



Airspace Systems Program Newsletter

QUARTER 1: OCT-DEC 2013



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Findings

// Technical/Programmatic Highlights



Satellite view of Charlotte/Douglas International Airport, NASA World Wind 1.3.5

NASA-US Airways Surface Concept of Operations Meeting, October 2012

NASA researchers held a two-day meeting on October 2 and 3 with US Airways technical staff and ramp operations personnel at Charlotte Douglas International Airport. The discussion concerned the joint development of a concept of operations for the ramp traffic management decision support tool based on NASA's Spot and Runway Departure Advisor (SARDA) technology. Points of consideration

specifically included core functions such as the surface scheduler and taxi-time predictor, the user interface for ramp controllers, including electronic flight strips, and the scope of potential human-in-the-loop simulation of the tool. The group is targeting completion of an initial draft concept of operations document by the end of November. NASA and US Airways plan to jointly develop a prototype decision support tool and evaluate performance and human factors via human-in-the-loop simulations at Ames Research Center's Future Flight



Charlotte-Douglas International Airport.

Central, a high-fidelity tower simulator. Following the technical meeting, the NASA researchers gathered operational observation data of both US Airways ramp operations and air traffic control tower operations.

(POC: Yoon Jung)

Langley Team Conducts Software Verification Workshop, October 2012

The Formal Methods Research Team at Langley Research Center organized and taught a class on software verification during a workshop October 9-12 at the National Institute of Aerospace (NIA) in Hampton, Va. Course instruction focused on the prototype verification system (PVS) theorem prover, which can be used to verify safety statements about software systems.

Forty-one people attended the workshop in person and three participated remotely via online connection. The list of attendees included not just those from the United States, but also researchers from Colombia, Brazil, Canada and the United Kingdom, among

others. Coursework was organized by Cesar Munoz and Anthony Narkawicz, who are members of the formal-methods team in the Safety Critical Avionics Systems Branch (SCASB) at NASA Langley. Lectures were given by team members, including Ricky Butler, Ben Di Vito, Alwyn Goodloe, Jeff Maddalon, Cesar Munoz and Anthony Narkawicz. Other presenters included Heber Herencia-Zapana of NIA, and Sam Owre of SRI International, the main developer of the PVS theorem prover. Sam Owre also gave an invited lecture on “PVS 6.0 and Beyond.”

The workshop was comprehensive in its treatment of PVS, including basic topics such as modeling, specification, and verification; intermediate topics such as PVS proving for algebra and propositional logic; and advanced topics such as computational reflection and proof scripting. The attendees expressed high interest in the covered subjects and provided positive feedback about the class.

Several participants expressed interest in collaborating with SCASB personnel on research of common interest, such as formal verification of safety-critical software. PVS is a key component of several formal verification projects at NASA Langley, including the software-intensive systems component of the System-wide Safety Assurance Technologies (SSAT) project, which is part of the Aviation Safety Program, and the separation-assurance component of the NexGen Concept and Technology Development (CTD) project, which is part of the Airspace Systems Program. PVS research advancing theorem-proving techniques for complex

safety-critical applications is important to the accomplishment of NASA's mission.

(POC: Anthony Narkawicz)

Presentations on CD&R at DASC, October 2012

Denise Jones presented two Conflict Detection and Resolution (CD&R) papers at the 31st Digital Avionics Systems Conference (DASC) in Williamsburg, Va., held October 14-18. The papers, entitled "Airport Traffic Conflict Detection and Resolution Algorithm Evaluation" and "SURF IA Conflict Detection and Resolution Algorithm Evaluation," were co-authored by Denise Jones, Ryan Chartrand, Sara Wilson and Sean Commo of NASA; Sharon Otero of Northrop Grumman; and Glover Barker of Science Systems and Applications, Inc. The papers described results of a fast-time simulation study to evaluate CD&R algorithms for collision avoidance in the terminal maneuvering area.

The NASA and Surface Indications and Alerts (SURF IA) algorithms were evaluated for various runway, taxiway, and low-altitude air-to-air scenarios, various levels of CD&R equipage, and various levels of horizontal position accuracy. Study results will be incorporated into future NASA research to develop technology to improve safety and operations on and around the airport during NextGen operations, and also support development of industry and government standards for conflict detection and resolution under

RTCA Special Committee (SC) 186 to prevent collisions on the runway.

Shannon Zelinski received a "best in track" and a "best in session" acknowledgement for two papers she presented at the DASC gathering. In addition, co-author Walt Johnson was recognized for his contributions to another "best in track" paper at DASC.

A list of papers, including these, can be found at

<http://toc.proceedings.com/16464webtoc.pdf>

(POC: Denise Jones)

SFO Stratus Ground Delay Program Completes Field Trial, October 2012

The operational field evaluation of a model designed to calculate key parameters that are used when planning ground delay programs at San Francisco International Airport, which began on May 15, was completed on October 15. The field trials were conducted at the Federal Aviation Administration (FAA) Air Traffic Control System Command Center in Vint Hill, Virginia. The dates of the field trial were selected to coincide with the period of the year during which the marine stratus layer typically affects arrivals into San Francisco International Airport.

Preliminary findings from the field trials indicate that the model was able to reduce the avoidable delay by an average of 900 minutes: valued in monetary terms at nearly \$90,000 per ground-delay event. In November 2013, the FAA is slated to decide if the model should be included in their Collaborative Air Traffic



San Francisco, Golden Gate Bridge encased in fog.

Management Technology Work Package 4, which is scheduled for operational deployment in 2016.

(POC: Shon Grabbe)

Simulation Achieves Major Milestone, October 2012

The Terminal Area Precision Scheduling and Spacing (TAPSS) research group made major strides over the past four months, extending the TAPSS system to include flight deck interval management capabilities for human-in-the-loop (HITL) evaluation. The advanced scheduling capabilities in the TAPSS system were also ported and tested in the FAA's software baseline. To validate the system integration and develop the concept of operations, procedures, symbology and phraseology, HITL simulations were completed with eight controllers and 13 pseudo pilots. The experiment, held October 15-19, investigated controller and

pilot interactions in a mixed-equipage environment. Simulation results will be used to refine the concept of operations in preparation for the Air Traffic Management (ATM) Technology Demonstration-1 (ATD-1), an operational demonstration of the integrated set of advanced time-based scheduling with controller- and flight deck-based precision spacing capabilities that expedites fuel-efficient arrival operations during periods of high throughput.

(POC Jane Thippavong)

Charlotte Airport Operations SME Workshop, October 2012

A two-day workshop was held at Ames Research Center October 22-23 to discuss surface traffic operations at Charlotte-Douglas International Airport (CLT). NASA researchers learned about CLT operations in great detail from subject matter experts (SMEs), including a retired ATC tower controller, a retired traffic management coordinator/supervisor, a US Airways ramp controller, and a pilot. The information gathered from the workshop will be used for modeling airport operations and designing a ramp controller decision support tool based on NASA's Spot and Runway Departure Advisor (SARDA) technology. The SMEs provided comprehensive overviews of their different roles, responsibilities, and interactions with others and also conducted a role-play to illustrate the flow of aircraft control from descent to takeoff. NASA researchers demonstrated the SARDA tool, and the

group discussed NASA's future development of surface tools. (POC: Yoon Jung)

Aircraft Self-Separation Experiment Data Collection, October 2012

Separation Allocations in Shared Airspace (SALSA) data collection was initiated on October 31 for a human-in-the-loop experiment, which investigates an advanced separation assurance concept for Air Traffic Management—Autonomous Flight Rules (AFR). AFR is a NASA Langley-developed airspace operating concept in which an aircraft equipped with Automatic Dependent Surveillance Broadcast (ADS-B) reception capability and a flight deck automation tool is responsible for maintaining separation from other traffic.

The three-week SALSA simulation experiment, conducted in the Langley Air Traffic Operations Lab (ATOL), focuses on airline pilot operations under AFR, and is a companion experiment to an air-traffic-controller-based experiment recently completed at the NASA Ames Airspace Operations Lab (AOL). In each of the three weeks of the Langley experiment, 10 to 12 airline pilots operated five to six desktop simulators equipped with self-separation technology in high-density simulated NextGen airspace managed by three air traffic controllers.

The challenge addressed in these two coordinated experiments, both sponsored by the NASA Airspace Systems Program's NextGen Concepts and Technology Development Project, is the development of a safe and operationally acceptable (to pilots and controllers)

integration in the same airspace of two “function allocations” for separation assurance: self-separating aircraft and ground-based separation for non-equipped aircraft (a.k.a. Instrument Flight Rules (IFR) aircraft). The integration rules establish that AFR aircraft are burdened to resolve any conflicts that occur with IFR aircraft and that air traffic control is not responsible for AFR-IFR separation.

The Langley ATOL experiment tests various conflict timings, geometries, and intent-information-sharing conditions to determine the performance and pilot acceptability of mixed operations from the pilot's perspective. The simulation platform incorporates the Autonomous Operations Planner (AOP), a NASA Langley-developed prototype flight deck tool for separation assurance. Results of the SALSA experiment will be combined with controller-based results from the NASA Ames AOL experiment to inform the airspace community on options for introducing new automation capabilities and revised air/ground allocations of the separation function in the pursuit of NextGen.

The potential impact of AFR to operators is a significant increase in operational flexibility and a significant decrease in the operating costs associated with ground delays and various airspace and operational restrictions imposed in today's airspace operations. In addition, if the mixed-operations concept tested in SALSA is successful, AFR compatibility with near-to-midterm NextGen operations would enable AFR implementation to be accelerated.

(POC: David Wing)

NASA Offers Support to RTCA SC-186 WG-4/EuroCAE WG51-Subgroup 3, November 2012

Dr. Bryan Barmore and Mr. Michael Koch attended a November 5-8 meeting of the Radio Technical Commission for Aeronautics (RTCA) Special Committee 186 (SC-186) and the European Organization for Civil Aviation Equipment (EuroCAE) Working Group 51 (WG-51) subgroup at the Airbus Company in Toulouse, France. 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 of the FAA's NextGen Airspace Program. The NextGen-System Analysis, Integration, and Evaluation (SAIE) Air Traffic Management (ATM) Technology Demonstration-1 (ATD-1) activity intends to demonstrate MOPS-based FIM procedures, software, and equipment for use in flight trials planned for 2015-2017.

This meeting was the third in a series of quarterly meetings and only included committee members supporting the FIM MOPS. Its primary focus was to discuss the results and status of several ongoing efforts in support of Operational Performance Analysis (OPA) and Operational Safety Analysis (OSA) activities. Dr. Barmore led the Delta operational services and environment description (OSED) discussion presenting a summary of final operational scenarios and the results of a workshop conducted to address several small OSED-related questions that rose out of previous meetings.

Mr. Koch held several breakout meetings with committee leadership and equipment manufacturer representatives to discuss the impacts of new display requirements the FIM equipment must support. New display requirements have impacted the architecture assumed for ATD-1, affecting planned experiments and the avionics development already underway.

The results of the OPA and OSA activities will drive many of the MOPS requirements, which will directly affect the FIM avionics development for ATD-1. Some analyses were mature enough to begin driving requirements. Others are still a work in progress and have not yet led to any tangible requirement recommendations. The objective of presenting such work was to gain committee buy-in with regard to the analysis approach, or to share preliminary results, which must be studied further. Once complete, the MOPS will pave the way for FIM to be integrated into commercial aircraft and into the national airspace system, contributing to efficiency gains in arrival operations and improvement in airport throughput and capacity.

The next meeting is scheduled for early March at the RTCA Headquarters in Washington D.C. The MOPS development is scheduled for completion in May, 2014. *(POC: Michael Koch)*

ATD-1 Field Test Demonstration Kickoff Meeting, November 2012

The November 6-7 meeting in Washington D.C. included the FAA chief scientist for architecture and NextGen development, the ASP deputy program

manager, research transition team members from NASA research centers Ames and Langley, and multiple FAA organizations and projects. The ATD-1 chief engineer presented information about ATD-1 and addressed key questions regarding field-demonstration constraints, FIM equipage, and use of National Air Traffic Controllers Association personnel. The FAA presented detailed schedules for Time-based Flow Management (TBFM); Surveillance and Broadcast Service (SBS); Terminal Automation and Modernization (TAMR); and En Route Automation Modernization (ERAM). Each showed investment decision points and deployments, and the test-NCP process for field-testing prototypes.

The primary outcome was identifying that the FAA's SBS office is looking at a field test in FY16 that would be an opportunity to use NASA FIM designs with the FAA equipping a few planes and providing a key site. The next step is for the ATD-1 team to draft a field demonstration description of what would be included to leverage the FAA field test, and to iterate the expected benefits of the demonstration. The FAA will provide feedback and, from its point of view, describe the necessary steps to prepare for and achieve demonstration objectives.

(POC: Ron Johnson)

ATD-1 Phase 1 Avionics Concept Development Report, November 2012

On November 12, Mr. Michael Koch hosted representatives from The Boeing Company who were

presenting results of a trade study report in support of the ATD-1 Phase 1 Avionics Concept Development contract. The meeting was well attended. ATD-1, sponsored by the SAIE Project within ASP, aims to demonstrate the feasibility and value of integrating three NASA research efforts intended to achieve high throughput, fuel-efficient arrival operations throughout a busy terminal airspace. Two of these efforts are focused on ground-based tools for center and terminal controllers while the third – FIM – focuses on the aircraft avionics and flight crew procedures to conduct airborne spacing operations. The heart of FIM operations is the algorithm used to achieve and maintain a desired spacing interval. NASA Langley researchers have developed a trajectory based algorithm called Airborne Spacing for Terminal Arrival Routes (ASTAR), which promises to support Performance-Based Navigation (PBN) requirements and address deficiencies found in other approaches. This contract represents the first step in a multi-phase effort to develop FIM avionics for the ATD-1 demonstration. It focuses on feasibility and trade studies, simulator and cockpit integration, a demonstration, and recommendations.

The trade study report and associated presentation represent the second major deliverable of the contract. The report focused on architectural evaluation of the integration of the ASTAR algorithm in air transport class aircraft during the NextGen midterm 2016-2020 timeframe. For existing aircraft, such as a 737-NG, configurations for both forward-fit and retro-fit

implementation types were considered. A 787-8 was also considered since it is representative of an advanced avionics platform from which a NextGen baseline type can be formed. A total of 28 architectures arising from seven trade variables were evaluated. Rough order-of-magnitude, non-recurring engineering estimates and approximate time-on-task development flow times were generated for each.

Moving forward, the results of the trade study will be used to guide ATD-1 FIM avionics development. ATD-1 aims to equip multiple aircraft to demonstrate in-flight interval management operations in the 2015–2017 timeframe. The information generated by all ATD-1 activities, including this trade study, the avionics development, and the in-flight demonstration, will inform the FAA and industry on the FIM concept and facilitate NextGen technology transfer into the national airspace system.

(POC: Michael Koch)

Presentation of CD&R Algorithm Evaluation to RTCA SC-186 SURF IA Committee, November 2012

On November 14, Denise Jones presented results of a fast-time simulation study to evaluate Enhanced Traffic Situation Awareness on the Airport Surface with Indications and Alerts (SURF IA) algorithm to the Radio Technical Commission for Aeronautics (RTCA) Special Committee 186 (SC-186). This committee developed SURF IA requirements to increase flight crew situation

awareness of the runway environment and facilitate an appropriate and timely response to potential conflict situations to prevent collisions on the runway. The goal of the fast-time study was to evaluate the performance of the SURF IA algorithm under various runway conflict scenarios, multiple levels of SURF IA system equipage, and various levels of horizontal position accuracy. The study uncovered some shortcomings with the SURF IA algorithm that the RTCA committee will address in further development of the SURF IA industry and government standards.

(POC: Denise Jones)

DWR Operational Trial Key Findings, November 2012

The Dynamic Weather Routes (DWR) tool has been running nearly continuously – 23 hours a day, seven days a week – at the American Airlines (AA) Operations Center in Fort Worth, Texas since the operational trial began on July 17, 2012. AA users – air traffic control



Dynamic Weather Routes tool in operation at the American Airlines System Operations Center in Fort Worth, Texas

coordinators and flight dispatchers – evaluate time and fuel saving routes proposed by DWR, and may also use DWR to evaluate reroutes for any of their flights, e.g., ones where a route is not proposed. Analysis of 60 days of trial data (from July 31 through September 30) comprising about 800 AA flights in Fort Worth Center airspace clearly shows that the DWR search engine, which automatically finds more efficient weather-avoidance routes, results in five times as many routes rated acceptable by AA users compared with the manually initiated search. Users are busy, especially during weather events, so it is more effective to let automation find the high-value reroutes.

The data show that 38% of DWR routes evaluated by AA users were rated as acceptable for a total potential savings of 311 flying minutes, with significant potential for additional savings. Reroutes totaling over 3,000 minutes of potential savings were left unevaluated mainly due to limited staffing during the trial. Assuming that the acceptance rates are consistent for unevaluated routes, 1,000 more minutes of potential savings could be achieved. User feedback has been very favorable and some DWR route clearances have been issued to AA flights; analysis of actual savings is under way.

(POC: Dave McNally)

NASA Develops Technology To Aid Regional Jet Operators, November 2012

NASA engineers met with flight operations personnel from regional jet operator SkyWest Airlines on

November 15 to discuss recent NASA findings, which suggest that SkyWest could save upwards of 50 pounds of fuel per regional jet flight by altering arrival procedures to use more optimal flight-path angles that would avoid the need to deploy speed brakes. NASA has developed an algorithm that can inform operators, such as SkyWest, what flight-path angle would be optimal given the prevailing winds, route of flight and other factors such as the descent-speed profile being advised by the Efficient Descent Advisor (EDA), where in use. These savings are above and beyond the fuel and environmental benefits provided by EDA, and the new algorithm/tool would also reap benefits for un-delayed flights (e.g., into low-density “out stations”), essentially providing EDA-like benefits without using EDA. The SkyWest officials quickly verified that even 20 pounds of fuel savings would make an operationally and economically significant difference, since their policy is to plan fuel loads down to tens of pounds. They also confirmed the viability of the proposed operational concept for the tool. An invention disclosure is being written, and planning for a January 2013 technical interchange meeting at Ames Research Center is underway.

(POC: Steve Green)

Initial International Collaborations Workshops, December 2012

Dr. Banavar Sridhar, Dr. Yoon Jung, and Mr. Ty Hoang attended two workshops in early December to kick-off recently signed international collaboration

agreements between NASA and the German Aerospace Center (Deutschen Zentrums für Luft- und Raumfahrt, DLR) and the National Aerospace Laboratory of the Netherlands (Nationaal Lucht en Ruimtevaartlaboratorium, NLR). The first workshop, hosted by DLR's Institute of Flight Guidance in Braunschweig, Germany, included participants from DLR research centers in Braunschweig, Hamburg, Cologne, and Oberpfaffenhofen, who shared their expertise in generating the impact of aviation emissions and contrails as a function of space and time. NASA shared its knowledge in generating trajectories to minimize environmental cost functions.

Methodologies were discussed for selecting and sharing suitable data needed to generate the computationally intensive environmental cost functions, and providing details about the traffic and weather information exchange needed to cover U.S., European and transatlantic airspace. Researchers from the two organizations also discussed simulation tools for global air traffic, climate impact, trajectory optimization, and relevant surface traffic management technologies, and refined the already signed three-year collaboration agreement. The surface work is intended to create a common integrated concept of departure management and taxi management on the airport surface, model DLR's time-based taxi scheduler at a U.S. airport, integrate with NASA's surface movement optimization algorithm, and perform fast-time simulations using NASA's fast-time surface simulation tool.

The NASA team attended the second workshop at NLR to explore a promising collaboration in surface conflict detection that complements current NASA research efforts in the airport surface domain. The joint NASA-NLR effort will focus on testing NLR's taxiway movement conflict detection technology, with the potential to later integrate this technology with NASA's surface movement optimization algorithm.

(POC: Dr. Banavar Sridhar, Dr. Yoon Jung, Ty Hoang)

Runway Configuration Management Discussions in Munich, December 2012

In support of the Runway Configuration Management research area of a collaborative agreement between the German Aerospace Center (DLR) and NASA under the Airspace Systems Program, Gary Lohr visited the Munich Airport Tower to gather information regarding the potential implementation of the Tactical Runway Configuration Management (TRCM) element of the NASA System Oriented Runway Management (SORM) work at an airport in Germany. The Munich Airport is the second busiest in Germany based on enplanements.

Mr. Lohr and Nikolai Okuniek (DLR's lead for the runway management collaboration area) were hosted by a senior air traffic controller who provided an overview of air traffic operations, including procedures, constraints and common practices. At a high level, International Civil Aviation Organization (ICAO) procedures are not significantly different from those

used in the United States, but further investigation is required to identify procedural differences that would potentially affect the suitability of SORM capabilities at German airports. Airport Tower personnel shared information enthusiastically and were excited that NASA was interested in their operation. Collaboration between NASA Langley SORM researchers and DLR will continue to advance the state of air traffic efficiency in their respective airspace systems.

Capabilities developed by DLR focus on efficiency for arrival, departure, and surface air traffic operations; however, they assume a static runway configuration. The TRCM capability provides runway configuration and usage recommendations that will complement these capabilities, thereby improving overall efficiency and minimizing disruption during configuration changes.
(POC: Gary Lohr)

Yearlong Traffic-Management Study Results Published, December 2012

Results of a yearlong study were recently published in Volume 20 (2012) Number 4 of the Air Traffic Control Quarterly journal. The study examined the potential impact of controlling Hartsfield Jackson Atlanta International Airport arrivals using a new control strategy that is referred to as a Traffic Management Advisor

Flow Program. This new capability reduces the demand for a capacity-limited airport by assigning pre-departure delays to flights bound for the airport.

With the help of traffic flow managers at the FAA's Air Traffic Control System Command Center, operationally viable scenarios were developed that were subsequently explored by NASA researchers through fast-time simulations. The emphasis of the study was on examining the distribution of delays and emissions for flights included and exempt from this new capability. Among the key findings from this study: as the rate of the Traffic Management Advisor Flow Program was increased from 54 aircraft per hour to 80 aircraft per hour, the fuel burn and emissions associated with airborne holding was found to increase by over 100%. Although this increase in fuel burn and emissions, in general, represents a small percent of the total fuel burn and emissions associated with the entire flight's trajectory, it does illustrate the importance of considering the delays as well as the emissions associated with future traffic flow management control strategies.

The study can be read in its entirety at: http://www.aviationsystemsdivision.arc.nasa.gov/publications/2012/ATCQ_20-3-203_Grabbe.pdf
(POC: Shon Grabbe)

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