**Long-Term FAA Research Topics**

1. Small UAS:  Owing to low-barrier of entry (cost, pilot skill requirements, infrastructure) the demand for sUAS airspace access is likely to continue to increase at a very rapid pace.  Operations are expected to span:
	1. agricultural applications in lightly used, unpopulated airspace of limited geographic range;
	2. applications of longer range but well defined flight paths (e.g. pipeline surveillance);
	3. applications without well-defined flight paths such a search and rescue;
	4. fully autonomous operations in urban areas.

The planned “small UAS rule”, while helpful, will satisfy only a fraction of these applications.  Specifically it does not allow beyond-line-of-sight operations, autonomous operations and operations over populated areas.  The more general FAA UAS CONOP for less restricted UAS flight 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 volume of operations that are expected. Research is needed to define and validate concepts of operation, air traffic management services, technologies and certification paths supporting the range of future sUAS operations. This research will need to include all aspects required to enable beyond line of sight operations, sense and avoid for aircraft above some operating ceiling, sUAS air traffic management including communications, roles and responsibility of pilots and ATC, and required ATM automation tools, airworthiness, and automation of flight control. There will need to be a set of requirements and enabling technologies that provides for increasing scope and tempo of operations over time, starting with a basic capability to enable limited beyond line of sight operations over low population areas such as search and rescue, increasing to beyond line of sight human piloted operations, and moving to fully automated operations in urban areas.

1. Highly automated, integrated air-ground air traffic management: Robust and sustained research is needed to continue the development of 4D-TBO concepts and technologies that accommodate both global efficiency (defined by ground automation) and avionics-managed, user-preferred trajectories. Several of the goals of the National Aviation Research Plan (NARP) have explicit links to such a capability, particularly Goal 3 (improved human-system integration and an increase in ATC efficiency through enhanced controllers-pilots coordination), and Goal 4 (feasible procedures, operational methods, and technologically-advanced systems that can decrease workload and increased efficiency in the NAS).

Research already conducted in this area has identified a number of challenges that impact the potential to leverage current systems (ground automation and airborne FMS systems) to realize potential efficiencies and other improvements.

* + Lack of common technical standards and requirements for FMS time-of-arrival control (TOAC)
	+ Requirements for wind forecast accuracy necessary to achieve required TOAC performance and reliability
	+ Means to identify and confirm aircraft with conforming avionics and TOAC performance capability
	+ Means to accomplish exchange of aircraft trajectory data (reflecting both user-preferences and aircraft control authority to achieve efficient times generated by ground automation) and integration of these data with ground automation and controller tools
	+ Aircraft certification and/or operations approval, safety standards, and aircrew training requirements
	+ Integration of this capability with other NAS Operational Improvements
1. Continuity of operations pace during adverse weather

Cancellations and diversions associated with thunderstorms, adverse winds, and changing airport ceiling and visibility continue to result in potentially avoidable delays that plague the traveling public.  NextGen procedures and technologies that rely on more precise control of aircraft trajectories, higher density operations, and collaborative information management may be even more sensitive to weather impacts than today’s NAS. Thus, the gap between fair-weather performance and weather-impacted performance may become larger than we experience today. As one current example, the enhanced predictability enabled by the Traffic Management Advisor (TMA) often cannot be realized during convective weather impacts since the system does not have the capability to model aircraft deviations around weather and the resultant effect on arrival timelines.

FAA investments in aviation weather research have resulted in significant enhancement to aviation-specific weather diagnoses and forecasts.   Significant research is needed, however, to develop effective approaches for estimating the impact on airspace resources (e.g., sector capacity, flow rates, runway throughput), characterizing the uncertainty of these impact estimates, and providing effective decision support for personnel responsible for traffic flow management. Modern machine learning techniques now provide the opportunity to more accurately model how complex weather situations impact capacity. In addition, these techniques are more robust to missing or incomplete data, and also provide a means with which the confidence in forecasted impact can be quantified. At the same time, there are significant research issues with respect to how uncertainties and forecasted impact information can be most effectively displayed and integrated with other information (e.g., demand data) for traffic managers and other stakeholders to aid in their collaborative decision-making processes. This information, in fact, could change the range of strategies available, resulting in more effective mitigation of weather impacts. Finally, there is no current means by which a given Traffic Management Initiative can be objectively scored in terms of its expected effectiveness in reducing air and ground delays, making it difficult to judge the relative merits of alternative strategies.

The FAA R&D portfolio should include components that address: (1) translation of weather conditions into quantified capacity impacts on airspace resources that are robust to variations in data availability and quality; (2) development of processes for site-specific or region-specific adaptation and validation; (3) capability to estimate the time-varying confidence of forecasted capacity impacts; (4) human-machine interfaces to convey expected impacts and their uncertainty levels, as well as procedures for decision-making based on that information; (5) methods for making quantifiable mappings between weather situation, capacity impacts, potential Traffic Management Initiative strategies, and resulting impacts on the NAS; and (6) improved training methods for traffic management including simulation, serious gaming, and incorporation of post-event review for continuous operational improvement.

1. Research supporting more effective controller/traffic manager selection, training and performance monitoring

As the NAS evolves towards trajectory based operations and tactical and strategic flow management (.e.g Time Based Flow Management, Airspace Flow Programs), control authority of flights is distributed between the cockpit, tactical controllers, automation systems and traffic managers. Controllers will need to consider the broader objectives established by ground and cockpit automation in providing separation services, while traffic managers will be expected to utilize an increasingly broad range of tools to maximize the efficiency of air traffic. It seems likely that today’s selection, training and performance-monitoring processes are decidedly suboptimal for maximizing the performance of the future workforce.

To enhance future controller and traffic manager selection, research is required to define the differing roles/responsibilities of the tactical controllers and traffic managers in the NextGen NAS. For each group, examples of successful decision making should be studied in order to evaluate the behavioral competencies that lead to such decisions (e.g. for Traffic Managers, the ability to improvise, make correct inferences, manage uncertainty and extract information to enhance their situational awareness). Metrics should be developed for relevant skills (or capacity to acquire such skills) and processes and technologies (e.g. virtual decision making environments) to measure these should be evaluated.

Today, significantly more effort is dedicated to training controllers as compared to traffic managers. The training academy provides procedural/regulatory knowledge and conveys basic controlling skills. In-depth facility training familiarizes the trainees with local procedures and on-the-job traffic control in an apprentice-style fashion. However, the failure rate of controllers at a demanding facility such as the New York TRACON remains so high that considerations are currently being given to reducing the facility’s capacity due to lack of controllers able to meet performance requirements. Consideration is given neither to the number/type of critical experiences (e.g., controlling traffic during convective weather and other off-normal conditions) required nor to the skill level ultimately required to be an operationally acceptable controller. Traffic management training is even less developed, consisting of a week of classroom discussions and then on-the-job experience training.

Research is required to enhance processes and technologies for training in the future NAS.Building on the workforce selection processes discussed above, the FAA will need to identify the critical experiences and skills required for both controllers and traffic managers to optimize safety and performance in the future NAS. Research and prototyping is required to identify the best means to deliver training and measure whether the controllers/traffic managers have achieved a certain level of performance. Operational evaluation must then occur to ensure that the training then translates to the desired operational benefits to the NAS.

Finally, continuous, real-time performance monitoring of the human element of the future NAS is needed to determine when alterations or improvements need to be made. Emerging cognitive performance monitoring techniques (involving vocal tract articulation, heart rate variability, facial expression, gene expression) should be evaluated to identify and prototype operationally acceptable forms of real-time individual performance monitoring for the purposes of identifying fatigue, workload, and operational proficiency. Techniques for monitoring the performance of a group of functionally coupled individuals (e.g. a traffic management unit, a tower control team) should also be evaluated.