



# Airspace Systems Program

A quarterly update of accomplishments and upcoming activities from NASA's Airspace Systems Program.

APRIL—JUNE 2010

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# Technical/Programmatic Highlights

## **1 Dynamic Airspace Configuration Research Transition Team Meeting, March 2010, NASA's Ames Research Center**

*Details:* Representatives from the FAA, MITRE, JPDO, and NASA gathered to discuss recent Dynamic Airspace Configuration (DAC) research and next steps for research transition. NASA received positive feedback on proposed research directions for flow corridors, flexible airspace, and generic airspace. Flow corridors enable high density traffic along compact corridors of airspace by segregating the corridor operations from surrounding airspace. NASA flow corridor research focuses on identifying volumes and percentages of aircraft equipage at which corridors allow a significant reduction in resolution maneuvers. NASA's flexible airspace research focuses on the benefits of modifying airspace boundaries in response to fluctuations in demand due to volume changes or reroutes around weather. The FAA suggested focusing this research on interactions with Traffic Flow Management. NASA's generic airspace research recently completed a human-in-the-loop experiment showing how NextGen automation tools allow controllers to manage unfamiliar airspace with only a minor workload increase. The FAA suggested studying how well controllers could manage unfamiliar airspace with mixed equipage operations or dynamic airspace operations. NASA DAC research continues to be reflected in the FAA's National Airspace and Procedures Plan, which is to be released in September 2010. When complete, NASA will present results of its planned research at a follow-on meeting hosted by MITRE, or the FAA Technical Center.

## **2 Coordinated experiment of an Automated Separation Assurance Human-In-The-Loop simulation successfully completed at NASA's Ames Research Center and NASA's Langley Research Center, February-March 2010**

*Details:* Researchers simulated an advanced operational concept of the Next Generation Air Transportation System (NextGen) using

an Automatic Dependent Surveillance Broadcast (ADS-B) enabled operation, self-separation and 4D trajectory-based operations at approximately two-times current air traffic control maximum capacity. This experiment achieved unprecedented commonality between Ames and Langley experiment designs for comparing disparate concepts. It matured flight-deck automation technology and was sponsored by the NextGen Airspace and Concepts & Technology Development Project of NASA's Airspace Systems Program. The Langley SA HITL experiment was paired with an Ames SA HITL experiment to investigate, through a jointly developed experiment commonality plan, different allocations of the traffic separation function of Air Traffic Management (ATM). The Langley experiment modeled a distributed airborne allocation of separation assurance using airborne self-separation capability, whereas the Ames experiment modeled a centralized ground-based allocation using trajectory data link capability, with both concepts relying heavily on Automatic Dependent Surveillance Broadcast (ADS-B) for surveillance and automated functions for conflict detection and resolution. Both concepts reflect the Next Generation Air Transportation System (NextGen) focus on 4D trajectory-based operations, and the experiments contribute to NASA's charter to research ATM function allocation for the Joint Planning and Development Office (JPDO). The experiments were coordinated to address the challenges in producing comparable results of disparate concepts represented at medium human-in-the-loop fidelity across disparate simulation platforms.

The Ames study on Ground-Based Automated Separation Assurance was conducted in the Airspace Operations Laboratory (AOL). Two primary air traffic control rooms were configured with ten test positions (eight controllers plus two supervisors) and produced 220 hours of data from the ten positions each working a total of 22 hours. Current FAA controllers and supervisors, as well as recently retired controllers, worked advanced NextGen workstations in the primary test sectors and support positions for the surrounding

airspace. Ten simulation pilots managed the aircraft for this simulation. In complex traffic scenarios of 15-minute, 30-minute and three-hour durations, controllers interacted with advanced technologies for ground-based separation assurance, weather avoidance and arrival metering to manage much higher traffic densities than currently experienced in the National Airspace System. During the simulation, traffic densities in some sectors were increased to more than 50 aircraft. For comparison, in today's system these sectors are configured to handle no more than 18 aircraft. The current approach to separation assurance at these high traffic levels is centered on sophisticated ground-based automation, which conducts routine operations, performs standard separation assurance tasks and provides a safety net. When more complex situations arise, controllers step in to make decisions and manage the automation.

Researchers in the Crew Systems and Aviation Operations (CSAOB) Branch at Langley have completed data collection for a simulation experiment of airborne self-separation. The Separation Assurance Human-in-the-Loop (SA HITL) experiment was conducted in the Air Traffic Operations Laboratory (ATOL) and involved 48 commercial airline pilots from the U.S. and Europe flying scenarios of high traffic density in simulated en-route airspace. The Langley experiment collected 264 pilot-hours of data across 14 scenarios simulating traffic densities up to two times today's traffic capacity. Pilot procedures included resolving traffic conflicts and adjusting trajectories to meet assigned arrival schedules. Independent variables included traffic density, the presence of arrival time constraints, and the timing of arrival delay assignment. Arrival delays requiring path changes were issued at either disbursed or synchronous times to investigate operational agility. In a first for Langley ATM experiments, one of the four subject groups included nine European pilots to support a global perspective on ATM research. The results of this and future studies on function allocation are expected to influence the direction of far-term operations in NextGen and beyond.

## Research Events and Activities

- **Jun. 1-30:** Separation Assurance with FANS-1 /A Automated Resolution Implementation, NASA Ames
- **Jun. 8:** Merging & Spacing/Interval Management (IM) Working Group
- **Jun. 8-10:** Closely Spaced Parallel Operations (CSPO) Working Group, Washington, DC
- **Jun. 8-11:** ACES Workshop, NASA Ames
- **June 10:** NASA/FAA NextGen V&V Technical Interchange Meeting, FAA Tech Center Atlantic City
- **Jun. 13-18:** ADS-B Requirements Focus Group (RFG) Working Group (RTCA-186 and EuroCae WG-51), FAA Tech Center, Atlantic City
- **Jun. 14-Jul. 2:** Generic Airspace Phase 4 HITL Experiment Study, NASA Ames
- **Jun. 21-Jul. 9:** Terminal Area Procedures for Paired Approaches Runways (TAPPR) Experiment 2, NASA Ames
- **Jul. 27-29:** Generic Airspace Phase 4 HITL Experiment, NASA Ames
- **Aug. 2-5:** AIAA Guidance, Navigation and Control Conference
- **Aug. 2-5:** AIAA Modeling and Simulation Technologies Conference
- **Aug. 10-19:** Flexible Airspace II Experiment, NASA Ames
- **Sep. 8-9:** Green Aviation Conference, NASA Ames
- **Sep. 13-15:** AIAA Aviation Technology, Integration and Operations Conference
- **Sep. 19-24:** International Council of Aeronautical Sciences (ICAS) 2010

### **3** Successfully completed human-in-the-loop simulation of the Efficient Descent Advisor (EDA), April 2010, NASA's Ames Research Center

*Details:* A simulation of the Efficient Descent Advisor (EDA) was successfully conducted in the Crew-Vehicle Systems Research Facility (CVSRF) using the air traffic control simulation laboratory and the Boeing 747-400 cockpit simulator. The primary objectives were to evaluate secondary advisories to correct for predicted arrival-time errors induced by trajectory-prediction uncertainty and/or flight technical error, and also to study cruise-altitude advisories used for resolving conflicts with over-flight traffic. Data was collected to assess automation performance and controller acceptability under varying EDA configurations and traffic loading. Three controllers from Denver Center were rotated through three adjacent arrival sectors. The Boeing 747 simulator (flown by pilots from United Airlines and Cathay Pacific) was included in each simulation scenario to evaluate how EDA advisories impact the flight deck, and the time required by crews to enter EDA clearances into airborne automation systems. Observers over the four-day simulation included subject-matter experts from Boeing, MITRE, the Federal Aviation Administration and the National Air Traffic Controllers Association. Data analysis is underway.

### **4** High-fidelity simulation environment built for Surface Advisory Tool Experiment, March 2010, NASA's Ames Research Center

*Details:* A high-fidelity Human-in-the-Loop (HITL) simulation environment was successfully built, thus forming the foundation for conducting research in the airport surface domain. The Spot and Runway Departure Advisory (SARDA) tool was tested as a possible near-term decision support tool for tower controllers to enhance the efficiency of surface traffic. Two optimization algorithms were developed:

- Spot Release Planner (SRP) – provides the ground controller with optimum spot release sequences and times that reduce taxi delay while maintaining maximum runway throughput.
- Runway Scheduler (RS) – provides local controllers with runway departure sequence advisories as well as arrival runway crossing advisories.

Human factors researchers investigated controller interactions with the tool and usability of the algorithms, followed by a data collection simulation.

### **5** Third surface optimization NRA Workshop, January 2010, San Jose State University

*Details:* Two NRA teams led by San Jose State University and the Georgia Institute of Technology presented their results on the development of surface optimization algorithms and the integration of those algorithms into simulation software platforms. The NASA team discussed the human-in-the-loop surface simulation of the Spot and Runway Departure Advisory (SARDA) tool that was completed in December 2009, as well as results from their surface optimization algorithms. The SARDA human-in-the-loop experiment is to provide an optimal sequence and timing for releasing departure aircraft from spots to the ground controller. The objective is to increase the departure runway throughput while reducing the runway queue size and minimizing taxi time by controlling spot release times of departure aircraft. Third-year goals of these NRA activities are to 1) improve robustness of the surface algorithms, 2) integrate algorithms, and 3) implement their algorithms into NASA's Surface Management System (SMS), which is a real-time simulation platform. The NASA team presented the new modular and extensible architecture of SMS software, from which the NRA teams showed a great interest in collaborating with NASA to implement their optimization algorithms for further evaluation on a common platform.

## 6 **Third Environmental NRA Workshop, February 2010, NASA's Ames Research Center**

*Details:* The NRA team led by Metron Aviation presented results of emissions and noise computations based on their Environmental Planner tool. Attendees included researchers from Metron Aviation, George Mason University, NASA, and UARC. The Environmental Planner uses emissions, noise, and/or fuel in an optimization algorithm to reduce environmental impacts while achieving efficient surface operations. Third year goals of this NRA activity are to 1) refine the Environmental Planner algorithms, 2) conduct extensive sensitivity analyses with varying environmental and operational parameters, and 3) develop a high level design of system architecture with input/output specifications of each component in the system.

## 7 **Second simulation completed for Terminal Area Paired Procedures Research (TAPPR), March 2010, NASA's Ames Research Center**

*Details:* The Terminal Area Paired Procedures Research (TAPPR) concept focuses on the delivery of aircraft pairs, one plane five to 25 seconds in trail of the other, to a coupling point 12 nautical miles from the runway threshold. Air traffic controllers have recommended that this type of decision support tool would be of value today during Simultaneous Offset Instrument Approach (SOIA) operations. Preliminary results show that most pairs met the timing constraint at the coupling point. This concept allows paired landings to closely-spaced parallel runways during Instrument Flight Rules conditions—furthering the NextGen goal of increasing the capacity of airports in all weather conditions. In this experiment, enhancements to the timeline display, pairing logic, and conformance monitoring were made using experimental data and participant feedback from the first TAPPR experiment. The experiment consisted of three levels of automation: 1) manual determination and management of pairs; 2) automated assistance to controllers in creating and managing pairs; and 3) more automated assistance in evaluating, selecting and managing pairs, as well as an automated pairing algorithm to assist in determining the best pairs. Controllers made effective use of timeline

guidance for pairing in the TRACON sectors and considered it a useful aid. In the first TAPPR experiment the controllers preferred the second level of automation. However, in this experiment, which included enhancements to the decision support tool, the highest level of automation was preferred. A conformance window was available on the controller display and this enabled the controllers to monitor the status of the trailing aircraft with respect to the timing constraint at the coupling point. The third experiment is scheduled for June/July 2010.

## 8 **Analysis of performance and feasibility of the Simplified Aircraft-based Parallel Approach (SAPA) Concept, March 2010, NASA's Langley Research Center**

*Details:* SAPA is one of the advanced concepts being considered for dependent, low-visibility operations for dual and triple runways spaced closer than 2,500 feet. For runways with centerline spacing closer than 2,500 feet, wake turbulence encounters between aircraft on parallel paths becomes problematic and dependent operations are required. At the request of the FAA, NASA performed an initial system study of the SAPA concept to assess operational benefits and constraints plus a preliminary technical feasibility analysis. While this assessment is preliminary, it has shown the basic SAPA concept to be technically and operationally feasible. An example implementation of the concept was developed in some detail, including identification of potential pilot/controller roles and responsibilities. Several design and implementation issues were explored, which should be useful to aid the FAA in the development and refinement of the SAPA concept. This effort was jointly funded by the FAA and the Airspace Systems Program. A white paper has been written to summarize this detailed study, and is in the process of being thoroughly reviewed within NASA with the intention of it being turned into a formal NASA Technical Memorandum (TM). Follow-on studies are being sought with our FAA customer to more fully explore the design space suggested by this concept of operations for closely spaced parallel runways.

## Research Events and Activities Continued

- **Sep.:** Collision Avoidance for Airport Traffic (CAAT) Fast-Time Simulation Study, NASA Langley
- **Oct. 3-7:** 29th Digital Avionics Systems Conference (DASC)
- **Oct. 6-7:** ASP Users Forum
- **Oct. 11-22:** Trajectory-based Operations with Datacom Simulation, NASA Ames
- **Oct.:** Separation Assurance Dynamic Weather Batch Study, NASA Langley
- **Nov.:** En Route Descent Advisor / 3D Path Arrival Management Experiment, NASA Ames

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- **Mar.:** ASP Technical Interchange Meeting

### **About This Newsletter**

The Airspace Systems Program issues this quarterly newsletter to report on completed research activities and to provide a record of current and upcoming events of interest to the community. If you have questions about any of the information in this issue, please contact John Cavolowsky at NASA-ASP@nasa.gov.

## **9 Simulation of market-based system for prioritizing flights shows promise among airline dispatchers, January 2010, NASA's Ames Research Center**

*Details:* An experiment using Credit-based User Preference System (e-CUPS) was conducted to evaluate a system for prioritizing flights traveling through congested airspace. e-CUPS allows airline dispatchers to specify their high priority flights by assigning them credits, which are allocated to dispatchers according to their number of flights. The system gives flights with the most credits their requested departure times and routes. Flights with fewer credits may be delayed or re-routed to alleviate congestion. To evaluate the system's feasibility and benefits, five airline dispatchers from American Airlines, AirTran Airways, Continental Airlines, Southwest Airlines, and United Airlines used the system to manage a set of flights through several simulated air traffic scenarios. A recently retired air traffic manager set constraints on airspace capacities. Data and post-experiment surveys indicated that dispatchers successfully distributed delays among their flights based on their priorities. Their priorities mainly consisted of maintaining schedule integrity, minimizing fuel consumption, and preserving flight connectivity. To make future experiments more realistic, participants suggested constraining airport arrival and departure rates and more realistically simulating weather, along with other enhancements. The next experiment is planned for the fall of 2010.

## **10 Accelerating FACET simulations March 2010, NASA's Ames Research Center**

*Details:* Optimal Synthesis wrapped up a Phase II SBIR and kicked-off a Phase III SBIR on the same topic: accelerating Future ATM Concepts Evaluation Tool (FACET) simulations. Their work on a Computational Appliance for the Rapid Prediction of Aircraft Trajectories (CARPAT) has produced a hardware-software co-design that is capable of predicting trajectories nearly 200 times faster than was previously possible. For Phase III they will be developing code that will ease the use of the tool for researchers in Traffic Flow Management. The tool's power also will be demonstrated through an experiment involving dozens to hundreds of FACET simulations to measure the effects of

uncertainty in TFM. Phase III was made possible through the use of Recovery Act funds.

## **11 Trajectory uncertainty modeling capability now available for fast-time simulations, March 2010, NASA's Ames Research Center**

*Details:* A major enhancement to the Airspace Concepts Evaluation System (ACES), the fast-time tested for large-scale simulations was completed the last week of March. The new capability incorporates realistic trajectory uncertainties into the ACES trajectory prediction. The software now allows for parametric variation of cruise speed, aircraft weight, top-of-descent point, and decent profile uncertainty. These enhancements open an important new avenue of research into the effects of trajectory prediction uncertainty on the performance of automated separation assurance tools.

## **12 NASA/FAA Data Comm experiment completion, March 2010, NASA's Langley Research Center**

*Details:* NASA Langley planned and conducted a human-in-the-loop simulation experiment for the FAA Data Comm Project. The purpose of the experiment was to investigate the acceptability of data communications (data comm) in the Terminal Maneuvering Area, as well as investigate issues of crew trust in data comm during rare events. Data collection for the experiment was completed in mid-March. Twenty-two current and qualified Airline Transport Pilots operated a Boeing 757-200 simulator Integration Flight Deck (IFD) in a high-fidelity replication of Boston (KBOS) airspace, and the associated airport runways, taxiways, and terminal gate areas. Operations included both arrivals to, and departures from, Boston, with the research focusing on data link-taxi-in and data link-taxi-out instructions. Researchers varied communications modality (voice, data link) and graphical display methodology (paper airport diagram, moving map display, with and without depicted routes). The simulation also included scenarios to examine the effects of rare events on crew trust. The simulation included a ten oculometer eye and head tracking system, believed to be the first (and most capable) of its kind in the world. This allowed quantitative measurements of head and gaze vectors as a function of time throughout the experiment, but without the requirement

for head-mounted equipment on the crew. Simulation scenarios involved multiple arrival and departure scenarios, using established KBOS procedures, for 21 scenarios per crew, providing 231 runs for the experiment. Significant new capabilities were added to the simulator for this experiment, including the ability to generate the approximately 200 traffic aircraft, as well as develop scenario scripts to control all research aspects of the scenario, outside the IFD. Crew response to the scenario realism, capabilities indicated by the systems and equipment simulated, and operational potential for data comm in the simulated environment, was positive. Data analysis is ongoing and will result in a final report.

## **13 Operational Traffic Management Advisor (TMA) data supports NASA research, April 2010, NASA's North Texas Research Station (NTX)**

*Details:* For nearly 15 years, NASA air traffic management research has benefitted from a TMA prototype in operational use at the FAA's Fort Worth Air Route Traffic Control Center (ARTCC). NASA researchers have collected data from the TMA system and have found that the operational TMA data provides unique Air Traffic Control (ATC) status, intent and action information not available from other sources. The NASA TMA prototype at Fort Worth ARTCC has recently been replaced by a production TMA system deployed under the FAA's Time Based Flow Management (TBFM) program. NASA and the FAA have jointly developed the Operational TMA/TBFM Repository (OTTR) system, which replaces and expands on the data analysis capabilities of NASA's TMA prototype. Hosted at NTX, OTTR processes raw data collected by the FAA from operational TMA systems at all 20 ARTCCs in the nation. The OTTR system generates daily reports concerning ATC status, intent and actions and delivers these both to the FAA to support TBFM development and to NASA to support NextGen research. NASA initially invested in OTTR to support departure scheduling analyses for the Precision Departure Release Capability (PDRC) research activity; however, OTTR data are available for use by all NASA NextGen researchers.