection and maintenance of the data with its utility to the broader aviation community.

Issue: Verification and Validation of Complex NAS Systems

The NAS is a very complex system as are the current and future systems that manage it. We require that these complex systems be extremely reliable and that they deliver their promised benefits. The Verification and Validation (V&V) of future NAS systems is an issue that will pace the FAA’s NAS modernization progress and therefore the FAA should “get ahead” of it. In anticipation of the implementation of increasing levels of autonomy and system complexity in NAS operations, FAA should focus on developing V&V techniques that handle both deterministic and non-deterministic system behavior (see related research opportunity below). The FAA should leverage research in other government agencies and V&V activities in other industries, particularly where there are likely to be overlaps in the physical and cyber-security components of the V&V process. This research should include not only the techniques for V&V; it should also address ways to introduce change into current institutional processes. Significant innovation is occurring in sectors that are not traditionally aviation-focused; there is a need to balance the disruptive approaches from “innovation” culture versus the traditional aviation safety culture. Software integrity and robustness is not only a concern for the end of a capability lifecycle. In addition to performing research specifically targeted to V&V techniques, the FAA should ensure that its research projects to develop new NAS capabilities address any unique V&V requirements for the new capability early in its development. Further, this research should be integrated into a broader evaluation of NAS robustness, addressing the various ways that efficient NAS operations can be disrupted.

**Research Opportunities for the FAA**

Research Opportunity: Increasingly Autonomous Systems in the NAS

This research opportunity is articulately summarized in the following excerpt from a National Research Council report[[3]](#footnote-3):

“The development and application of increasingly autonomous (IA) systems for civil aviation is proceeding at an accelerating pace, driven by the expectation that such systems will return significant benefits in terms of safety, reliability, efficiency, affordability, and/or previously unattainable mission capabilities. IA systems range from current automatic systems such as autopilots and remotely piloted unmanned aircraft to more highly sophisticated systems that are needed to enable a fully autonomous aircraft that does not require a pilot or human air traffic controllers. These systems, characterized by their ability to perform more complex mission-related tasks with substantially less human intervention for more extended periods of time, sometimes at remote distances, are being envisioned for aircraft and for air traffic management and other ground-based elements of the national airspace system. Civil aviation is on the threshold of potentially revolutionary improvements in aviation capabilities and operations associated with IA systems. These systems, however, face substantial barriers to integration into the national airspace system without degrading its safety or efficiency.”

Increasingly autonomous systems have the potential to significantly improve NAS safety and performance, particularly as applied to the planning, negotiation, and real-time monitoring of aircraft trajectories that satisfy user preferences in the presence of dynamic and stochastic airspace constraints. However, significant research and development is required to achieve these benefits.

While the FAA has the opportunity to leverage autonomy research at NASA and in the commercial world there is a need for a focused FAA effort to ensure that these sophisticated non-deterministic and adaptive software systems can be trusted and remain resilient in the NAS. There is a need to adapt current certification mechanisms and policies to ensure that they scale to the complexity of evolving automation technologies. The FAA research should address revisions to certification processes as well as new techniques for verification, validation, test and evaluation that can generate the data necessary for a safety determination. It should also address the new software and system architectures that ensures that increasingly autonomous operations have the level of robustness necessary for NAS operations.

Research Opportunity: Big Data/ Measuring the NAS

As described in its Strategic Plan, the FAA is committed to a consistent, data-driven approach when making system-level decisions. Given the complexity of the NAS and the exponential growth of data available (see related issue above), there is a need for a systematic approach to the collection and analysis of NAS performance data. There are many measures of NAS performance – some of them reflect the satisfaction of user demand and others reflect more technical aspects of system performance that enable optimization and problem diagnosis. The FAA should leverage industry and research community “big data” practices to guide its research on the collection and analysis of NAS data in order to inform its decision-making. Related to this is the challenge of defining new data sources, especially with the introduction of new entrants such as UAS or commercial space. This research opportunity is related to, but distinct from the data integrity issue described above in that the research here would be focused on the algorithms used to organize and analyze the data and the means to present that analysis to support decision making.

Aviation supplies excellent data for measuring system performance, compared to other modes of transportation, but aviation performance measurement lags other modes. Now that delay is coming to be understood as a feature of a healthy transportation network, it is time to research additional measures for evaluating the impact of real-time decisions. Large-scale transformations of the NAS need large-scale measures of performance. Research is needed to understand the NAS in its proper context: supplying high-price, high-value connections to parts of the economy that could not function at longer time scales.

Research Opportunity: Modeling and Simulation

Modeling and Simulation (M&S) are the principal tools that enable the FAA and the broader aviation community to understand how the NAS could operate in the future. A robust M&S capability allows researchers to design and test new concepts early in the development cycle, before proceeding to more costly field trials. Both fast time and human-in-the-loop simulations enable new concept validation and risk reduction that is essential to successful transition to operations. While it is important to perform M&S studies at an appropriate level of fidelity to ensure the validity of results, in general, the M&S capability can be matched to the specific research and development question being answered, thus reducing development cost.

The subcommittee has observed that the FAA has recently significantly scaled back its M&S efforts for operational concept validation. While this may be due to funding limitations, the subcommittee is concerned that a de-emphasis on M&S will simply pass on risk to the deployment phase of new capabilities, resulting in implementation delays and further funding shortfalls. FAA should invest in and utilize M&S to the maximum extent possible when exploring new concepts and continue its use of M&S throughout the development cycle. As part of this investment, FAA needs to ensure that M&S tools incorporate new entrants to the NAS such as the wide range of UAS operations and performance , commercial space operators, and other emerging users. The FAA should maintain a portfolio of simulation capabilities for concept development and risk reduction. The portfolio should be made broadly available to the FAA research community along with guidelines for its use. This will help ensure that results are equally valid across the research domains. Because there will be a continuing need for high fidelity, distributed, human-in-the-loop simulation that reflects the operational diversity of the future NAS, and because these large scale simulations are expensive to develop, the FAA should leverage the significant investment that DoD has made in live virtual simulation technology.

1. National Transportation Safety Board Review of US Civil Aviation Accidents (NTSB/ARA-12/01) October 2012. [↑](#footnote-ref-1)
2. Sobieralski, J.B., The Cost of General Aviation Accidents in the United States, Transportation Research Part A: Policy and Practice, Volume 47, January (2013). [↑](#footnote-ref-2)
3. National Research Council. “Autonomy Research for Civil Aviation: Toward a New Era of Flight”. Washington, DC: The National Academies Press, 2014. [↑](#footnote-ref-3)