Improving Operational Acceptability of Dynamic Weather Routes (DWR) Through Analysis of Commonly Used Routings

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DWR Use and Estimated Actual Savings

January 2013 to September 2014

40% of dispatcher accepted routes see actual savings

DWR Route Advisory Acceptance by ATC
Dynamic Weather Routes (DWR)
Motivation

• Can the operational acceptability of DWR route advisories to dispatchers and ATC be increased?
  – Increase savings
Outline

• Approach
• Sample application
• Performance on historical flights
• Acceptability analysis
• Conclusions
Approach

ASDI Data

Historical FPs, Amendments

Common Routing Tables

Original DWR Route Advisory

Modified DWR Route Advisory with increased Historical Usage
Constructing Modified Routes using Historical Data
Building Common Routing Tables
### Sample Common Routing Table

<table>
<thead>
<tr>
<th>Route Start Sector</th>
<th>Via</th>
<th>Final Route</th>
<th>Hist. Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZFW48</td>
<td>PNH.TCC.ACH.CLUMP.</td>
<td>ABQ</td>
<td>526</td>
</tr>
<tr>
<td>ZFW48</td>
<td>SPS.GANJA.TURKI.TXO.MIERA.</td>
<td>ABQ</td>
<td>373</td>
</tr>
<tr>
<td>ZFW48</td>
<td>UKW.GTH.TXO.MIERA.</td>
<td>ABQ</td>
<td>157</td>
</tr>
<tr>
<td>ZFW48</td>
<td>TXO.MIERA.</td>
<td>ABQ</td>
<td>109</td>
</tr>
<tr>
<td>ZFW48</td>
<td>-</td>
<td>ABQ</td>
<td>101</td>
</tr>
<tr>
<td>ZFW48</td>
<td>TCC.ACH.CLUMP.</td>
<td>ABQ</td>
<td>74</td>
</tr>
<tr>
<td>ZFW48</td>
<td>PNH.TCC.ACH.</td>
<td>ABQ</td>
<td>54</td>
</tr>
<tr>
<td>ZFW48</td>
<td>MRMAC.IRW.CRUSR.GOONI.PNH.TCC.ACH.CLUMP.</td>
<td>ABQ</td>
<td>44</td>
</tr>
<tr>
<td>ZFW48</td>
<td>PNH.ACH.</td>
<td>ABQ</td>
<td>37</td>
</tr>
<tr>
<td>ZFW48</td>
<td>CRUSR.GOONI.PNH.TCC.ACH.CLUMP.</td>
<td>ABQ</td>
<td>36</td>
</tr>
<tr>
<td>ZFW48</td>
<td>ACH.</td>
<td>ABQ</td>
<td>27</td>
</tr>
<tr>
<td>ZFW48</td>
<td>ADM.TXO.MIERA.</td>
<td>ABQ</td>
<td>26</td>
</tr>
<tr>
<td>ZFW48</td>
<td>GTH.TXO.MIERA.</td>
<td>ABQ</td>
<td>24</td>
</tr>
<tr>
<td>ZFW48</td>
<td>ADM.PNH.TCC.ACH.CLUMP.</td>
<td>ABQ</td>
<td>22</td>
</tr>
<tr>
<td>ZFW48</td>
<td>ADM.PNH.TCC.ACH.</td>
<td>ABQ</td>
<td>22</td>
</tr>
<tr>
<td>ZFW48</td>
<td>ADM.SPS.GANJA.TURKI.TXO.MIERA.</td>
<td>ABQ</td>
<td>21</td>
</tr>
<tr>
<td>ZFW48</td>
<td>TXO.</td>
<td>ABQ</td>
<td>17</td>
</tr>
<tr>
<td>ZFW48</td>
<td>KA30Y.</td>
<td>ABQ</td>
<td>15</td>
</tr>
<tr>
<td>ZFW48</td>
<td>ABI.CME.HONDS.CNX.</td>
<td>ABQ</td>
<td>14</td>
</tr>
<tr>
<td>ZFW48</td>
<td>IRW.CRUSR.GOONI.PNH.TCC.ACH.CLUMP.</td>
<td>ABQ</td>
<td>11</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Constraints for Common Route Selection

- Weather
- Route frequency in historical data (e.g., \( \geq 1 \))
- Time savings (e.g., \( \geq 5 \) minutes)
- Route complexity (e.g., \( \leq 5 \) waypoints)

- Trade-off between route frequency and delay savings
Sample Application

- Return Capture Fix
- Original DWR Advisory Reroute
- Maneuver Start Point
- Auxiliary Waypoint
- Flight Plan Routing
- Maneuver Start Point
- Sector: ZHU65
Sample Application
Sample Application

Historical Count = 5

ZFW65

ZHU65
Sample Application

Delay Savings 22 min

Historical Count = 5

Historical Count = 40

Historical Count = 5
Sample Application
Sample Application

Historical Count = 762

Historical Count = 127

Delay Savings 23 min
Sample Application: Results

<table>
<thead>
<tr>
<th>Routing</th>
<th>Delay Savings [min]</th>
<th>Via Waypoints</th>
<th>Hist. Count (concatenated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZHU65.JEN.ALS (original)</td>
<td>24</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>ZHU65.LFK.JEN.PNH.ALS</td>
<td>22</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>ZHU65.LFK.JEN.GTH.ALS</td>
<td>23</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>ZHU65.LFK.JEN.GTH.PNH.ALS</td>
<td>22</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ZHU65.LFK.JEN.ALS</td>
<td>23</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>ZHU65.ACT.PNH.ALS</td>
<td>23</td>
<td>2</td>
<td>127</td>
</tr>
<tr>
<td>ZHU65.ACT.ALS</td>
<td>24</td>
<td>1</td>
<td>35</td>
</tr>
<tr>
<td>ZHU65.ACT.GTH.ALS</td>
<td>24</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>ZHU65.ACT.GTH.PNH.ALS</td>
<td>23</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

- Concatenated historical usage based on smallest historical usage of each routing segment
- Choice of routing based on tradeoff across criteria
  - Highest delay savings: ZHU65.ACT.ALS
  - Highest historical usage: ZHU65.ACT.PNH.ALS
Performance on Historical Flights

ASDI Data

Historical FP Amendments

Common Routing Tables

Original DWR Advisory Reroutes

22:49 to 23:19 Zulu (30 minutes)

51 DWR Advisory Reroutes

Modified Reroutes

Performance Results

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparing full DWR advised route</td>
<td>50</td>
<td>11.3 min</td>
<td>24</td>
</tr>
<tr>
<td>Comparing full DWR advised segments</td>
<td></td>
<td></td>
<td>53</td>
</tr>
<tr>
<td>(applying concatenation approach)</td>
<td></td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>Comparing full common routing</td>
<td>42</td>
<td>10.5 min</td>
<td>46</td>
</tr>
<tr>
<td>Comparing common routing segments</td>
<td></td>
<td></td>
<td>112</td>
</tr>
<tr>
<td>(applying concatenation approach)</td>
<td></td>
<td></td>
<td>57%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>
Of 51 flights with DWR route advisories:

- Solutions identified for 50 flights
  - 1 case where no solution identified
- Solutions meeting constraints identified for 42 flights
  - 8 cases where solutions identified with insufficient time saving
Performance Results

51 Original DWR Advisories
- % in Hist. Data
- % Not in Hist. Data

42 Modified Advisories
- % in Hist. Data
- % Not in Hist. Data
Acceptability Analysis

ASDI Data

Historical FP Amendments

Common Routing Tables

DWR AA Data

Initial DWR Advisories

Final DWR Advisories

FP Amendments

Acceptability Statistics

<table>
<thead>
<tr>
<th>Dispatcher Response: DWR Route Advisories</th>
<th>Number of Observations in Validation Set (29 days, 2014)</th>
<th>Average number of times routing observed in historical data (April 2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accepted</td>
<td>Rejected</td>
</tr>
<tr>
<td></td>
<td>194</td>
<td>33</td>
</tr>
<tr>
<td>ATC Response: Center Route Amendments</td>
<td>198</td>
<td>146</td>
</tr>
</tbody>
</table>
### Acceptability Results: ATC Response

<table>
<thead>
<tr>
<th>Number of Observations In Validation Set (29 days, 2014)</th>
<th>Average number of times routing observed in historical data (April 2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accepted</td>
<td>Rejected</td>
</tr>
<tr>
<td>198</td>
<td>146</td>
</tr>
</tbody>
</table>

#### Route Observed Historically (April 2015)

- **ATC Response to DWR Route Advisory**
  - **True**
    - Accepted: 96%
    - Rejected: 66%
  - **False**
    - Accepted: 4%
    - Rejected: 34%
Conclusions

• DWR route advisories with increased historical usage can be generated with little reduction in delay savings
  – Approach demonstrated with small set of real DWR route advisories
  – Solution identified for 42 of 51 flights
  – Maintain between 80% and 95% of original DWR savings
  – All modified advisories are observed historically

• Historical route usage does appear to be a criteria for implementation by ATC
Identify Maneuver Start Sector (MSS)

Filter corresponding common routing table for RCF

Select most common routing from MSS to RCF

Routing meets constraints?

Yes

Record routing from MSS to RCF

No

Select next most common routing

Routing meets constraints?

Yes

Record routing from MSS to RCF

No

Filter table for AWP

Select most common routing from MSS to AWP

Routing meets constraints?

Yes

Record routing from MSS to AWP

No

Find a new nearby AWP

Select next most common routing

Routing meets constraints?

Yes

Record routing from MSS to AWP

No

Another nearby AWP available?

Yes

Identify AWP Sector (AWS)

Filter corresponding common routing table for RCF

Select most common routing from AWS to RCF

Routing meets constraints?

Yes

Record routing from AWS to RCF

No

Select next most common routing

Any RCFs still available?

Yes

Any routings recorded

Yes

Evaluate all routings from MSS to RCF

Select routing based on delay saving, commonality and complexity

No

Select next most common routing

Find a new RCF

Revert to original DWR trial plan

No

More routings available?

Yes

No

More routings available?

Yes

No

More routings available?

Yes

No

More routings available?
### Acceptability Results: ATC Response

<table>
<thead>
<tr>
<th>ATC Response: Center Route Amendments</th>
<th>Number of Observations In Validation Set (29 days, 2014)</th>
<th>Average number of times routing observed in historical data (April 2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accepted</td>
<td>Rejected</td>
</tr>
<tr>
<td>Direct to return capture fix</td>
<td>170</td>
<td>102</td>
</tr>
<tr>
<td>Via auxiliary waypoint</td>
<td>28</td>
<td>44</td>
</tr>
</tbody>
</table>

#### ATC Response to DWR Route Advisory

<table>
<thead>
<tr>
<th>ATC Response to DWR Route Advisory</th>
<th>Route Observed Historically (April 2015)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Accepted</td>
<td>True: 97%</td>
<td>False: 3%</td>
</tr>
<tr>
<td>Rejecteal</td>
<td>True: 83%</td>
<td>False: 17%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ATC Response to DWR Route Advisory</th>
<th>Route Observed Historically (April 2015)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Accepted</td>
<td>True: 93%</td>
<td>False: 7%</td>
</tr>
<tr>
<td>Rejecteal</td>
<td>True: 25%</td>
<td>False: 75%</td>
</tr>
</tbody>
</table>