Operational Demonstration of a Performance-Based Separation Standard at The Hartsfield-Jackson Atlanta International Airport

Implementation and Benefits of Equivalent Lateral Spacing Operation (ELSO) Departures

Ralf H. Mayer, Dennis J. Zondervan, Rémi L. Gottheil, Graham K. Glover

Tenth USA/Europe Air Traffic Management Research and Development Seminar (ATM2013)
Chicago, IL
10 June 2013
Outline

- **Background**
  - Performance Based Navigation (PBN)

- **PBN-Enabled Separation Standard**
  - Equivalent Lateral Spacing Operation (ELSO) Concept

- **Operational Demonstration of the ELSO Concept**
  - Implementation
    - The Hartsfield-Jackson Atlanta International Airport (KATL)
  - ELSO-Based Operational Changes
    - Evaluation Methodology
  - Estimation of Operational Benefits
    - Evaluation Results

- **Conclusions and Next Steps**
Background

- **Performance Based Navigation (PBN)**
  - Cornerstone of the FAA’s Next Generation Air Transportation System (NextGen)
  - Improvements in navigation precision pave the way for re-evaluating current standards
    - E.g., terminal divergence standard
  - In 2010, MITRE developed the Equivalent Lateral Spacing Operation (ELSO) standard concept
    - ELSO enables reduced-divergence departure operations
  - In 2011, The Hartsfield-Jackson Atlanta International Airport (KATL) implemented RNAV ELSO departure procedures
    - Operational demonstration of the ELSO concept

ELSO Concept and Benefits

- **Equivalent Lateral Spacing Operation (ELSO) Standard**
  - Capitalizes on improved navigational precision of PBN operations
  - Defines *credits* for reducing divergence requirements
    - PBN credit
    - Runway spacing credit
    - Runway stagger credit

**Reduced Divergence Benefits**

- Procedure design options
- Increased departure efficiency

*Simultaneous departure operations (independent)*
RNAV ELSO Departure Procedures*

- **2007: Before ELSO**
  - RNAV route design based on conventional divergence

- **2011: With ELSO**
  - RNAV route design based on ELSO-enabled reduced divergence

* Dual Departure Runway Configurations
Key Operational Changes

- Consistent use of RNAV off-the-ground operations
  - Successive departures and dual/triple simultaneous parallel departures

- Dual diverging departure operations from Runway 08R and Runway 27R
  - Improved airport departure efficiency and schedule/system integrity
  - Dual Departures
  - Triple Departures

- Changes to the routing of Runway 08R and Runway 27R operations
  - North and South departures
Evaluation of Operational Changes

- **Evaluate key operational changes**
  - Changes directly associated with the additional, ELSO-enabled diverging departure operations from two of KATL’s runways

- **Estimate net benefits to aircraft operators**
  - Departure Efficiency
    - Departure delay reduction benefits that result from increase in departure runway capacity
  - Departure Track Miles
    - Routing changes generally entail increases in distances (or track miles) flown
  - Departure Climb Continuity
    - Routing changes result in prolonged level flight segments (at 10,000 feet) to de-conflict departures from arrivals approaching over the Northeast and Southwest corner posts
Evaluation Methodology – Data

- **Operational Evaluation**
  - Data: Radar tracks of departures from KATL’s primary runways
  - Three evaluation time periods
  - Total: 337,132 departure tracks

- **Model Evaluation**
  - Model: changeEvaluator simulation of departures from KATL’s primary runways
  - Demand: One year of FAA Traffic Flow Management System (TFMS) flight plan data (2011)
  - Future Demand: FAA Terminal Area Forecast (TAF) demand level forecasts
    - Ten-year time range (2011-2021)
  - Total: 12 million simulated departures

### Table: Number of Radar Tracks

<table>
<thead>
<tr>
<th>Runway</th>
<th>Before ELSO</th>
<th>With ELSO 1</th>
<th>With ELSO 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>08R</td>
<td>19,732</td>
<td>21,151</td>
<td>25,365</td>
</tr>
<tr>
<td>09L</td>
<td>19,729</td>
<td>19,443</td>
<td>20,607</td>
</tr>
<tr>
<td>10</td>
<td>1,030</td>
<td>281</td>
<td>147</td>
</tr>
<tr>
<td>26L</td>
<td>40,159</td>
<td>36,169</td>
<td>38,241</td>
</tr>
<tr>
<td>27R</td>
<td>30,613</td>
<td>29,567</td>
<td>28,974</td>
</tr>
<tr>
<td>28</td>
<td>2,537</td>
<td>1,806</td>
<td>1,581</td>
</tr>
</tbody>
</table>

* July - September 2011
** November 2011 - January 2012
*** 7 March 2012 - 6 June 2012

### Table: Number of Modeled Departure Operations

<table>
<thead>
<tr>
<th>Demand Scenario</th>
<th>Number of Modeled Departure Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before ELSO</td>
<td>East Operation</td>
</tr>
<tr>
<td>2011</td>
<td>438,994</td>
</tr>
<tr>
<td>2011 + 3.7%</td>
<td>455,011</td>
</tr>
<tr>
<td>2011 + 10.5%</td>
<td>485,015</td>
</tr>
<tr>
<td>2011 + 15.7%</td>
<td>507,825</td>
</tr>
<tr>
<td>2011 + 20.6%</td>
<td>529,250</td>
</tr>
<tr>
<td>2011 + 25.6%</td>
<td>551,199</td>
</tr>
</tbody>
</table>
Evaluation Methodology – Metrics

- **Operational Evaluation**
  - Departure efficiency*
    - Metrics: Departure Spacing Time and Departure Spacing Distance
  - Departure track miles
    - Metric: track length
  - Departure climb continuity
    - Metric: time in level flight

- **Model Evaluation**
  - Departure efficiency*
    - Metric: Departure Spacing Time
  - Runway system delay
    - On per-runway basis
    - Sum of delays aircraft accrue while awaiting take-off clearance at the runways

* Departure efficiency served to validate the changeEvaluator model of departure operations
Evaluation Results – Departure Delay

- **Departure Efficiency**
  - Spacing most often observed
    - Before ELSO: 3.0 NM (63 seconds)
    - Reflects application of Radar Separation
    - With ELSO: 2.2 NM (48 seconds)
    - Reflects application of Same Runway separation in diverging departure operations

- **Departure Delay – Average Per Departure**
  - Runway 08R
    - Before ELSO: 4.0 minutes
    - With ELSO: 0.6 minutes
  - Runway 27R:
    - Before ELSO: 7.0 minutes
    - Dual and Triple: 3.2 minutes
    - With ELSO:
      - Dual and Triple: 1.2 minutes
Evaluation Results – Delay Reduction Benefits

- **Average Delay**
  - Per departure (2011)
    - Before ELSO
      - East: 2.3 min.
      - West: 2.4 min.
    - With ELSO
      - East: 0.6 min.
      - West: 0.9 min.
      - Delay Benefit
        - East: 1.7 min. benefit
        - West: 1.5 min. benefit

- **Average Delay Benefit**
  - Per departure (2011)
    - 1.5 minutes
    - $50

- **Total Delay Benefit**
  - Per year (2011)
    - 0.67 million minutes
    - $21.8 million
Evaluation Results – Track Miles

- **Average Track Miles**
  - Based on procedures via all 16 departure fixes and departures from primary runways
  - **East Operation**
    - Average increase in distance flown of 4.6 NM by North departures via the COKEM, CADIT, NUGGT, and SUMMT
  - **West Operation**
    - Average increase in distance flown of 4.7 NM by South departures via the PNUTT, BRAVS, THRSR, and NOVSS
  - Little or no changes observed for departures via all other departure fixes

- **Track Mile Impact (2011)**
  - Average cost per departure: $4.36
  - Total annual cost: $2.00 million
Evaluation Results – Climb Continuity

- **Average Time in Level Flight**
  - Considered procedures via all 16 departure fixes and level-offs at 10,000 feet of departures from primary runways
  - **East Operation**
    - Average increase in level flight of 36 seconds for North departures via COKEM, CADIT, NUGGT, and SUMMT
  - **West Operation**
    - Average increase in level flight of 44 seconds for South departures via PNUTT, BRAVS, THRSR, and NOVSS
  - Little or no changes observed for departures via all other departure fixes

- **Climb Continuity Impact (2011)**
  - Average cost per departure: $1.38
  - Total annual cost: $0.63 million
Conclusions

- **PBN-Based Divergence**
  - KATL commenced ELSO-based reduced-divergence departures on 20 October 2011
    - RNAV ELSO departure procedures

- **Operational Changes**
  - Diverging departure operations from two additional runways
    - Consistent use of RNAV off-the-ground departure operations

- **Operational Benefits (2011)**
  - Average delay benefit: 1.5 minutes per departure
  - Net average benefit: $44 per departure
  - Net annual benefit:
    - Total operator benefit: $19.2 million
    - Environmental benefit: 13,000 metric tons of CO₂
Next Steps

- **ELSO Working Group**
  - Support FAA AJV-14 in efforts adopting PBN-based divergence standard
    - JO 7110.65 change proposal for national application of the standard
    - Identification of candidate airports

- **ICAO Separation and Airspace Safety Panel (SASP)**
  - Support FAA AFS-470 in efforts socializing concepts and harmonizing efforts
    - Terminal area separation minima and procedures

- **Future Concept**
  - ELSO-inspired PBN arrival concept
Thank You!


Mayer, Ralf H., Dennis J. Zondervan, Rémi L. Gottheil, Graham K. Glover, June 2013, Operational Demonstration of a Performance-Based Separation Standard at The Hartsfield-Jackson Atlanta International Airport, Tenth USA/EUROPE Air Traffic Management Research and Development Seminar (ATM2013), Chicago, IL