Aviation Systems Division

The Aviation Systems Division of NASA Ames Research Center conducts research and development in air traffic management (ATM) and high-fidelity flight simulation to improve the safety, capacity, and efficiency of the National Airspace System (NAS), and to reduce the environmental impact of air transportation operations. We perform research in support of multiple NASA aeronautics programs emphasizing airspace operations, safety, the development of advanced test-beds for modeling and simulation, unmanned aircraft systems, and the application of autonomy towards aircraft and airspace operations. For high-fidelity flight simulation, we operate the Vertical Motion Simulator, the world’s largest flight simulator, as well as more traditional cockpit simulators, air traffic control simulation laboratories, and a full-scale, 360° visualization simulator.

We have a long history of researching, developing, and transferring ATM technologies for the flying public. We study all airspace domains in which commercial air traffic operates: the airport surface, the terminal area, the en-route environment, and the overall system from regional and nationwide perspectives. Each of these domains has unique challenges and operating constraints that limit efficiency. We are also researching how unmanned aircraft systems (UAS) can be safely integrated into the NAS as demand for their unique capabilities increases.

The Next-Generation Air Transportation System and Beyond
Our ATM researchers are creating and testing concepts that will enable the NAS to safely and efficiently meet projected increases in the demand and complexity of today’s and tomorrow’s commercial air traffic, as well as accommodate novel new aircraft and flying vehicles. How to safely introduce and manage new algorithms, new procedures, and increased levels of automation, and consider the appropriate role of the human operator, are key areas of ATM research.

On the airport surface, our researchers are working with airlines, airport authorities, and the Federal Aviation Administration (FAA) to evaluate the constraints and sources of uncertainties (such as weather), and to
develop algorithms, technologies, and procedures to minimize the impact of those uncertainties. We also develop trajectory-based, optimized taxi planning and gate, spot, and runway scheduling strategies and solutions that will reduce delays and the noise and emissions due to increased surface traffic.

The terminal area, representing approximately the last 50 miles of airspace operations into and out of busy airports, has long been a focus of our research, leading to tools such as the Precision Departure Release Capability (PDRC) and Terminal Sequencing and Spacing (TSS) technologies, transferred to the FAA in 2013 and 2014. These tools help address the complexity of terminal area operations, constrained by high density traffic and fewer options to absorb delay. We are working towards an integrated arrival-departure-surface solution to provide seamless technologies to pilots and controllers that will produce efficiencies for the entire operation, and not just for each individual domain.

The en-route environment poses challenges in separation assurance and severe weather avoidance. With the Dynamic Weather Routes (DWR) tool, we collaborated for several years with airline partners to provide solutions for aircraft to route around severe weather such as thunderstorms, and regain some time savings typically lost during severe weather operations.

In considering regional and national traffic flow management, our researchers are actively developing sophisticated models and performing detailed simulations of airspace operations, environmental and weather impact, and projections of future air traffic, to create solutions for large-scale traffic management initiatives that can improve efficiency across the national airspace. This modeling and simulation approach also helps to guide the research and establish a cost-benefits case for new concepts.

NASA is actively informing and guiding the nation’s policy with regard to how to operate UAS safely within the existing commercial airspace, and to help establish, through scientific and engineering studies, the recommendations for regulations in this dynamic new area of airspace operations. We are also researching the development of a UAS Traffic Management (UTM) system to accommodate the many public and private uses of UAS at low altitudes not frequented by commercial aviation.

**Advances In Computing and Autonomy**

As computing capabilities continue to evolve and advance, we are increasing the integration and fidelity of modeling and simulation to evaluate more detailed and revolutionary concepts for improving airspace operations. More sophisticated approaches to evaluating historical traffic management initiatives as well as projecting how new procedures and algorithms will perform, under increased, novel or unusual (off-nominal) traffic conditions, are being researched along with methods to improve efficiency and capacity through advanced networking and data sharing.

Autonomy and the increased dependence upon automation has grown in aviation and air transportation research. Researchers are seeking how to best allocate the operational functions between automation and human operators, and ways to introduce increased automation and autonomy to the commercial aircraft cockpit and the airspace system.

**Facilities and Capabilities**

The Aviation Systems Division houses some of the most sophisticated simulation and testing facilities in the world. We support a wide range of research, with emphasis on aerospace vehicles, aerospace systems
The Future ATM Concepts Evaluation Tool (FACET) is used to model the flow of air traffic across the U.S. A snapshot of all the flights over the U.S. at a given time is depicted.

and operations, human factors, accident investigations, and studies aimed at improving aviation safety. Our engineering modeling and simulation tools include the Airspace Concept Evaluation System (ACES) to evaluate the benefits of new ideas at a system level as well as examine and refine individual concepts. The Future ATM Concepts Evaluation Tool (FACET) has been used extensively to model the flow of air traffic across the U.S., and is used to evaluate new concepts in airspace design, traffic flow management, and optimization. Lastly, the overall air traffic control environment can be simulated in real time in our air traffic management automation laboratory, which is a unique capability that receives live radar data feeds of the nation’s air traffic to enable our concepts to be tested using real-world conditions.

Our ATM Data Warehouse, dubbed Sherlock, enables researchers to perform large-scale analyses on NAS data, stored in a central location. Sherlock contains several forms of air transportation data: raw flight plan and track data collected from the live FAA operational systems, weather observations, and NAS advisories and statistics; NASA-processed data which are parsed and merged data sources and metadata; derived data of pre-packaged analysis results; and reports based on commonly-used queries. Sherlock currently contains over 22 TB of data added continuously and collected since 2009. The data have been used for published research studies, such as finding similar days in the NAS and predicting imposition of traffic flow management restrictions.

For larger-scale, human-in-the-loop experiments and simulations, we operate a suite of laboratories with additional capabilities to link the facilities and to utilize live-virtual-constructive (LVC) operations.

The Vertical Motion Simulator (VMS) enables advanced research in a unique flight simulation complex. The facility provides researchers with exceptional tools to explore, define, and solve issues in both aircraft and spacecraft design. It offers fast and cost-effective solutions using real-time piloted simulation, realistic sensory cues, and the greatest motion range of any flight simulator in the world. Flexibility in both hardware and software allows any type of existing or conceptual vehicle to be simulated and evaluated. Past vehicles simulated include airships, helicopters, fighter jets, and the Space Shuttle Orbiter. Conceptual vehicles simulated include Tilt-Rotor, Tilt-Wing, High-Speed Civil Transports, Advanced Vertical Short Take-off and Landing (VSTOL) aircraft and next-generation space transportation vehicles.

FutureFlight Central (FFC) is a national simulation facility that presents a full-scale, 360° view of a three-dimensional (3D) database, using twelve 7.5x10 ft. tall displays. The facility can serve as a real-time air traffic control (ATC) tower simulator or can be used for any other application where an interactive, computer-generated, 360° visual is beneficial. As an ATC tower simulator, FFC allows stakeholders such as air traffic controllers, pilots, airports, and airlines to develop and test surface and terminal area concepts and tools for the next-generation air transportation system and beyond. FFC also has extensive video streaming capabilities, which combined with the 3D database makes the facility ideal for applications requiring an immersive virtual and/or video environment.

The Distributed Simulation Research Lab (DSRL) is the development and advancement facility for our LVC distributed test environment. The facility provides the infrastructure for conducting human-in-the-loop testing and enables the connection of any of our simulation facilities with simulated and live test environments at remote NASA, FAA, and industry partner facilities.
across the nation. The end result is a “virtual test range” that enables researchers to conduct human-in-the-loop testing using a broad variety of simulated and live systems without the need for a complete test architecture in a single location. The DSRL is a critical capability that currently supports NASA’s UAS Integration in the NAS project.

The Crew-Vehicle Systems Research Facility (CVSRF) houses two high-fidelity motion flight simulators—a Level D compliant Boeing 747-400 simulator and the Advanced Concepts Flight Simulator (ACFS)—and an ATC laboratory with ten radar positions to simulate terminal and/or en-route ATC operations. The facilities are capable of full-mission simulations that can interact with each other, allowing for enormous flexibility and customization, thus enabling the study of the effects of automation on human performance.

The NASA/FAA North Texas Research Station (NTX) is a collaborative effort between NASA Ames Research Center and the FAA to support ATM research through field evaluations, shadow testing, simulation evaluations, data collection, and data analysis. NTX is located on the premises of the FAA’s Fort Worth Air Route Traffic Control Center, in close proximity to Dallas/Fort Worth International Airport and several major airline facilities. This unique location, combined with an experienced engineering staff, high-quality infrastructure and long-standing relationships with key FAA, air carrier, and airport organizations, enables NTX to support the full range of ATM research activities.

The Air Traffic Control Simulation Laboratory with eleven radar positions is used to simulate advanced ATM concepts with human operators in the loop. Researchers can collect engineering data on algorithm and concept performance, human reaction time, user preferences, interface design, procedures, and communications. The lab is equipped with communication systems to enable controller–pilot voice exchanges, and pilot stations, as well as actual FAA terminal automation system hardware and displays, to provide a high level of realism in ATC simulations.

The Aviation Systems Division’s approximately 75 civil servants and 130 contractors have a variety of technical backgrounds in all areas of engineering, science, human factors, and flight simulation. We engage in research collaborations outside of NASA with partners such as the FAA, the Departments of Defense, Homeland Security and Transportation, and the National Transportation Safety Board as well as US commercial airlines and avionics manufacturers, and aerospace research laboratories in Europe and Asia.

For more information about the NASA Aviation Systems Division, visit [www.aviationsystems.arc.nasa.gov](http://www.aviationsystems.arc.nasa.gov).

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