Miles-in-Trail Restrictions Relaxation: A Key Benefit Mechanism of Integrated Arrival Departure Surface Traffic Management
Motivation

• Transit of departures through airport surface, TRACON airspace and finally merging into overhead enroute traffic streams is a major source of delay
  • Especially in busy metroplex areas such as New York

• NASA plans to demonstrate integrated arrival, departure, surface (IADS) traffic management technologies for improving metroplex traffic management
  • Supported by ATM Technology Demonstration-2 (ATD-2) sub-project
  • Time-based scheduling algorithms for departure metering
  • Collaborative decision making leveraging enhanced information sharing
Motivation (Cont.)

• ATD-2 is expected to improve current-day departure management procedures
  • Flights pushback when ready
  • Controlled in a First Come First Served (FCFS) manner thereafter
  • Excess departure restrictions imposed to address airspace constraints: Miles-in-Trail (MIT), Approval Requests (APREQs)

• Lack of coordination between ATD-2 time-based schedules and departure restrictions may become a major factor limiting ATD-2 benefits

• This paper studies effect of relaxing MITs when ATD-2 scheduling is active
  • Can efficiency of operations be increased and by how much?
  • Does relaxation of MIT restrictions maintain safety of operations?
Outline

• Research Motivation
• CLT Case Study Description
• Analysis Method
  • Historical Track Data Analysis
  • Departure Restrictions Analysis
  • Metroplex Departure Metering Simulation
• Analysis Results
• Conclusions & Future Work
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ATD-2 Operational Environment

- One or more well-equipped airports
- Multiple less-equipped airports
- Departure-fix merging
- Weather impacts on departure-fix capacities
- Downstream constraints: APREQs, MITs, landing time-slots at destination airports

Graphic taken from NASA ATD-2 slides
CLT Airport Case Study

Airport Surface Constraints

- Departures
- Arrivals
- Active Runway Crossings

Enroute Merge Constraints

- Departures to KEWR
- Departures to KLGA
- Departures to KJFK

Single-lane Taxi Path

Merge occurs at these points
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Analysis Method

• Develop a fast-time metroplex departure metering simulation model for the ATD-2 operational environment
  • Realistic queuing models of major TRACON and enroute departure flows
  • Realistic models of departure restrictions

• Develop emulation of departure management procedures
  • Current-day operations
  • ATD-2 operations

• Conduct fast-time simulations
  • Current-day operations, with current levels of MIT restrictions
  • ATD-2 operations, with current levels of MIT restrictions
  • ATD-2 operations, with progressively relaxed MITs

• Compare efficiency metrics and safety measures
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Identification of Major Departure Flows

• Performed FAA PDARS* track data analysis for three full days of operation in the summer of 2015

• FAA PDARS
  • Fuses radar data from NAS-wide ARTCCs, TRACONs, and major airport surfaces with other flight and environmental data
  • PDARS analyst services aid more than 75 FAA offices

• Our analysis focused on CLT and ATL departures going to destination airports in the Northeast U.S.

*PDARS: Performance Data Analysis and Reporting System
Departure Flows Analysis Using SkyView

Detailed identification of merge-locations for each destination-specific departure flow, shown here for departures to EWR.
## Where do departure traffic streams merge?

<table>
<thead>
<tr>
<th>Destination Airport</th>
<th>Merge-point for KATL and KCLT departure traffic streams</th>
<th>Implication for APREQ Modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>KLGA</td>
<td>ZITTO</td>
<td>Reserve enroute traffic stream time-slots at ZITTO</td>
</tr>
<tr>
<td>KJFK</td>
<td>TYI</td>
<td>Reserve enroute traffic stream time-slots at TYI</td>
</tr>
<tr>
<td>KEWR, (also KPHL and KBOS)</td>
<td>FAK</td>
<td>Reserve enroute traffic stream time-slots at FAK</td>
</tr>
<tr>
<td>KIAD, KDCA, KBWI</td>
<td>Merge in descent phase of the flight</td>
<td>Reserve time-slots at the destination landing runway</td>
</tr>
</tbody>
</table>
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Departure Restrictions Analysis

- Performed National Traffic Management Log (NTML) data analysis for entire year 2015

- Analyzed MIT and APREQ departure restrictions for CLT and ATL airports

- Two-fold purpose of NTML analysis
  - Identify a suitable historical day for simulation modeling
  - Support accurate modeling of these restrictions in MDMS
6/10/2015 had severe departure restrictions caused by Volume, and severe delay impact.
**Departure Restrictions on 6/10/2015**

<table>
<thead>
<tr>
<th>Time Duration for Restriction</th>
<th>Departure Restrictions Imposed On</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00 to 13:30</td>
<td>KATL Departures</td>
</tr>
<tr>
<td></td>
<td>APREQ for impacted NAS element 'GSO/PHL'</td>
</tr>
<tr>
<td></td>
<td>KCLT Departures</td>
</tr>
<tr>
<td></td>
<td>20 MIT restriction for NAS element 'GSO/PHL'</td>
</tr>
<tr>
<td>12:45 to 18:30</td>
<td>KATL Departures</td>
</tr>
<tr>
<td></td>
<td>APREQ for LGA departures</td>
</tr>
<tr>
<td></td>
<td>KCLT Departures</td>
</tr>
<tr>
<td></td>
<td>APREQ for LGA departures</td>
</tr>
<tr>
<td>13:00 to 17:45</td>
<td>KATL Departures</td>
</tr>
<tr>
<td></td>
<td>APREQ for DCA departures</td>
</tr>
<tr>
<td></td>
<td>KCLT Departures</td>
</tr>
<tr>
<td></td>
<td>30 MIT for DCA departures</td>
</tr>
<tr>
<td>18:15 to 20:15</td>
<td>KATL Departures</td>
</tr>
<tr>
<td></td>
<td>APREQ for IAD departures</td>
</tr>
<tr>
<td></td>
<td>KCLT Departures</td>
</tr>
<tr>
<td></td>
<td>30 MIT for IAD departures</td>
</tr>
<tr>
<td>21:45 to 23:00</td>
<td>KATL Departures</td>
</tr>
<tr>
<td></td>
<td>APREQ for TEB departures</td>
</tr>
<tr>
<td></td>
<td>KCLT Departures</td>
</tr>
<tr>
<td></td>
<td>30 MIT for TEB departures</td>
</tr>
<tr>
<td>22:45 to 23:30</td>
<td>KATL Departures</td>
</tr>
<tr>
<td></td>
<td>APREQ for LGA departures</td>
</tr>
<tr>
<td></td>
<td>KCLT Departures</td>
</tr>
<tr>
<td></td>
<td>APREQ for LGA departures</td>
</tr>
</tbody>
</table>

- **General observed trend**
  - ATL departures exclusively receive APREQs for NE departure constraints
  - CLT traffic going to the same airports is managed via restrictive MITs, with the exception of LGA-bound departures
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  • **Metroplex Departure Metering Simulation**
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Metroplex Departure Metering Simulation (MDMS)

- Queuing simulation with key control nodes located at:
  - Terminal-gate areas
  - Departure runways
  - Departure fixes
  - Enroute merge-fixes

- Link-node representation of major departure flows on the surface and in the airspace:
  - PDARS and ASPM data-derived transit time models for links
  - Realistic controller action models for managing queues at key nodes
MDMS Key Features

• Easily configurable network of surface and airspace routes
• Realistic transit time models derived from historical data
• Realistic models for ANSP actions
  • APREQ implementation
  • MIT application at departure runways
  • MIT application at departure-fixes
  • Managing merges at enroute stream entry points
• Pluggable model of departure management procedures
  • Current-day procedure
  • ATD-2 procedure
• Uncertainty models
  • Randomized pre-pushback uncertainty model
  • Taxi time uncertainty model
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Metroplex Departure Metering Analysis

• **Two operations models:** (i) Current-day and (ii) ATD-2

• **Multiple MIT levels:** (i) Current-day, (ii) Relaxed by 5 nmi, (iii) Relaxed by 10 nmi, ...

• **Analysis Steps:**
  • Run current-day operations sim with current MIT levels
  • Run ATD-2 operations sim with current MIT levels
  • Run ATD-2 operations sim with MIT levels relaxed by 5 nmi each
  • Run ATD-2 operations sim with MIT levels relaxed by 10 nmi each
  • Continue until relaxation of MITs leads to “unsafe” airborne delay levels
Results: Distribution of Delays

Delay aggregated over 792 CLT departures for each scenario

- **Current Day Operations**: 6828 minutes (9 minutes)
- **ATD2 Operations, Current-day MITs**: 4008 minutes
- **ATD2 Operations, Current-day MITs – 5**: 3369 minutes
- **ATD2 Operations, Current-day MITs – 10**: 2839 minutes

- **Total Gate Delay**: +2%
- **Total Taxi Delay**: -1%
- **Total TRACON Delay**: -3%
Results: Delay Savings

<table>
<thead>
<tr>
<th>Flight Domain Specific Delay Savings</th>
<th>ATD2 Operations</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current-day MITs</td>
<td>Current-day MITs - 5</td>
<td>Current-day MITs - 10</td>
</tr>
<tr>
<td>Taxi Out Delay Saving (%)</td>
<td>52</td>
<td>46</td>
<td>40</td>
</tr>
<tr>
<td>TRACON Delay Saving (%)</td>
<td>21</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Enroute Delay Saving (%)</td>
<td>44</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>Total Delay Saving (%) (Including Gate Delay)</td>
<td>-2</td>
<td>+1</td>
<td>+3</td>
</tr>
</tbody>
</table>
Results: Double Penalty Delays

Double penalty delays (Gate and runway queue delays experienced by many flights)
Results: Is Safety Compromised?

No significant difference between inter operation times.
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Conclusions & Future Work

• ATD-2 departure metering with current MIT levels
  - Significant airborne and taxi delay savings over current-day operations
  - Higher total delay (gate + taxi + airborne) due to double penalty delays

• ATD-2 departure metering with MITs relaxed
  - Maintains airborne and taxi delay savings
  - Reduces double penalty delays to provide total delay savings
  - Safety of TRACON departure merging operations uncompromised

• Future Work
  - Validate the enroute merge geometry and departure restrictions modeling approach
  - Conduct simulations over wider set of historical days
  - Leverage NASA’s high-fidelity surface simulation platform (SOSS)
  - Enhance ATD-2 scheduling algorithm emulation
Questions
Realistic Models of Major Departure Flows

Departure flows going to New York airports are separated from departure flows going to Washington D.C. area airports.