Dynamic Weather Routes

A Weather Avoidance Concept for Trajectory-Based Operations

Dave McNally and John Love

Airspace Systems Program
2011 Technical Interchange Meeting
March 28–31 2011
San Diego, CA
www.nasa.gov
Background

- No real-time automation to find better weather routes
- Integrated operation of wind-route analysis, trial planning, and weather modeling triggers analysis
- Closed trajectories desirable for trajectory-based ops
- Today’s data comm appears suitable for weather routes
Objective

Trajectory automation and metrics for real-time identification and evaluation of time and fuel saving convective weather reroutes
Resolve Weather Conflicts
Detect Traffic Conflicts
Resolve Traffic Conflicts
Setup for Example Cases
UAL975 IAD/SFO
Flight Plan Route

UAL975 IAD/SFO
Direct-To Route
Best Aux Waypoint Route

9.8 min savings
UAL975 IAD/SFO
Snap to Fix Route

9.1 min savings
UAL975 IAD/SFO
Actual Track

UAL975 IAD/SFO
Flight Plan Route

CPZ5663 DFW/MSP
Direct-To Route

13 min savings
CPZ5663 DFW/MSP
Weather Resolved Route

11 min savings
CPZ5663 DFW/MSP
Weather & Traffic Resolved Route

9.1 min savings
CPZ5663 DFW/MSP
Snap to Fix Route

8.4 min savings
CPZ5663 DFW/MSP
Actual Track

CPZ5663 DFW/MSP
Flight Plan Route

SWA418 JAX/LAS
Direct-To Route

12 min savings
SWA418 JAX/LAS
Best Aux Waypoint Route

7.5 min savings

SWA418 JAX/LAS
Snap to Fix Route

7.1 min savings
SWA418 JAX/LAS
Another LAS Flight, Same Route

7.1 min savings
AAL1821 MIA/LAS
Actual Tracks, 4 LAS Arrivals
## Metrics

<table>
<thead>
<tr>
<th></th>
<th>Weather Conflicts (min to LOS)</th>
<th>Traffic Conflicts (min to LOS)</th>
<th>Number aux waypoints</th>
<th>Time savings (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWA418 JAX/LAS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flight plan route</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct-To route</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best aux waypoint route</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snap to fix route</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best aux waypoint route, traffic conflict-free</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Metrics

<table>
<thead>
<tr>
<th></th>
<th>Weather Conflicts (min to LOS)</th>
<th>Traffic Conflicts (min to LOS)</th>
<th>Number aux waypoints</th>
<th>Time savings (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight plan route</td>
<td>24</td>
<td>0</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Direct-To route</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best aux waypoint route</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snap to fix route</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best aux waypoint route, traffic conflict-free</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Metrics

<table>
<thead>
<tr>
<th>SWA418 JAX/LAS</th>
<th>Weather Conflicts (min to LOS)</th>
<th>Traffic Conflicts (min to LOS)</th>
<th>Number aux waypoints</th>
<th>Time savings (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight plan route</td>
<td>24</td>
<td>0</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Direct-To route</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Best aux waypoint route</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snap to fix route</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best aux waypoint route, traffic conflict-free</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Metrics

<table>
<thead>
<tr>
<th>SWA418 JAX/LAS</th>
<th>Weather Conflicts (min to LOS)</th>
<th>Traffic Conflicts (min to LOS)</th>
<th>Number aux waypoints</th>
<th>Time savings (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight plan route</td>
<td>24</td>
<td>0</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Direct-To route</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Best aux waypoint route</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>7.0</td>
</tr>
<tr>
<td>Snap to fix route</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best aux waypoint route, traffic conflict-free</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Metrics

<table>
<thead>
<tr>
<th>SWA418 JAX/LAS</th>
<th>Weather Conflicts (min to LOS)</th>
<th>Traffic Conflicts (min to LOS)</th>
<th>Number aux waypoints</th>
<th>Time savings (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight plan route</td>
<td>24</td>
<td>0</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Direct-To route</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Best aux waypoint route</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>7.0</td>
</tr>
<tr>
<td>Snap to fix route</td>
<td>0</td>
<td>0</td>
<td>2 (UBC, ATS)</td>
<td>6.7</td>
</tr>
<tr>
<td>Best aux waypoint route, traffic conflict-free</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Metrics

<table>
<thead>
<tr>
<th>SWA418 JAX/LAS</th>
<th>Weather Conflicts (min to LOS)</th>
<th>Traffic Conflicts (min to LOS)</th>
<th>Number aux waypoints</th>
<th>Time savings (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight plan route</td>
<td>24</td>
<td>0</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Direct-To route</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Best aux waypoint route</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>7.0</td>
</tr>
<tr>
<td>Snap to fix route</td>
<td>0</td>
<td>0</td>
<td>2 (UBC, ATS)</td>
<td>6.7</td>
</tr>
<tr>
<td>Best aux waypoint route, traffic conflict-free</td>
<td>N/A</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
Potential Flying Time Savings

5 hours Fort Worth Center traffic over 2 weather days

Number of flights

Total potential savings (min)

Potential flying time savings (min)
Challenges

- Objective criteria for consideration
- Common stakeholder (FAA, airspace users) understanding of
  - Controller workload, Playbook non-conformance (cost)
  - Airspace user savings (benefit)
- Who initiates? AOC requests when potential savings greater than parameter (8 min?)
- Operational trials to validate concept
Concluding Remarks

• Large potential for time and fuel savings
• Simple route changes enabled by trajectory automation, weather modeling, and air/ground data comm - no new aircraft equipage
• Common objective stakeholder consideration criteria a key requirement

• Next Steps:
  – Expand benefits analysis using more actual traffic samples
  – Collaborate with FAA and airspace users on operating concept
  – Simulations, field trials
Potential Flying Time Savings

5 hours Fort Worth Center traffic over 2 weather days

Number of flights

Potential flying time savings (min)
Concluding Remarks

- Large potential benefits: 354 min flying time savings in 5 hours of weather-impacted ZFW traffic
- Enabled by integrated trajectory automation: wind-favorable routes, weather modeling, rapid feedback trial planning, autoresolver for weather and traffic
- Concept integrates cleanly with today’s air/ground data comm (FANS-1/A) -- no new aircraft equipage
- Next Steps
  - Automate real-time weather reroutes (AAC autoresolver)
  - Expand lab analysis of benefit potential
  - Study operating concept options (who initiates, TFM metrics)
  - Stakeholder feedback
Potential Flying Time Savings

5 hours Fort Worth Center traffic over 2 weather days

Number of flights

Total potential savings (min)

Potential flying time savings (min)

Potential flying time savings (min)

Potential flying time savings (min)