Assessing Tactical Scheduler Options for Time-Based Surface Metering

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Time-Based Surface Metering

- Improve efficiency
- Improve predictability

- earliest pushback times
- target pushback times
- hold advisories
- pushback clearance
- taxi and departure clearances
- ready for pushback

UNCERTAINTY
ATD-2 Parallel Efforts

• Field Demonstration
  – Demonstrate viability of ATD-2 tools in the real operating environment

• Human-In-The-Loop simulation
  – Develop/test human factors interfaces and procedures

• Fast-time simulation
  – Extrapolate field results
  – Refine scheduler for future phases of field demonstration
  – Easily adapt concepts to other airports
Objective

- Benchmark evaluation of the ATD-2 tactical scheduler in fast-time simulation
- Parametric analysis of taxi time delay buffer mitigation of surface congestion uncertainty
Outline

Tactical Scheduler

Fast-Time Simulation

Evaluation Results

- Average Delay (minutes)
- Taxi Delay Buffer Value (minutes)
- Throughtput Prediction Error
- Number of Departures
- Taxi Delay Buffer
- Avg Max

- Ramp
- AMA
- Taxi
- Line

- Standard Deviation

- Taxi Delay Buffer β (minutes)
Tactical Scheduler

- Earliest Pushback Time
- Earliest Runway Time
- Target Runway Time
- Target Pushback Time
- surface congestion

- Trajectory Prediction
- Runway Scheduling
- Advisory Generation

- Flight state and intent
- Separation constraints
- Taxi time delay buffers
Advisory Generation

\[
\text{Target Pushback Time} = \text{Target Runway Time} - \underbrace{\left(\text{Unimpeded Transit Time} - B\right)}_{\text{Surface Congestion}}
\]

- **A**: accounts for congestion along route
- **B**: accounts for congestion at runway

**Taxi Time Delay Buffers**
Outline

Tactical Scheduler

Fast-Time Simulation

Evaluation Results
Fast-Time Simulation

Surface Operations Scheduler & Simulator (SOSS)

Charlotte Douglas International (CLT)

South flow configuration

Arrivals 18C

Departures 18L

Active Movement Area (AMA)
Traffic Scenario

4 hours from 3/11/2016, high demand, low weather impact

ops per 15-min

ops

per

15-

min

18L dep

18C dep

simulation time (min)
Traffic Scenario

4 hours from 3/11/2016, high demand, low weather impact

ops per 15-min

simulation time (min)

18L dep

18C dep

18C arr

18L arr
Traffic Scenario

4 hours from 3/11/2016, high demand, low weather impact
Simulation Parameters and Variables

**SOSS**
- 0.5 sec time step
- Surface congestion uncertainty modelled

**Tactical Scheduler**
- Called every 10 sec
- Delay Buffers
  - $A = 1.05$
  - $B = \{0, 1, 2, \ldots\}$ min

**Evaluation Metrics**
- Departure Delay
- Runway Time Prediction
- Throughput Prediction
- Departure Queue
Departure Delay Results

Best job moving delay to gate without increasing total much

- AMA
- Ramp
- Gate
- Total
Runway Time Prediction Results

Departures are late on average

Predictability (stdev) worsens quickly as taxi time buffer is increased

Runway Time Prediction Error (min)

Late

Early

0 0.5 1 1.5 2 2.5 3 3.5 4

 NASCAR

taxi time buffer B (min)

avg

stddev
Throughput Prediction Results

Predictability (stdev) independent of buffer

Better to under predict throughput slightly to keep pressure on the runways
## Departure Queue

<table>
<thead>
<tr>
<th>Departure queues</th>
<th>Number of departures:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ramp</strong></td>
<td>In ramp</td>
</tr>
<tr>
<td><strong>AMA</strong></td>
<td>In Active Movement Area (AMA)</td>
</tr>
<tr>
<td><strong>Taxi = Ramp + AMA</strong></td>
<td>In ramp and AMA</td>
</tr>
<tr>
<td><strong>Queue</strong></td>
<td>in line from runway within 200m of each other</td>
</tr>
</tbody>
</table>
Departure Queue Results

Maximum queue lengths for 18L (0-120 min)

- Taxi, AMA, and Queue increase with buffer
- Taxi begins to saturate
- Queue > AMA when line extends into the ramp
- Ramp saturates quickly and does not increase with taxi delay buffer
Maximum Queue Length Example

Runway 18L

\[ B = 10 \text{ min} \]

\[ q_{\text{AMA}} = 11 \]

\[ q_{\text{line}} = 12 \]
Maximum queue lengths for 18L (0-120 min)
## Summary and Conclusion

<table>
<thead>
<tr>
<th>Departure Delay</th>
<th>Move as much delay to gate without increasing total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runway Time Prediction</td>
<td>Keep buffers small for better predictability</td>
</tr>
<tr>
<td>Throughput Prediction</td>
<td>Under-predict slightly to maintain pressure on runways</td>
</tr>
<tr>
<td>Departure Queue</td>
<td>Avoid saturating the Taxi and AMA queues</td>
</tr>
</tbody>
</table>

### Buffer B

<table>
<thead>
<tr>
<th>Buffer B</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>

Recommend buffers between 2 and 5 minutes for future simulations.
Future Work

• Add other uncertainties
• Add traffic management initiatives
• Add airline priority
Questions

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