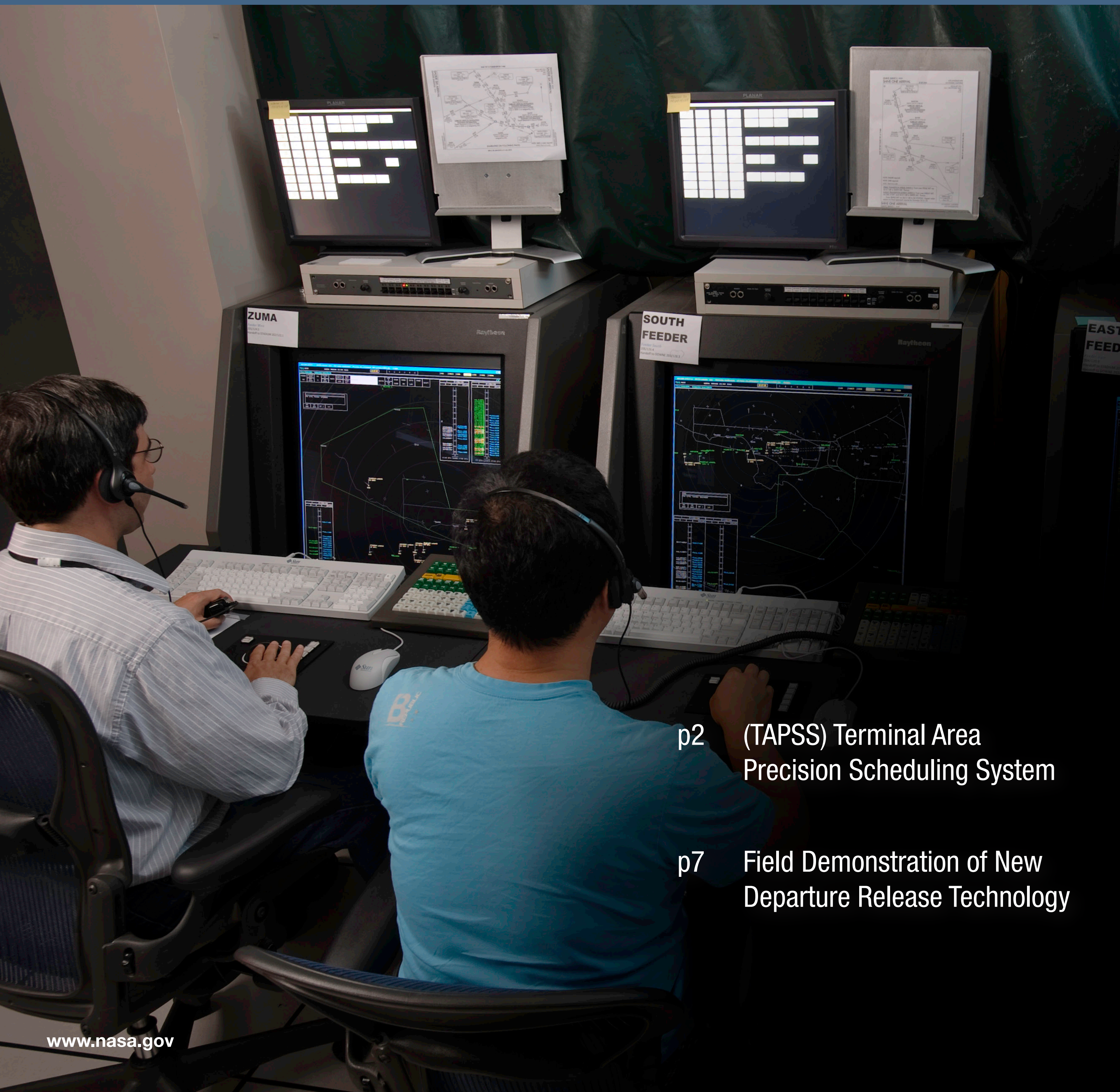
National Aeronautics and Space Administration

Airspace Systems Program Newsletter

QUARTER 4: JUL–SEP 2011



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// Technical/Programmatic Highlights

NASA researchers participate as air traffic controllers during Terminal Area Precision Scheduling System (TAPSS) shakedown simulations in NASA's Air Traffic Management Laboratory. Photo credit: NASA/Dominic Hart

(TAPSS) Terminal Area Precision Scheduling System

Air traffic controllers currently rely on simple decision support tools to safely separate and maintain an orderly flow of aircraft within the National Airspace System (NAS). As the volume of air traffic grows, greatly enhanced tools will be needed to maintain and increase system performance.

To help controllers keep up with the anticipated heavy workload, NASA is developing several advanced automation tools that will provide controllers with more accurate predictions about the nation's air traffic flow, weather, and routing. The greater precision in this information will enable a next-generation air traffic management system (referred to as NextGen), which will be safer, greener, and more efficient. These new tools require increased information sharing and coordination among air traffic controllers and pilots within the future NextGen. A critical goal in NASA's air traffic management research and development process is ensuring that these tools work well together.

The Terminal Area Precision Scheduling System (TAPSS) research at NASA Ames Research Center tests the integration of many of NASA's technologies that aim to improve operations in the airspace immediately surrounding the airport, known as the terminal area. These technologies include:

- Precision scheduling enhancements to the previously deployed Traffic Management Advisor (TMA), which creates time-based metering arrival schedules for terminal-merge points

NASA researchers evaluate the performance of NextGen air traffic management technologies during TAPSS simulations. Photo credit: NASA/Dominic Hart

- Required Navigation Performance/Area Navigation (RNP/RNAV), which enables aircraft to fly more fuel efficient routes from cruise altitude to landing
- Controller Managed Spacing (CMS) tools, which provide speed advisories for metering in the terminal airspace
- Efficient Descent Advisor (EDA), which enables aircraft to use minimum fuel consumption descents while being metered in busy terminal areas, thereby minimizing environmental emissions

TAPSS research uses human-in-the-loop simulations to evaluate the performance of the NextGen tools in congested airspace where there is a significant need for high-precision automation aids, such as the Southern California Terminal Radar Approach Control (TRACON) Metroplex, an airspace environment comprising multiple large, interdependent airports. Several traffic scenarios with varying levels of complexity are studied using models of traffic into Los Angeles International Airport, a high-flow airport.

The concept of precision metering with staged delay distribution is evaluated to account for uncertainty within the airspace system. Traditionally, most arrival delay is absorbed near the airport where controllers and pilots use vectoring, or circling, to accommodate delay, which increases congestion in the terminal area. By applying simple variations in speed from cruise altitude to landing, instead of vectoring in the terminal area, small amounts of delay are distributed over the length of a flight, relieving some of the congestion that builds up near the airport. This leads to a much more efficient

NASA researchers participate as air traffic controllers during TAPSS shakedown simulations in NASA's Air Traffic Management Laboratory Photo credit: NASA/Dominic Hart

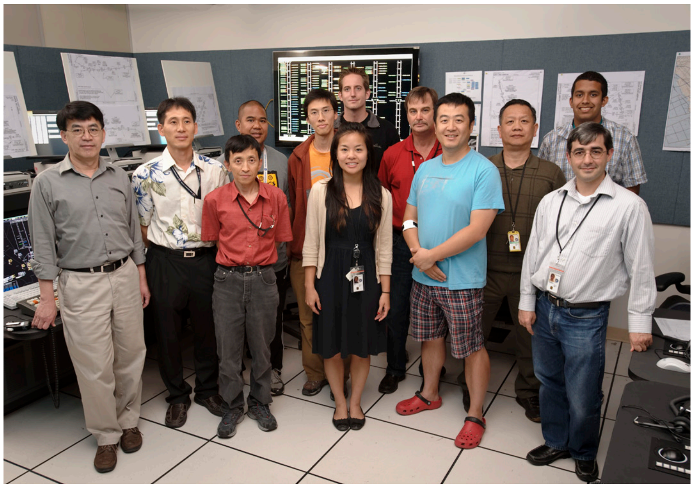
NASA researchers test pilot aircraft simulation workstations during TAPSS shakedown simulations in NASA's Air Traffic Management Laboratory. Photo credit: NASA/Dominic Hart

flow into busy terminal areas, less fuel burn, and reduced workload for pilots and controllers. Both nominal and off-nominal conditions are tested to understand the robustness of the automation under anticipated air traffic growth projections for NextGen.

The first two TAPSS simulations modeled three Air Route Traffic Control Center (or simply, "Center") arrival-metering sectors and five TRACON (three feeder and two final) sectors with controller positions interacting with workstation-based pilot/aircraft simulation positions. The current air traffic control paradigm of voice and radio-based arrival clearances is used, allowing for near-term implementation into the NAS. Simulation participants, who often include experienced air traffic controllers and pilots, provide feedback on performance, workload, and acceptability in order to improve the functionality of the automation. Data on delay and controllability of the traffic along RNP/RNAV routes is collected during each simulation and the results are compared against current-day operations. The data collected may also provide insights into changes in airspace volume and fuel savings.

The third high-fidelity human-in-the-loop simulation will assess the feasibility, performance and potential benefits for near-term application in the NAS over a two week period in November and December. Major questions to be answered by the HITL are:

- Is the system robust enough to include airport routing infrastructure with a limited set of Area Navigation (RNAV)/Required Navigation Performance (RNP) procedures, and can those RNAV/RNP



TAPSS Development Team. In this photo (l to r): Hai Ou-Yang, Anthony Seo, Daniel Du, Leonard Bagasol, Paul Lin, Jane Thipphavong, Chris Sullivan, Harry Swenson, Liang Chen, Danny Chiu, Arjun Ravishankar, Alex Sadovsky. Photo credit: NASA/Dominic Hart

procedures co-exist with the more common arrival procedures?

- For very-high density operations, are the advanced controller display enhancements necessary to gain the full advantage of the TAPSS capability to increase airport throughput by 10% while also increase efficient descents by 50%?

Teams from Raytheon and General Electric Aviation also have visited the simulation to evaluate implications for implementation in the Federal Aviation Administration's (FAA's) Standard Terminal Automation Replacement System (STARS) as well as impact to the avionics community. Ames additionally hosted representatives of the reorganized FAA's Advanced Technology Development and Prototyping Group that may consider this technology to meet some of the FAA's NextGen implementation goals.

Another goal of the TAPSS research is to further develop air traffic management simulation capabilities and to validate the infrastructure for studying integrated NextGen tools in complex human-in-the-loop simulations. In the future, TAPSS will explore the issues of arrival schedule non-conformance and recovery from the air traffic controller's perspective to provide insight into the development of automated schedule recovery tools.

(POCs: Harry Swenson, Jane Thipphavong)

AIAA's 3rd Atmospheric and Space Environments Conference, June 27-30, 2011

Drs. Fred Proctor and Nash'at Ahmad represented the Airspace Systems Program (ASP) at the conference. Both Drs. Ahmad and Proctor co-chaired and presented papers in the session on "Lidar Wake Applications, Database Management and Atmospheric Simulation." Additionally, Dr. Proctor co-chaired and presented in the session on "Wake Vortex Modeling and Analysis." In the first session, Dr. Ahmad presented five case studies of LES simulation of convective storms and their association with convection induced turbulence. The convective events modeled in the five simulations ranged from large mesoscale convective systems to isolated tropical maritime convection. The validation of model results with radar data and other observations was reported and an aircraft-centric turbulence hazard metric calculated for each case was discussed. The turbulence analysis showed that large pockets of significant turbulence hazard can be found in regions of weak radar reflectivity. Moderate and severe turbulence was often found in building cumulus turrets and overshooting tops. In the second session, Dr. Proctor presented results from large eddy simulations (LES) that explored the influence of crosswind shear on aircraft wake vortices. The LES parametric studies confirmed that the vertical gradient of crosswind shear can influence vortex trajectories and rate of circulation decay. The effect of shear may cause the vortices to tilt and separate. Also, the vortex linking time may either decrease or increase depending upon the sign of both the first and second vertical derivates of the environmental crosswind.

Several papers were also presented that described the work sponsored under the ASP's NextGen-Concepts and Technology Development (CTD) project's NASA Research Announcement, "Enabling Super-Dense Operations by Advancing the State of the Art of Fast-Time Wake Vortex Modeling." The papers discussed the development and accuracy of fast-time wake prediction models, and assessed the accuracy of pulsed Lidar in tracking and estimating the circulation strength of aircraft wake vortices. All papers are listed below. *(POC: Fred Proctor)*

1. F. Proctor and N. Ahmad, "Crosswind Shear Gradient Affect on Wake Vortices," AIAA-2011-3038.
2. N. Ahmad and F. Proctor, "Large Eddy Simulations of Severe Convection Induced Turbulence," AIAA-2011-3201.
3. M. Pruis (Northwest Research Associates) and D. Delisi (Northwest Research Associates), "Assessment of Fast-Time Wake Vortex Prediction Models using Pulsed and Continuous Wave Lidar Observations at Several Different Airports," AIAA-2011-3035.
4. M. Pruis (Northwest Research Associates) and D. Delisi (Northwest Research Associates), "Comparison of Ensemble Predictions of a New Probabilistic Fast-Time Wake Vortex Model and Lidar Observed Vortex Circulation Intensities and Trajectories," AIAA-2011-3036.
5. M. Pruis (Northwest Research Associates) and D. Delisi (Northwest Research Associates), "Correlation of the Temporal Variability in the Crosswind and the Observation Lifetime of Vortices Measured with a Pulsed Lidar," AIAA-2011-3199.
6. D. Lai (Northwest Research Associates), D. Jacob (Lockheed Martin Coherent Technologies), F. Lo (Northwest Research Associates) and D. Delisi (Northwest Research Associates), "Assessment of Pulsed Lidar Measurements of Aircraft Wakes Using a Lidar Simulator: Vortex Position Estimates for IGE, Linking, and Oblique Viewing, and Dependence of Vortex Lifetime on SNR," AIAA-2011-3197.
7. D. Jacob (Lockheed Martin Coherent Technologies) et al., "Assessment of Lockheed Martin's Aircraft

Wake Vortex Circulation Estimation Algorithms Using Simulated Lidar Data," AIAA-2011-3196.

8. D. Ramsey (Aerospace Innovations) and D. Nguyen (Aerospace Innovations), "Characterizing Aircraft Wake Vortices with Ground-Based Pulsed Coherent Lidar: Effects of Vortex Circulation Strength and Lidar Signal-to-Noise Ratio on the Spectral Signature," AIAA-2011-3198.

Successful FBTM Technology Transfer, July 14, 2011

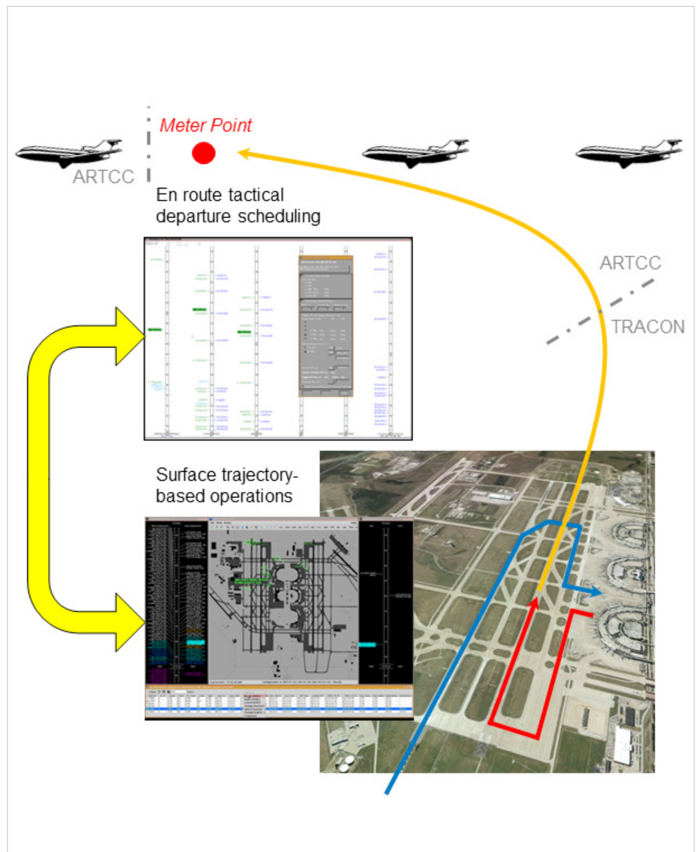
In a model of effective collaboration, an FAA-NASA Research Transition Team successfully refined the Flow Based Trajectory Management (FBTM) concept. FAA, NASA and JPDO executives met to complete the official close out and declare success on FBTM, a NextGen technology transfer initiative between the FAA and NASA.

FBTM modifies aircraft trajectories in flight to reduce airspace complexity and increase capacity. It is a major NextGen component and part of a larger plan to integrate and facilitate seamless trajectory management among the major National Airspace System automation functions. FBTM researchers conducted two major human-in-the-loop simulations, each of which simulated operations at FAA en route centers with participation by air traffic controllers, traffic managers, and supervisors. Results showed that the FBTM concept is not only feasible, but beneficial in supporting NextGen initiatives toward "best-equipped, best-served" operations.

(POC: Kevin Hatton, AJP-66)

Field Demonstration of New Departure Release Technology, July 2011

ASP researchers in collaboration with the FAA, American Airlines, and Dallas/Fort Worth (DFW) airport have completed a multi-week field evaluation of the Precision Departure Release Capability (PDRC). PDRC uses trajectory-based takeoff time estimates



NASA develops PDRC by integrating a representative surface traffic management system (base of the yellow arrow) with an arrival/departure management system (head of the yellow arrow).

from a surface automation system to improve en route tactical departure scheduling into constrained overhead flows. This initial field evaluation began on July 13th and ended on July 29th. PDRC user interfaces and NASA observers were stationed at four locations: the Fort Worth Air Route Traffic Control Center's Traffic Management Unit, the DFW East air traffic control tower, American Airlines' DFW ramp tower, and NASA's North Texas research station. The first week was devoted to system shakedown and controller training. During the second week, the system was used in a shadow mode that evaluated PDRC advisories without affecting actual operations. The 12-day test period concluded with several operational evaluations where controllers successfully used PDRC advisories to schedule actual DFW departures. Anecdotal feedback from these initial evaluations indicated that PDRC takeoff time estimates and en route departure schedules were usable, and that PRDC shows promise of providing the expected benefits. Detailed results are forthcoming. NASA's PDRC research activity is on track for technology transfer to the FAA in June 2012.
(POC: Shawn Engelland)

T-TSAFE Vertical Resolutions Tested, July/August 2011

Controllers evaluated the vertical resolutions and expanded controller interface for Terminal Tactical Separation Assured Flight Environment (T-TSAFE) in July and conducted pseudo pilot training in August to prepare for the upcoming evaluation of the conflict detection and resolution tool. The T-TSAFE concept takes TSAFE, as developed for use in en route airspace, and adapts it for use in terminal airspace. Terminal airspace is crowded and has more complicated separation criteria than high altitude airspace, and current tools flag too many false conflicts, which lowers controller trust in the automation and decreases its usefulness. T-TSAFE is designed to reduce false alerts in this complex airspace and provide controllers with suggested conflict resolutions. The current implementation of T-TSAFE now provides controllers with alerts for possible losses of separation and suggests conflict resolutions based on altitude changes. Suggested resolutions based on speed and heading changes will be added later this year. The focus of this evaluation was to validate the reasonableness of the T-TSAFE altitude resolutions and to get controller feedback on the expanded interface. Data collection with retired controllers and pilots occurred later in August.
(POC: Savvy Verma)

Visit to the Washington ARTCC, August 2011

Jeremy Smith, Patricia Glaab, Jeff Viken, Nelson Guerriero from NASA, and Ty Marien and members of Intelligent Automation, Inc. (IAI), visited the Washington Air Route Traffic Control Center to help inform the development, validation and benefits assessment of NextGen concepts currently being modeled in

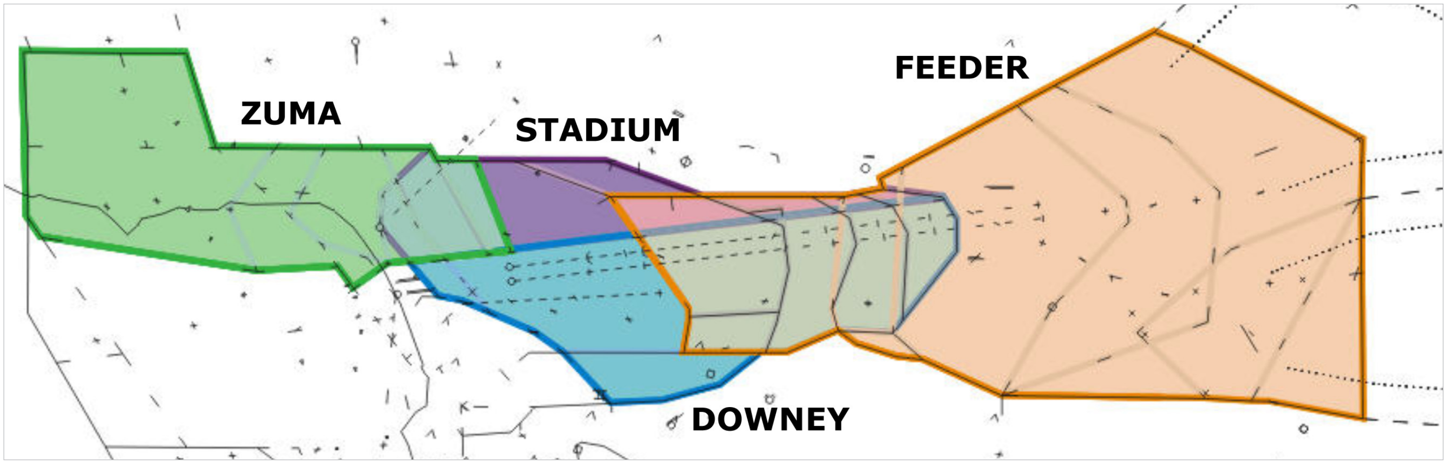
systems-level simulations. This visit, arranged by IAI, allowed participants to talk directly with operations managers and to observe controllers in the process of handling air traffic. Tony Manzione of the FAA hosted the visit, which spanned the late morning to early afternoon time frame. The professionalism and capabilities of the controllers were continuously demonstrated as they managed routing around storms in the northeast and responded to varying arrival and departure rates caused by changing weather conditions. Each participant was allowed to sit with a sector controller to observe and listen as they worked. The Washington Center management appeared to be very receptive to new technologies and tools to facilitate their operations. They are very close to deploying the En-Route Automation Modernization system, which will replace the current en-route host computer and add significant situational awareness and user configurability improvements. The departure flow manager demonstrated use of the Corridor Integrated Weather System, Departure Spacing Program , and Traffic Situation Display that are part of the current FAA tool suite. The arrival flow manager demonstrated time-based arrival management and the shuffling of arrivals to accommodate traffic delayed either en-route or at the origin airport. Information gathered from this air traffic facility visit will be used by the Airspace Systems Program to advance the state of knowledge regarding air traffic operations.
(POC: Jeremy Smith)

Phase 3 SBIR Mid-Term Review, August 2011

Members of Intelligent Automation, Inc. (IAI) presented Airspace Systems Program (ASP) staff with a mid-term briefing and interim demonstration on the ASP Phase 3 SBIR for developing develop enhanced systems analysis and simulation capabilities to support exploration of NextGen operations concepts. When completed, the software will provide enhancements to software previously delivered to model Merging and Spacing (M&S) in the terminal airspace as well as new development of integrated weather effects and traffic flow management in the Airspace Concept Evaluation System simulation. IAI is also conducting benefits assessment studies of the M&S concept using models for Newark's Liberty, Atlanta's Hartsfield-Jackson, and the Dallas Fort Worth airports as part of this effort.
(POC: Jeremy Smith)

T-TSAFE Second Simulation, August 2011

After two weeks of data collection, the second Terminal Tactical Separation Assured Flight Environment (T-TSAFE) experiment was completed in late August. The experiment simulated the complex SoCal Terminal Radar Approach Control (TRACON) airspace surrounding the Los Angeles International airport because of the complexity of this airspace. The focus of the second T-TSAFE human-in-the-loop experiment was to add altitude-based conflict resolutions for the controllers. The experiment added



A simulation of the Southern California TRACON airspace surrounding Los Angeles International Airport produced for the T-TSAFE study.

refinements to the T-TSAFE controller interface. It also tested T-TSAFE conflict alerts in the final approach all the way to the threshold instead of using Automated Terminal Proximity Alert on the final approach and T-TSAFE in the rest of the TRACON. In addition to digital data, the study assessed controller workload, situation awareness, trust, and obtained controller feedback on operational procedures.
(POCs: Savvy Verma, Debbi Ballinger)

FAA Visits to Discuss NextGen Facilities and Technologies, August 2011

FAA representatives from the FAA Tech Center, Cleveland Center, and the National Air Traffic Controllers Association (NATCA) visited NASA for a NextGen briefing to help inform their facilities modernization plan. NASA provided briefings on a wide range of topics that included project overviews and technical discussions on dynamic airspace configuration, traffic flow management, flexible airspace concepts, runway management, 3D path arrival management and near-term trajectory based operations.
(POCs: Karl Bilimoria, Shon Grabbe, Yoon Jung)

Climb Trajectory Prediction Improves, August 2011

A new technique developed by NASA researchers has reduced climb-trajectory prediction errors by as much as 90% in laboratory testing. Aircraft climb trajectories are the most difficult to project. High errors in this regime increase the rate of false and missed alerts from separation assurance automation and reduce the

potential operational benefits of some advanced concepts for NextGen. In simulations with fuel weight uncertainty of up to 50% (or roughly 15% of gross weight), the algorithm is able to adapt to within 1% of gross weight within two minutes. As a result, the standard deviation of five-minute prediction altitude errors declined by 90%, from about 1000 ft to 100 ft. When uncertainties in climb speed and climb mach were modeled (at up to 10% each), the algorithm still improved climb prediction accuracy by 20-40% (roughly 300 to 600 feet). Based on these results, the adaptive climb-trajectory prediction algorithm is slated for integration into the trajectory predictor of the Center/TRACON Automation System, NASA's real-time ground-based prototype system.
(POCs: David Thipphavong, Charles Schultz)

Simulation Shows Viability of Efficient New Weather-Avoidance Routing Capability, September 2011

The "Trajectory-Based Automation System for En Route and Transition Airspace" (TBAS-ET) project successfully completed a two-week simulation evaluation with controllers and pilots in the loop. This

Pilots on the flight deck of NASA's Boeing 747-400 simulator during the TBAS-ET simulation.

TBAS-ET simulation studied a trajectory-based air traffic management operational concept that encompasses the use of datalink communication in a near-term, mixed-equipage environment. Initial results support the conclusion that significant operational efficiencies can be achieved by issuing complex yet efficient weather-avoidance routes via datalink communication. Furthermore, such operations appear to be viable even in the near-term, before data communications are ubiquitous. In addition to investigating strategic and tactical weather avoidance, the simulation also evaluated new clearance procedures to improve controller/pilot communications, automated conflict resolution advisories, and improved tactical conflict detection using the ground-based TSAFE algorithm.
(POC: Chester Gong)

Meeting Kicks Off New DAC Research Effort, September 2011

A team of experienced air traffic management researchers from Metron Aviation, Intelligent Automation, Inc. (IAI), and the State University of New York at Stony Brook presented a research plan for Dynamic Airspace Configuration (DAC) in response to uncertain weather. Severe weather makes regions of airspace unsuitable for air traffic, resulting in flight rerouting and delays. The adjusted flight patterns can be considerably different than the normal flight patterns, which current static airspace boundaries divide into regions of traffic that can be appropriately managed by a single team of air traffic controllers. This mismatch can lead to overworked air traffic controllers and potentially even more delayed and rerouted flights. The team presented methods for dynamically adjusting airspace boundaries that are robust to relevant uncertainties in order to better handle the unusual and uncertain flight patterns resulting from severe weather. Approaches for coordinating changes to flight patterns with airspace boundary changes were also presented. The team will evaluate their approaches with simulations conducted in the Airspace Concept Evaluation System.
(POC: Michael Bloem)

FAA Visits to Discuss Air Traffic Management Collaborations, September 2011

FAA traffic flow management leads from the Air Traffic Control System Command Center, the Tech Center, and FAA Headquarters visited NASA to hear presentations on its efforts to model the integrated impact of national- and local-level traffic management initiatives, the impact of aviation on the environment, methods for improving the flow of air traffic into Denver during the convective weather season, and the Efficient Descent Advisor. Discussions also included work on sector demand estimation, modeling the integrated impact of pre-departure reroutes and ground holding, and development of a tool to acquire, evaluate, and develop data mining techniques using digitized traffic management initiatives. Lastly, a

demonstration of the dynamic weather routing tool was provided. Follow-on discussions included an invitation by the FAA to participate in a detailed research gap analysis activity in November to identify areas of mutual interest.
(POC: Shon Grabbe)

NASA Surface Researchers Meet with US Airways, September 2011

Yoon Jung, Gautam Gupta, and Waqar Malik visited Charlotte (CLT) and Philadelphia (PHL) airports to discuss partnering opportunities with US Airways executives and staff including the vice president of CLT operations, Terri Pope, and the director of air traffic control and flight operations, Bill Murphy. The US Airways management team has a strong desire to improve CLT operations by adopting new technologies that would help to more efficiently manage ramp operations through improved coordination with air traffic control counterparts including the air traffic control tower. They also have a strong motivation to collaborate with the airport authority, the FAA and the local community in order to reduce environmental impacts. CLT is the second largest airport in the east coast after Atlanta in terms of traffic volume and almost 90% of aircraft operations are from US Airways. Many of the flights are regional jet traffic. Airport surface traffic at CLT is experiencing significant departure delays due to lack of coordination between en route/terminal and surface, often resulting in 15-20 aircraft sitting in the departure queue wasting fuel and generating carbon emissions. A few specific collaboration ideas for NASA/US Airways were discussed, including environmental analysis and modeling as well as adopting a time-based sequencing tool for air traffic control and airlines at CLT.
(POC: Yoon Jung)

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