NASA Research to Support the Airlines

Richard Mogford, Ph.D.
NASA Ames Research Center
Examples of NASA Aeronautics Projects

- Airline Operations Workshop
- NASA/Airline industry forum
- Flight Awareness Collaboration Tool
- Dispatcher human factors study
- Airline Operations Research Group
- Infrasound-based turbulence detection
- Incursion detection in aircraft safety zone
- Dynamic Weather Routes
- Traffic Aware Strategic Aircrew Requests
Held an Airline Operations Workshop at NASA Ames in August 2016
- About 200 attendees - airlines and airline software vendors, NASA, FAA, and academia
- Focused on NASA, FAA, and private sector innovations to support the airlines (AOC and flight deck)
- Identified gaps where research is needed
- Formed partnerships with airline industry

Research themes
- AOC simulation
- Study dispatcher workload, situation awareness, errors
- Display/system integration
- Managing/accessing large information databases from multiple sources
- Preferred routes

AOC = airline operations center
Emphasis on Airline Operations


FOC = flight operations center
Being created to support airline industry and NASA technical discussions
Flight Awareness Collaboration Tool

• Developing the “Flight Awareness Collaboration Tool” (FACT)
• Concentrates information about winter weather events on one display
• Includes predictive tools
• Supports collaboration between AOC, air traffic control, airport authority, and de-icing operators
• Web-based application
• Includes:
  - Weather status and forecasts
  - FAA Winter Weather Dashboard
  - Prediction/reporting of runway closures for snow/ice treatment
  - Runway braking action
  - Airport runway configuration (capacity)
  - De-icing operations
  - FAA actions (e.g., ground stops, miles-in-trail, etc.)
# FACT Design

<table>
<thead>
<tr>
<th>Profiles Bar</th>
<th>Quick View Tabs</th>
<th>Quick View Tabs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Map View</strong></td>
<td>displays current US map</td>
<td><strong>Surface Map View</strong></td>
</tr>
<tr>
<td>ZOOM/PAN CONTROLS/COLLAPSIBLE MENU</td>
<td>ZOOM/PAN CONTROLS/COLLAPSIBLE MENU</td>
<td></td>
</tr>
<tr>
<td>Quick View Tabs</td>
<td>Quick View Tabs</td>
<td></td>
</tr>
<tr>
<td><strong>Information View</strong></td>
<td>formatted data for current airport</td>
<td><strong>Communication View</strong></td>
</tr>
<tr>
<td>ZOOM/PAN CONTROLS/COLLAPSIBLE MENU</td>
<td>ZOOM/PAN CONTROLS/COLLAPSIBLE MENU</td>
<td></td>
</tr>
</tbody>
</table>
FACT User Interface
FACT Primary Map View
FACT Surface Map View
FACT Information View (Text)

### ATCSCC ADVISORIES FOR WEDNESDAY, 06-10-2015

<table>
<thead>
<tr>
<th>#</th>
<th>Control Element</th>
<th>Date</th>
<th>Brief Title</th>
<th>Send Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>004</td>
<td>FCAA16</td>
<td>06/10/2015</td>
<td>CDM Airspace Flow Program CNX</td>
<td>06/10/15 00:18</td>
</tr>
<tr>
<td>003</td>
<td>ATL/ZTL</td>
<td>06/10/2015</td>
<td>CDM Ground Delay Program</td>
<td>06/10/15 00:14</td>
</tr>
<tr>
<td>002</td>
<td>LGA/ZNY</td>
<td>06/09/2015</td>
<td>CDM Ground Delay Program CNX</td>
<td>06/10/15 00:13</td>
</tr>
<tr>
<td>001</td>
<td>DCC</td>
<td>06/09/2015</td>
<td>CDM Ground Delay Program</td>
<td>06/10/15 00:05</td>
</tr>
</tbody>
</table>

Quicklinks

- FAA OIS
- Aviation Weather Center
- FAA NOTAMs
- WWACM
FACT Information View (Graphics)
FACT Communication View

MY QUEUE

LGA: Too many aircraft in de-icing area.
15:30:02
AUTHOR: rmogford

JFK: UAL 3740 stall in de-icing area. Expect a 20 min delay.
11:18:16
AUTHOR: dpek nik

Comments:
13:30:45  dpek nik: Not sure how to deal with this one, any suggestions?
Here's the procedure. attachment
13:42:34  rmogford: I'll update and send a new document to the team.
FACT Communication View

Hello there...
Richard Mogford 8:56:14 AM

It seems like we're getting a lot of warnings about ice and heavy freezing rain.
Richard Mogford 8:56:14 AM

The group is tracking and shows an hour or more...
Richard Mogford 8:56:14 AM

Thanks for the update, have a good one.
Before I forget, there's another front coming in, so stay tuned for additional info.
Richard Mogford 8:56:14 AM

Type your message here & press Enter or the send icon to submit...
Winter Weather Airport Capacity Model

- Deterministic precipitation rate forecast
- Median actual precipitation for similar forecasts and lead times
- 80% confidence interval on forecast temperature

1. Water content of Snow on Runway (WSR)
   - Deterministic WSR
   - Median WSR

2. Temp (deg)
   - 80% confidence interval on forecast temperature

3. RDP
   - Median Relative Departure Rate (RDR)

4. Baseline Departure Rate (RDR)
   - Median Predicted Departure Rate

Time (February 2013)
FACT Status

• User interface design completed and web-based prototype under development
• Winter Weather Airport Capacity Model being evaluated at several facilities
• User group at Detroit airport
• Plan to begin showing FACT to potential users to request feedback on functionality and user interface design
• Will visit US airlines to review FACT and other research issues
Dispatcher Human Factors Study

• Suggestions for a human factors study of dispatcher tasks at the Airline Operations Workshop
• Partnering with two major airlines
• Will visit AOCs to shadow dispatchers during various shifts across several days
• Trying to better understand the work of dispatchers in several configurations
  – Extended operations flights
  – Transcontinental flights
  – Weather events
• Will provide a basis for more detailed studies and better informed research
Airline Operations Research Group

Laboratory created at NASA Ames
Infrasound-based Turbulence Detection Feasibility Study

• Partnering with University Corporation for Atmospheric Research to determine if clear air turbulence detection by infrasonic microphone arrays is feasible

• Study objectives:
  – What are the spectral characteristics of the acoustic energy?
  – How are the spectral characteristics of the acoustic energy related to turbulence intensity metrics that, in turn, can be related to aircraft response?
  – What are the transmission properties of the acoustic signal (i.e., attenuation, refraction, and diffraction) as the acoustic waves propagate from the source to the receivers?
  – Given the proposed geometries of a receiver array, what are the temporal and spatial accuracies that can be achieved?
  – What are the appropriate signal processing methods to ensure adequate detection and minimal false alarms?

• Dr. Qamar Shams at NASA Langley has an infrasound array set up
  – Second array needed to test localization
Acoustic Array

Microphone Array and Detection Example
Incursion Detection in Aircraft Safety Zone

- How to reduce ground vehicle incidents?
  - Will analyze ramp area video recordings provided by partner airlines
  - Determine if ground vehicle incursion into aircraft safety zone can be reliably detected
Incursion Detection in Aircraft Safety Zone
Dynamic Weather Routes (DWR)

What's the Problem?

- Convective weather cells, or severe thunderstorms, are leading cause of flight delay in US airspace
- Flight dispatchers file flight plans 1-2 hours prior to departure utilizing routes with conservative buffers to severe forecast weather
- Weather changes as flights progress
- No automation to help operators determine when weather avoidance routes have become stale and could be corrected to reduce delay
Continuous Automatic Search Finds High-value Route Correction Opportunities, Airborne Flights, En Route Airspace
Potential Benefits Analysis
All Airlines, All Flights, Fort Worth Center 2013

100,000 min for 15,000 flights
Fort Worth Center 2013

Potential Flight Time Savings (min)

Potential savings
Potential savings corrected for observed amendments
Traffic Aware Strategic Aircrew Requests (TASAR) NASA Flight Deck Application for En Route Flight Optimization

David Wing, TASAR Principal Investigator
NASA Langley Research Center
david.wing@nasa.gov
TASAR Design

Enhanced User Request Process leveraging Cockpit Automation and Networked Connectivity to real-time operational data to optimize an aircraft’s trajectory en route

**Increased flight efficiency**

**Enhanced ATC request/approval process**  
**Enhanced dispatch/aircrew coordination**

<table>
<thead>
<tr>
<th>Traffic</th>
<th>Weather</th>
<th>Airspace</th>
</tr>
</thead>
</table>

Externally sourced data

Internally sourced data

Avionics Data Feed

Navigation Database

Aircraft Performance

Real-Time Trajectory Optimizer Application

ATC = air traffic control

TASAR Overview, March 2016
Traffic Aware Planner (TAP) Auto Mode
Simulation Experiments
Aug 2013, Oct-Nov 2014

Objectives
1. Assess TASAR effect on workload
2. Assess potential interference with primary flight duties
3. Assess TAP HMI design update
4. Assess CBT effectiveness

Two flight trials also completed

Results
1. No effect on pilot workload compared to standard flight-deck baseline condition
2. Non-normal event response not adversely affected
3. TAP useful, understandable, intuitive, easy to use
4. Standalone CBT was as effective as live instructor

Fixed-based commercial transport simulator
24 pilots (left seat, pilot flying)
2 simulated flights each, 5-6 use cases
Two HMI designs (separate simulations)

Rigorous human factors experimental design
Evaluated normal and non-normal flight conditions

HMI = human machine Interface
CBT = computer based trainer
U.I. = Operator Performance Lab, Univ. of Iowa
Questions?
richard.mogford@nasa.gov