National Aeronautics and Space Administration

Airspace Systems Program Newsletter

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// ASP Completes Annual Agency Priority Goals

NASA defines its agency priority goals (APGs) within its strategic plan. NASA's own priority goals represent

challenging, near-term targets that the agency pursues to benefit the American people. The Airspace Systems

Program had two APGs for FY12, "Initial Weather Translation Models" and "Demonstrate Safe Interval

Management to a Single Airport with Dependent Parallel Runways."

// Technical/Programmatic Highlights

CTD Project Completes APG "Initial Weather Translation Models," August 2012

This research focused on predicting weather impacting airport arrival rate (AAR), which is a critical parameter used by the (FAA in developing ground delay programs, ground stops, and for metering traffic into the nation's busiest airports. Three models provided an estimate of the weather's impact (e.g., high surface winds, low visibility, etc.) on an airport's capacity for one to eight hours in the future. These models incorporated forecasts from three state-of-the-art, airport-centric weather forecasts from the National Weather Service. Two of the models on average were able to predict the weather-impacted AAR at two representative airports over a one-hour look-ahead time horizon within 10-15% of the actual weather impacted AAR. The third model was able to estimate the weather impacted AAR within 5% of the actual weather that impacted AAR at three representative airports.

The direct effect of this research is evident in the FAA's approval to conduct an operational field evaluation of a model that translates the probabilistic forecast of stratus clearing time at San Francisco International Airport (SFO) into an AAR used by traffic management coordinators. Analysis indicates that unnecessary delay for SFO arrivals can be reduced by 29%, which translates into an annual savings of $2.8 million in airline operating costs. The following manuscripts describe the three models: "The Utilization of Current Forecast Products in a Probabilistic Airport Capacity model," 92nd Annual American Meteorological Society Meeting, and "Prediction of Weather Impacted Airport Capacity using RUC-2 forecasts," 31st Digital Avionics Systems Conference (DASC/accepted). (Airports used: Newark, Chicago and Atlanta)
(POC: William Chan)

SAIE Project Completes Interval Management APG, July 2012

The "Demonstrate Safe Interval Management to a Single Airport with Dependent Parallel Runways" APG is the culmination of a multi-year, joint-project, Research Transition Team effort to quantify the benefits of interval management (IM) procedures at a single airport with dependent parallel runways, utilizing mid-term Next Generation Air Transportation System (NextGen) technologies in a mixed-equipage environment. Specifically, the purpose of this APG was to evaluate IM flight crew procedures into a single airport using mid-term technologies: coordinated data analysis (CDAs) to closely spaced parallel approaches (CSPAs), area navigation/required navigational performance (RNAV/RNAP) routing, and a flight deflection measurement system (FDMS)) in mixed operations to multiple runways.

The APG's objectives were to quantify benefits, such as throughput, delay and efficiency in both batch and human-in-the-loop (HITL) simulations, assess pilot acceptability and workload using HITL simulations, and assess man/machine functional allocation with increasing technology. Using the results from several batch studies and one HITL simulation, the capability

to precisely deliver aircraft to the runway threshold was quantified. Results also included an analysis of pilot acceptability and workload impact from the HITL simulation, along with an evaluation of IM procedures to an airport with dependent parallel runways. The three objectives of the effort were met.

Outcomes indicated that pilots delivered their aircraft to the runway threshold within +/- 3.5 seconds of their assigned arrival time and reported that procedures were associated with low workload levels. Pilots also found the IM concept, procedures, speeds, and interface acceptable, with 92% of pilots rating the procedures as complete and logical. Lastly, a mean time of under 43 seconds for the flight crew was noted in loading the clearance into the IM spacing tool, reviewing the calculated speed, and responding to air traffic control.

The results, analysis and evaluations have been captured in several publications, including "Interval Management with Spacing to Parallel Dependent Runways (IMSPiDR) Experiment and Results" (Baxley, et. al., ICAS 2012-9.10.3); "A Concept for Airborne Precision Spacing for Dependent Parallel Approaches" (Barmore, et. al., NASA TM 2012-217346); "Evaluation of an Airborne Spacing Concept, On-board Spacing Tool, and Pilot Interface" (Swieringa, et. al., AIAA 2011-6902); "Use of Data Comm by Flight Crew to Conduct Interval Management Operations to Parallel Dependent Runways" (Baxley, et. al., AIAA 2011-6972); "An Overview of a Trajectory-Based Solution for En Route and Terminal Area Self-Spacing to Include Parallel Runway Operations" (Abbott, NASA CR-2011-217194); and "The Effect of Aircraft Configuration and Flight Crew Compliance with Procedures While Conducting Flight deck based Interval Management (FIM) Operations" (Shay, et. al., ATIO 2012). *(POCs: Bryan Barmore, Brian Baxley)*

// ASP NASA Research Announcement (NRA) News & Awards

July 2012

Saab-Sensis provided a final briefing on the "Requirements, and Algorithms for Ground-based Airport Surface Conflict Detection and Resolution" NRA at NASA's Ames Research Center on July 20. New technologies developed included advanced decision support systems and automation technologies for surface traffic management using robust optimization techniques for the scheduling and control of ramp, taxiway, and runway operations. The concept of time-based (4-dimensional, or 4D) taxi clearances that would be generated by an automation tool and digitally issued to the flight deck, the synthesis of detailed 4D surface trajectories of individual aircraft from the surface schedule using knowledge of aircraft dynamics, and other factors were also included. Their final report has been completed and is available upon request from: *NASA-ASP@nasa.gov*
(POCs: Justin Montoya, Seth Kurasaki)

August 2012

NASA's NextGen CTD Project's Surface Conflict Detection and Resolution (SCDR) with Emphasis on Trajectory Based Operations NRA to conduct research to develop concepts and technologies that would enable significant increases in efficiency and throughput of airport surface operations while maintaining safety was completed as of August 29. As part of this NRA, Optimal Synthesis and Tufts University developed advanced decision support systems and automation technologies for surface traffic management for the scheduling and control of ramp, taxiway, and runway operations. Included were the concept of 4D taxi clearances that would be generated by an automation tool and digitally issued to the flight deck, the synthesis of detailed 4D surface trajectories of individual aircraft from the surface schedule using knowledge of aircraft dynamics, as well as other factors.
(POCs: S. Lozito, S. Kurasaki)

Partners Saab-Sensis and Texas A&M validated SCDR against diverse scenarios, integration with the Surface Management System (SMS), generating spot-release conflicts in the SMS environment, and development of architecture for flexible integration with the SMS. Recommendations for next steps include investigating safety and efficiency, interaction with surface optimization tools, and how controller alerts compare with cockpit alerts.
(POCs: J. Montoya, S. Kurasaki)

August 2012 NRA Awards

- "NASA Com50," awarded to Rockwell Collins.
- "Comprehensive Analysis of Uncertainties in the National Airspace System," awarded to
- Purdue University.
- "Comprehensive Analysis of Uncertainties in the National Airspace System and Their Implications for Operational Concepts," awarded to Metron.

September 2012

The final brief for the first year of the Saab/Sensis "Adaptation of a Surface Traffic Management Tool to

Multiple, Capacity-Constrained Airports" NRA was conducted on September 27. This NRA assessed Spot and Runway Departure Advisor (SARDA)-like schedulers at three airports (Charlotte Douglas, Boston's Logan, and New York's John F. Kennedy) using fuel-trim simulations. The movement area delay savings translated to shorter movement area taxi-out times and reduction in fuel burn and emissions. At Charlotte Douglas a more-than-50% savings in movement area taxi-out time was observed, and a 25% savings in fuel burn and emissions. The comparable figures at Kennedy were 15% and 13%, respectively, and for Logan 32% and 24%.

Update on the NAS Uncertainties Analysis NRA, September 2012

Work began on research to enlist a top-down, state-based system modeling method to comprehensively identify sources of uncertainty related to the predictability of the national airspace system, the characteristics and the implications of that uncertainty, and to consider how to reduce or mitigate that uncertainty.

The highly innovative approach utilizes on a state-based modeling methodology developed under a previous NASA research project to comprehensively enumerate the uncertainties. Moreover, the method identifies the relationship of uncertainties to specific agent capabilities and system functions, including how uncertainties primarily viewed as affecting one function will also affect other functions. Benefit mechanisms and estimates will also be computed.

Typically, identification of uncertainties is performed using enumeration, where past literature or experts are referenced. However, enumeration cannot be trusted to be exhaustive, since it is always possible that past data and experts may have missed something. Moreover, new or highly modified systems, such as NextGen, are very likely to encounter uncertainties, or reactions to uncertainties, not previously encountered. The state-based modeling method utilized in this proposed work is demonstrably complete, and can therefore be defended as being exhaustive.

At the end of the project period NASA will have a comprehensive repository of the best-known uncertainty estimates and confidence intervals on those estimates, analysis and documentation of how those sources of uncertainty can be affected or mitigated, and estimates of cost-benefit tradeoffs in affecting or mitigating those sources of uncertainty. NASA will be able to utilize this repository in future simulations, including determining how robust solutions are to mistakes in determining the estimates. This work will directly contribute to project milestones by identifying specific concepts, procedures, and technologies that, when implemented, can reliably produce improvements in total delays of 10% or an improvement in user preference accommodation of at least 8%, and by providing NASA with information sufficient to test such concepts, procedures, and technologies in simulation. *(POC: Lawrence Green)*

TASAR Concept/ R&D Plans Briefed to Operational Community, June 2012

David Wing briefed members of the aviation community on the Traffic Aware Strategic Aircrew Request (TASAR) concept and technology, with support from CTD Project Scientist Mark Ballin, aviation consultant Bill Cotton, and CTD Deputy Project Manager Rudy Aquilina. TASAR is a NASA-developed, near-term application of Automatic Dependent Surveillance Broadcast (ADS-B), intended to accelerate ADS-B equipage while providing immediate benefits to operators. It accomplishes this through an onboard automation tool that monitors trajectory-improvement opportunities that are compatible with traffic separation requirements. Those opportunities are presented to the pilot, who uses standard procedures to make trajectory change requests to air traffic control. Pre-computed compatibility with the traffic environment, using ADS-B data, will allow air traffic controllers to more frequently approve aircrew requests for beneficial trajectory improvements.

During onsite visits between June 21 and June 29, a diverse set of organizations were briefed on TASAR. Included were business jet manufacturer Gulfstream, FAA SE-2020 prime contractor General Dynamics Information Technology, member representative the National Business Aviation Association, fractional ownership aircraft fleet operator Flight Options, and major air carrier United Airlines. NASA's purpose for these visits was to elaborate the TASAR concept and NASA's two-year research and technology development plans,

which culminate with an initial flight evaluation on a Piaggio Avanti flight-test aircraft.

These visits lay the groundwork for potential future partnerships to transfer the TASAR software for near-term operational use and provide feedback to NASA for further development and partnered advancements. Feedback from all organizations was very positive, with several senior managers expressing intent to brief TASAR to their senior company leadership to explore potential engagement with NASA. Exchange of ideas of how TASAR could be used was also fruitful and will lead to improved capabilities in the technology. TASAR concept of operations, its enabling automation technology which is currently under development, and NASA's plans for concept assessment and maturation can be found at *http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20120014582_2012016103.pdf*.

Expected opportunities for use and benefits have been quantified and can be found in the paper "Preliminary Benefits Assessment of Traffic Aware Strategic Aircrew Requests (TASAR)" at *http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20120014584_2012016105.pdf (POC: David Wing)*

Aeronautics Students Brief the Aeronautics Research Mission Directorate, July 2012

Aeronautics Academy students and Aeronautics Scholarship recipients participated in a student forum called Ideas in Flight. Enthusiasm for the first "A" in NASA runs high among this group. Students from NASA research centers at Ames, Dryden, Glenn and

Langley met with Associate Administrator for Aeronautics Jaiwon Shin and his staff for two days of presentations in the James E. Webb Auditorium at NASA Headquarters. Fifty-six students had up to 10 minutes as individuals or teams to summarize what they had done over the summer, and describe what being at NASA meant to them or how the work they observed will benefit the nation. Administrator Bolden dropped by to listen and to speak briefly with the students on both days. The event was recorded, with some students

Ideas in Flight Program Cover

being interviewed for a "This Week at NASA" segment, and many students were invited to visit their congressional representatives. Students came away with a greater sense of their potential role in the future aeronautics workforce. The event program can be viewed at *http://www.aeronautics.nasa.gov/pdf/ideas_in_flight_program_2012.pdf*.

For more information on the Aeronautics Academy, visit *http://aero.larc.nasa.gov/academy.html*

For information on the Aeronautics Scholarship Program, visit *http://nasa.asee.org*
(POC: Mark Ballin)
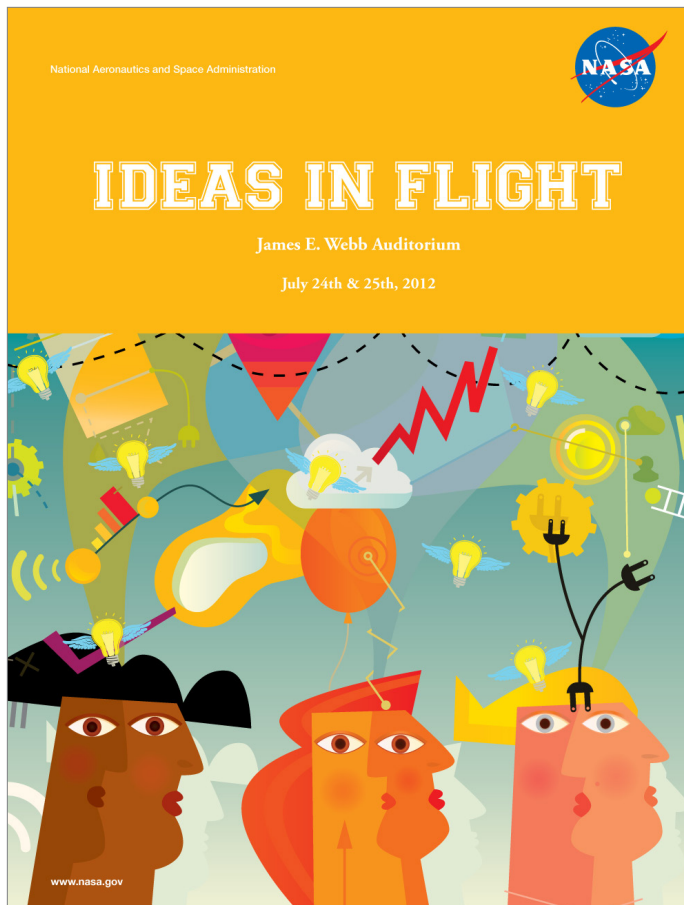
NASA Completes T-TSAFE3 HITL Simulation, July 2012

Two weeks of data collection for the Terminal-Tactical Separation Assured Flight Environment-3 (T-TSAFE3) Human-in-the-Loop (HITL) simulation were completed on July 20. T-TSAFE is a tactical conflict detection and resolution tool for terminal airspace that uses a combination of flight plan, nominal routing, terminal area procedures, and dead reckoning to infer flight intent, thereby improving conflict prediction accuracy and reducing false alerts. The T-TSAFE3 experiment studied the effect of switching between instrument and visual approaches; prior experiments focused only on instrument approaches.

Previous experiments also relied on the FAA's Automated Terminal Proximity Alert (ATPA) to monitor compression on final approach. The ATPA alerts are in the form of "cones" on the final approach controller's

radar display, depicting required wake separation of the target aircraft relative to leading aircraft within line-of-sight. The length of the cone and number within the cone indicate required separation, and color of the cone indicates estimated time to loss of separation. The T-TSAFE3 experiment studied the effect of using T-TSAFE logic to drive ATPA cones rather than line-of-sight, along with other improvements. Preliminary results, based on simulation observations, indicate a strong controller preference for T-TSAFE-driven ATPA cones.

Most notable improvements with T-TSAFE-driven ATPA cones include earlier depiction of the cones prior to establishing line-of-sight with the leading aircraft, thus aiding merges onto final approach; providing a numerical indicator for time to predicted loss of separation rather than color coding ranges; and replacing the numerical indicator for required separation with actual separation because the length of the cone already indicates required separation. Data analysis for the T-TSAFE3 experiment is underway. The T-TSAFE tool will be further investigated in another simulation incorporating the flight deck, scheduled for February 2013. *(POC: Savita Verma)*

PDRC Initial Field Evaluation Completed and Transition Products Delivered, July 2012

NASA completed an initial field trial of the Precision Departure Release Capability (PDRC) tool, scheduling a 100th flight since data collection began on April 30, 2012, at the Dallas/Ft. Worth air traffic control tower and the Ft. Worth En Route Center. PDRC enables

an automated exchange of automated surface information to improve scheduling of departures within an en route center into a busy overhead stream by linking the en route scheduling automation with highly accurate surface trajectory predictions of aircraft take-off times. Without PDRC, the coordination process between a tower and an en route center is completely manual and accomplished with phone calls needed to coordinate departure release times. Using PDRC, surface trajectory predictions are used to refine the departure release time, and these predictions are available to the en route traffic management unit to integrate within their traffic planning.

While results are undergoing analysis, initial trends suggest significant improvement in off-time compliance relative to a baseline condition without using PDRC, including takeoff time compliance from an average absolute error of 108 seconds to less than 59 seconds. More information can be found in "Impact of Departure Prediction Uncertainty on Tactical Departure Scheduling System Performance" by Capps, A., Day, Kevin, Walenciak, E., and Engelland, S., AIAA-2012-5674, 12th American Institute of Aeronautics and Astronautics Aviation Technology, Integration, and Operations Conference, Indianapolis, Ind., 17-19 Sept. 2012. *Download PDF Version*.

On July 2, NASA delivered an interim set in a series of PDRC research transition products to the FAA for use in developing NextGen automation systems. The PDRC research transition products delivered included a concept of operations, a technology description, and field evaluation results in the form of published papers

and pre-prints. Technology transfer between the two agencies has been coordinated via the Integrated Arrival/Departure/Surface (IADS) Research Transition Team (RTT). PDRC technology is anticipated to be included the FAA's Tower Flight Data Manager (TFDM)'s new automation system for tower controllers. NASA's PDRC research team coordinated directly with FAA personnel from the TFDM program to ensure that PDRC research transition products are well-aligned with FAA development needs. Updated research transition products are scheduled to be delivered in June 2013, which will incorporate PDRC's latest research findings.

The NASA/FAA IADS RTT, one of several teams charged with coordinating the transition of NASA research products to the FAA in support of NextGen, also held a meeting at NASA Ames. The IADS RTT is currently coordinating transition of four NASA research products: PDRC; Spot and Runway Departure Advisor; Integrated Surface Management and Flight Deck; and Airport Runway Management. FAA participants at the meeting represented NextGen organizations responsible for technology development, prototyping, and specifying and procuring automation systems such as Time Based Flow Management and Tower Flight Data Manager. FAA personnel provided updates on NextGen technology development and prototyping, as well as new FAA processes for transitioning ideas to implementation. NASA researchers and managers supporting the Airspace Systems Program participated and provided updates on the four research products along with demonstrations at FutureFlight Central and the Airport and Terminal Area Simulator at NASA's Ames

Research Center. The RTT concluded their meeting with observations of a terminal sequencing and spacing simulation experiment.
(POC: Shawn Engelland)

ATD-1 Procurement, July 2012

The Air Traffic Management Technology Demonstration 1 (ATD-1) Avionics, Phase 1 procurement was awarded July 2. The scope of this effort is to research the feasibility of developing prototypes and associated detailed concept engineering designs for potential implementation of the NASA Airborne Spacing for Terminal Arrival (ASTAR) prototype algorithm guidance within avionics systems envisioned for use in NextGen. The results of this work will provide data to NASA to assist in its understanding of the best approach for possible incorporation within the most appropriate avionics platform of some, or all, of the proposed ASTAR capabilities for purposes of the ATD-1 operational demonstration. The objectives of this task order are to explore and define potential prototype constraints and needs for, and to evaluate the feasibility of, implementing Flight-deck Interval Management with the ASTAR prototype algorithm guidance on avionics platforms envisioned for use in the NextGen midterm timeframe of 2016 to 2020 in aircraft.
(POC: Mike Koch)

ATD-1 Industry Day, August 2012

On August 29, the ATD-1 Industry Day event was held at NASA's Langley Research Center (LaRC). Representatives from airlines, avionics and aircraft manufacturers, the FAA, and NASA participated in a full day of briefings, discussions, and demonstrations of select NASA ATD-1 airborne technologies and activities, as well as integrated air traffic management capabilities. Jaiwon Shin, associate administrator for NASA's Aeronautics Research Mission Directorate, was also in attendance.

Industry Day focused on providing an update on ATD-1 to industry stakeholders and soliciting ATD-1 industry support. Visitors were presented with the breadth of ATD-1 activities and airborne automation plans by William C. Johnson. Brian Baxley presented the ATD-1 Concept of Operations (ConOps), and there was a demonstration of the Interval Management Near-term Operations Validation of Acceptability (IM-NOVA) simulation in both the LaRC Air Traffic Operations Lab (ATOL) and the Cockpit Motion Facility by Jennifer Murdoch and her experiment team. The demonstrations included tours of operations in the enhanced LaRC ATOL air traffic control room and the ASTOR pseudo-pilot stations. Visitors also were able to participate in the IM-NOVA demonstration in the integrated flight deck simulator where they were given an opportunity to fly an interval management scenario.

ATD-1 Industry Day resulted in valuable collaboration and energized interest from industry stakeholders in ATD-1 participation. Early feedback from participants and NASA programs and projects has been tremendously positive. Several airlines and manufacturers have already expressed a desire to immediately continue individual discussions regarding ATD-1 participation. As ATD-1 moves forward into FY13, ATD-1 Industry Day should ultimately lead to demonstrable collaboration between NASA ATD-1 and even more industry stakeholders.
(POC: Will Johnson)

IM-NOVA Experiment Executive Summary, Summer 2012

As part of initial preparations for the ATD-1 field trial, the Interval Management Near-term Operations Validation of Acceptability (IM-NOVA) experiment was conducted at LaRC during the summer of 2012. This human-in-the-loop experiment served as the first successful integration of the Langley (LaRC) and Ames (ARC) research centers' flight- and ground-based interval management (IM) technology systems using a full mission flight cab simulator. The integrated set of technologies included the LaRC flight deck-based interval management (FIM) system and the ARC Traffic Management Advisor with Terminal Metering (TMA-TM) and controller-managed spacing (CMS) tools. The objective of the IM-NOVA experiment was to assess if the procedures outlined in the ATD-1 concept of operations, when used with a minimum set of FIM equipment and a prototype flight crew interface, were

acceptable to and feasible for use by flight crews in a voice communications environment when precision to an achieve-by point (i.e., the final approach fix) was expected. To meet this objective, data were collected from 10 crews of current, qualified Boeing 757/767 pilots throughout a seven-week time period.

During a single two-day experiment session, one two-person crew of pilot participants flew LaRC's high fidelity, fixed-base Integration Flight Deck (IFD) simulator to complete scenarios conducted within an airspace environment modeled on the Dallas-Fort Worth (DFW) Terminal Radar Approach Control (TRACON) area. The IFD was equipped with the ASTAR algorithm and an IM crew interface consisting of two side-mounted electronic flight bags and two ADS-B guidance displays mounted under the glare shield. Two researchers used pseudo-pilot stations located in LaRC's Air Traffic Operations Lab to control the 24 ASTAR aircraft that provided multiple air traffic flows into DFW, and four recently retired DFW air traffic controllers served as confederate Center, Feeder, Final, and Tower controllers.

To assess the acceptability of the proposed ATD-1 flight crew procedures, qualitative data were collected in the form of acceptability, usability, and workload ratings via electronic questionnaires and a post-experiment debrief session. To assess the procedures' feasibility, quantitative data were collected including spacing error at the final approach fix and the number and rate of speed changes. All of the planned experiment scenarios were successfully executed to fully support the pre-experiment designed analyses. As the detailed analyses currently underway are completed, results will be reported in various documents and will contribute to the iterative development of the ATD-1 ConOps.

Feedback from the pilot participants obtained during post-experiment questionnaires and debrief sessions indicate that the IM-NOVA experiment's scenarios as well as the voice communications environment simulated using pseudo pilots and confederate controllers were well-constructed and realistic. The majority of the pilot participants found the IM concept to be acceptable, and indicated that the IM procedures could be successfully executed in a near-term voice communications environment. However, additional research is being planned to investigate the effects of winds, weather, and turbulence on the acceptability and feasibility of the ATD-1 crew procedures. Additionally, feedback obtained from the IM-NOVA experiment's confederate controllers regarding FIM procedures and phraseology as well as ways to support the continued development and improvement of LaRC's new Air Traffic Control lab facility is being considered while planning future ATD-1 research endeavors. (*POCs: Jennifer L. Murdoch, Sara R. Wilson*)

ATD-1 Activities Planned for Fiscal Year 2013

The system check-out for the next integrated ATD-1 simulation (IM-TAPSS follow-on) was conducted the

week of August 6 with the simulation scheduled for October 2012. The fully integrated ATD-1 technology completed its third integrated ATD-1 controller/pilot human-in-the-loop checkout on September 24–28. It evaluated wind scenarios with wind errors and identified the necessary set to go forward. Data-collection simulation for version 1.0 of ATD-1 is set for the week of October 15.

SAIE Project Scientist Granted U.S. Patent, July 2012

Natalia Alexandrov, project scientist for NASA's NextGen Systems Analysis, Integration, and Evaluation Project (SAIE) was granted a U.S. Patent (number 8,229,716; co-inventors - Carolyn Kaplan, Elaine Oran and Jay Boris of the Naval Research Laboratory (NRL); rights assigned to NASA and NRL) titled "Fast Tracking Methods and Systems for Air Traffic Modeling Using a Monotonic Lagrangian Grid." The system is the basis for a new research platform, the Air Traffic Monotonic Lagrangian Grid that has been developed to serve as a simulation tool for easy and fast testing of various air traffic control concepts. The platform is intended for investigating the fundamental properties of new control algorithms before selecting the most promising algorithms for further investigations in higher-fidelity systems. The work was conducted under a three-year NASA-NRL interagency agreement.

(POC: Natalia Alexandrov)

NASA Air Traffic Management Research Presented at AIAA Conference, August 2012

Research describing results of quantifying environmental/climate impacts due to aviation, computing fuel use for various descent procedures, aircraft scheduling modeling, and the fast-time analysis of a NASA-developed surface scheduling tool were among the papers presented at the 2012 AIAA Guidance, Navigation and Control conference in Minneapolis, Minn., August 13–16.

Two papers examining the aviation impact on the environment were presented. The first described the evaluation of a set of contrail-reduction strategies based on the flight range of aircraft. In this work, division researchers found that contrail-reduction strategies using various trade-off factors gave different results in contrail formation and carbon dioxide emissions from short-range flights to long-range flights. The results provide a starting point for developing operational policies to reduce the impact of aviation on climate using aircraft flight distances.

A second climate paper described the integration of a national-level air traffic simulation and optimization capability with simple climate models and carbon cycle models, and climate metrics to assess the impact of aviation on climate. The new capability can be used to make trade-offs between extra fuel cost and reduction in climate impact.

Another paper described the comparison of fuel consumption due to alternative descent trajectories

from cruise altitude to a meter fix when a delay was required at the meter fix. The study showed that the most fuel-efficient speed control procedure for absorbing delay is reducing descent speed as much as possible and then reducing cruise speed. For some of these aircraft, flying at a fixed flight path angle and constant Mach number and calibrated-airspeed combination resulted in lower fuel consumption compared to standard descents at idle-thrust and constant Mach speed and calibrated airspeed.

A study describing a multi-stage scheduling process for controlling arrivals destined for Alaska's Ted Stevens Anchorage International Airport (ANC) when low visibility conditions are impacting the airport was also presented. Although the majority of the flights in the scenarios were able to arrive at ANC without receiving any delay, pre-departure scheduling was the dominant control for internal departures from within Anchorage Center. For long-haul flights, the strategic scheduling algorithm performed best when the strategic scheduling horizon was greater than 1,000 nautical miles. In these cases, strategic scheduling delays were generally less than 15 minutes and changes to the calibrated airspeed were, on average, less than approximately 40 knots.

Finally, a fast-time study of a surface scheduling tool, the Spot and Runway Departure Advisor (SARDA) was performed and validated results from a human-in-the-loop simulation that was conducted in 2010. The results of the fast-time analysis bore out the potential benefits of SARDA and also determined that the result-

ing delays were about half that generated by a first-come-first-served scheduler.

Links to all the ASP papers presented at GNC can be found at *http://www.aviationsystemsdivision.arc.nasa.gov/publications/2012/2012_gnc.shtml*
(POCs: William Chan, Sandy Lozito, Banavar Sridhar)

Efficient Descent Advisor at Aero Day on the Hill, July 2012

The Efficient Descent Advisor (EDA) was demonstrated during Aeronautics Day on the Hill on July 18 at the Rayburn House Office Building   in Washington, DC. The event – the first of its kind devoted solely to NASA Aeronautics – provided an opportunity for members of Congress to learn about how the agency is making air transportation more efficient, safe and environmentally friendly. EDA was showcased as an example of NASA technology that was developed in

Rich Coppenbarger demonstrates EDA to visitors during Aeronautics Day on the Hill

partnership with industry and recently transferred to the FAA for deployment in the Next Generation Air Transportation System.

The exhibit explained and demonstrated how air-traffic controllers can use EDA to reduce fuel consumption and environmental emissions by allowing aircraft to perform continuous descents in busy traffic conditions where time-based metering is in effect. Visitors to the overall event included 11 members of Congress along with congressional staff and interns. The 206 staff members in attendance included seven professional staff for the Senate Committee on Commerce, Science and Transportation, and all professional staff for the House Committee on Science, Space and Technology. NASA and FAA personnel were available at the EDA exhibit to answer questions from a steady stream of visitors eager to learn more about the underlying technology and NASA's role in the modernizing the air-traffic system. *(POCs: Rich Coppenbarger)*

Researchers Support Volpe Wake Data Review, August 2012

Fred H. Proctor, Brad Perry, and Ed Johnson attended the 31st FAA-Volpe Wake Data Review held at Volpe Center, Cambridge, Mass. on August 27–28. The review is a forum held quarterly in which Volpe and its subcontractors report progress on research funded by the FAA Wake Turbulence Research Program (WTRP). Proctor and Perry were invited to attend the meeting by the FAA, due to previous discussions with the FAA on how to improve collaboration and data sharing between NASA and the FAA. Dr. Johnson regularly attends the

Volpe data reviews as part of his support for the WTRP under a reimbursable arrangement.

Briefings at the Volpe data review included: statistical analysis for the FAA's aircraft wake turbulence ReCategorization (RECAT) project, Wake Turbulence Mitigation for Arrivals and Departure (WTMA/WTMD) status, diagonal separation procedures, track error analyses, measurements of initial wake vortex core separations, an update on FAA wake vortex field measurement campaigns, and the status of NASA's wake vortex NASA Research Announcement. Implementation of WTMD at an operational airport is to begin soon, and will represent the first time that weather is dynamically used in determining aircraft wake separations. The WTMD and WTMA concepts were jointly formulated with NASA, the FAA, and industry partners.

Data collection of meteorological data at New York's JFK airport in support of NASA's wake vortex NRA has begun. This effort is to complement simultaneous FAA lidar data collection, with the new data to be used to enhance the wake vortex modeling development and validation process. Plans are also moving forward for additional joint NASA/FAA data collection at other locations.

Development of NASA's new wake vortex postprocessing algorithm continues, with an initial version to be transferred to the FAA/Volpe for evaluation. This algorithm offers the potential for significant improvements in the ability to determine the circulation and hazard characteristics of wake vortices.

The Cambridge meeting succeeded in strengthening future collaboration between the FAA and NASA for

wake research. Immediately following the Volpe data review, Proctor attended a two-day FAA working group meeting at Volpe that addressed Airbus-380 in-trail wake spacing issues. Proctor was specifically asked to participate by the FAA based on his wake expertise and past experience.
(POC: Neil O'Connor)

NASA DAC Team Visits the ZOB, August 2012

Six members of the Dynamic Airspace Configuration (DAC) team traveled to Cleveland, Ohio on August 30-31 to address feedback on the Operational Airspace Sectorization Integrated System (OASIS) and to discuss the Cleveland Air Route Traffic Control Center (ZOB) airspace redesign project. Detailed briefings on the OASIS algorithm and its graphical user interface (GUI) were presented, covering key properties of OASIS-generated sector configurations compared with historical sector configurations, as well as the design/usage of the GUI. The briefings were very well received, and ZOB staff provided valuable feedback that will help the OASIS team refine both the algorithm and the GUI.

The NASA team also spent several hours on the ZOB operational floor, observing sector combine/decombine operations during high-activity times bracketing the three shift changes over a 24-hour period. The information gained from these observations helped the team prepare for a human-in-the-loop evaluation of OASIS functionality at NASA's Ames Research Center in the fall of 2012. The DAC team met with the ZOB airspace redesign project staff who are in the process of

significantly modifying sector boundary definitions to conform with the new navigational aid-independent Q-routes that will replace many of the ZOB's conventional jet routes. The DAC team will contribute a technical analysis of the resulting sector loading patterns, and will help the ZOB airspace redesign team formulate, refine, and validate their new sector designs. These activities will contribute to NASA's development of an "airspace refresh" methodology that can be applied to other centers in the national airspace system.
(POC: Karl Bilimoria)

New NextGen Capabilities Focus of Seattle Meeting, August 2012

Bryan Barmore and Michael Koch from NASA's Langley Research Center attended a meeting of the Radio Technical Commission for Aeronautics Special Committee 186 (SC-186) and the European Organization for Civil Aviation Equipment Working Group 51 (WG-51) subgroup August 27-30 at the Boeing Company in Seattle, Wash.. SC-186 and WG-51 are developing flight deck interval management (FIM) and traffic situation awareness with alerts (TSAA) minimum operational performance standards (MOPS), which are new capabilities being introduced as part the FAA's NextGen Airspace Program. The SAIE Project's Air Traffic Management Technology Demonstration-1 (ATD-1) activity intends to develop FIM equipment based on the MOPS for use in flight trials planned for 2015-2017.

This was the second in a series of quarterly meetings with a primary focus of finalizing the scope of and

fleshing out plans for operational performance analyses (OPA) and operational safety analyses (OSA). A day and a half was spent reviewing TSAA status, plans, and working papers, and it was determined that OPA and OSA drafts will be submitted prior to the next meeting. The remainder of the time was dedicated to FIM-related topics finalizing scope, reviewing working papers, and evaluating high-level plans for OPA and OSA development. Detailed OPA and OSA plans will be developed and presented at the next group meeting.

It is likely that several OPA tasks will dovetail nicely with those of ATD-1 and may be areas in which the two activities can benefit from a synergistic relationship. The FIM core team reported that it plans to use the NASA Langley-developed trajectory-based spacing algorithm Airborne Spacing for Terminal Arrival Routes – ASTAR – as a sample algorithm for the FIM MOPS. The MOPS development is scheduled for completion in May 2014.
(POC: Mike Koch)

Dynamic Weather Routes Highlights, September 2012

The Dynamic Weather Routes (DWR) research and development effort made tremendous progress in 2012. In 12 months, the project transitioned from laboratory testing at NASA's Ames Research Center to operational testing at the American Airlines (AA) System Operations Center (SOC) in Fort Worth, Texas.

DWR is a real-time trajectory automation system that continuously and automatically analyzes in-flight aircraft in en route center airspace to find opportunities for time- and fuel-saving corrections to convective weather-avoidance routes. Weather-avoidance routes usually are filed an hour before takeoff using best estimates of weather en route; but as weather evolves, these routes may no longer be the most efficient option, and airline dispatchers and FAA traffic managers do not always notice opportunities for better solutions. DWR continuously analyzes flight trajectories, models weather, and proposes simple reroutes that avoid current and forecast bad weather to save at least five minutes of wind-corrected flying time.

Interactive automation enables users to visualize proposed routes, modify them if necessary, and evaluate flying time savings or delay, proximity to predicted weather, traffic conflicts, downstream sector congestion, and active special-use airspace. Common automation supports both airline dispatchers and FAA traffic managers.

DWR has been in operation at the AA SOC since July 17, 2012, with more than 150 flights evaluated by AA users; 45% of those with a total savings of 470 flying minutes were deemed acceptable to AA. Potential savings for all flights in Fort Worth Center's high-altitude airspace during the months of August, September, and October 2012 totaled over 23,000 flying minutes for 2,600 flights, which equates to a $3.8 million potential savings in airline operating costs.

In September 2011, the DWR concept and laboratory test results were presented to senior AA managers and representatives of the airline dispatchers union at the AA SOC in Fort Worth. A letter to NASA from the
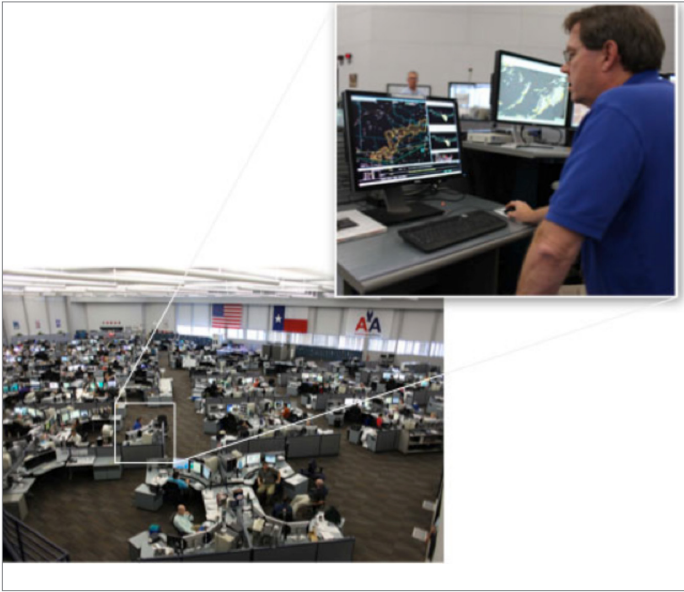
Dynamic Weather Routes tool in operation at the American Airlines System Operations Center, Fort Worth, TX

AA vice president for operations and the Flight Dispatch Transport Workers Union president followed, requesting that a trial of the DWR concept and prototype be conducted at the AA SOC. Plans for a trial were reviewed with managers at the FAA Fort Worth En route Center. In January 2012, the operational concept for a field trial was established: the DWR automation system would run at the NASA/FAA North Texas Research Station with dispatcher displays located at the air traffic control desk on the AA SOC operations floor, and with traffic management coordinator displays at the Fort Worth Center Traffic Management Unit (TMU). Phase 1 of the trial would only involve evaluation and displays at AA, with the TMU evaluation and displays in a second phase. A non-reimbursable

Space Act Agreement with American Airlines for testing DWR was signed on July 11, 2012.

Shadow testing of DWR at American Airlines began on July 17, 2012. A live-traffic DWR display was installed in a weather planning area adjacent to the main SOC operations floor. The NASA test team and Massachusetts Institute of Technology-Lincoln Laboratory collaborators demonstrated the DWR prototype with live and recorded traffic feeds for 20 members of the AA SOC including senior managers, training managers, flight dispatchers, air traffic control coordinators, union representatives, and automation staff. DWR training material was refined and provided to the AA training staff who ultimately conducted most of the training for the primary users of the DWR tool: air traffic control coordinators and flight dispatchers. Feedback from AA staff was overwhelmingly positive and much of the discussion during the first week centered on the operating concept and equipment locations for transition from shadow testing to operational testing.

On July 26, the DWR display was moved to its current location at the air traffic control (ATC) desk on the main operations floor (see figure). Under the trial operating concept, ATC coordinators evaluate routes proposed by DWR, modify them if necessary, and then alert the dispatcher in charge of the flight when they find a route deemed workable and acceptable to AA. If the dispatcher concurs, the DWR route is sent to the flight crew; the flight crew evaluates and requests the route change, all using normal procedures.

Outside of American Airlines and the Fort Worth Center, DWR was briefed to other FAA and airline parties. In April 2012, principal investigator Dave McNally co-presented the DWR concept and analysis results with Captain Rick Shay of United Airlines at the FAA/Industry Data Communications Implementation Team (DCIT) meeting. The DCIT is focused on near-term applications for today's air/ground data communications (Data Comm); their current emphasis is departure clearance messages, and they have expressed interest in DWR-like technology for en route trials planned for 2014. Captain Shay, a long standing, active member of the DCIT, co-presented the DWR material, answered questions from the group, and urged the FAA to back DWR as the basis for the 2014 en route Data Comm trials.

Approximately 50 airline representatives attended the meeting, including members from United, American, FedEx, and Delta, all of whom indicated strong support for the concept. In October 2012,

DWR co-investigator Kapil Sheth presented the DWR concept and lab results at the Airline Dispatchers Federation. This meeting resulted in requests from Delta Airlines and FedEx to participate in the DWR trials.

A paper describing the DWR concept and initial laboratory analysis results, "Dynamic Weather Routes: A Weather Avoidance Concept for Near-Term Trajectory Based Operations," was presented at the 28th International Congress of the Aeronautical Sciences in Brisbane, Australia, September 2012. Two additional papers, one describing the impact of DWR on traffic flow management, and the other describing initial simulation results, were presented at the AIAA Aviation Technology, Integration, and Operations Conference in Indianapolis, Ind., September 2012.

Provisional patents for the DWR concept and prototype were filed with the U.S. Patent Office in 2012, and preparation of the actual DWR patent is underway. *(POCs: Dave McNally, Kapil Sheth)*

Congratulations to the 2012 NASA Honor Awards Recipients, August 2012

Aisha R. Bowe
> Equal Employment Opportunity Medal

Michelle M. Eshow
> Exceptional Achievement Medal

Shawn A. Engelland
> Exceptional Service Medal

David H. Williams
> Exceptional Engineering Achievement Medal

Yoon C. Jung
> Outstanding Leadership Medal

Rudy A. Aquilina
> Outstanding Leadership Medal

Ronald D. Lehmer
> Outstanding Public Leadership Medal

Michael T. Gaunce
> ICESCAPE Team – Group/Team

Boeing 737-800W Aircraft Model Integration
> Team – Group/Team

Shawn Engelland, Ron Lehmer, and Michelle Eshow, recipients of 2012 NASA Honor Awards

CAAT Experiment Team
> Group/Team

CAPIO Simulation Team
> Group/Team

Three-Dimensional Path Arrival Management
> (3D-PAM) Group/Team