Assessing Tactical Scheduler Options for Time-Based Surface Metering

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Time-Based Surface Metering

- Tactical Scheduler
  - earliest pushback times
  - target pushback times
  - hold advisories
  - ready for pushback
  - pushback clearance

• Improve efficiency
• Improve predictability

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
Tactical Scheduler

- Trajectory Prediction
  - Earliest Pushback Time
  - Earliest Runway Time
  - flight state and intent

- Runway Scheduling
  - Target Runway Time
  - separation constraints

- Advisory Generation
  - Target Pushback Time
  - taxi time
delay buffers

- surface congestion
Advisory Generation

Advisory Generation

Target Pushback Time = Target Runway Time - \( A \) - \( B \)

\( A \): Unimpeded Transit Time

\( B \): Surface Congestion

\( A \): accounts for congestion along route

\( B \): accounts for congestion at runway

Surface Congestion

Taxi Time Delay Buffers
Fast-Time Simulation

Surface Operations Scheduler & Simulator (SOSS)
Charlotte Douglas International (CLT)
South flow configuration
Traffic Scenario

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

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)

18C dep
18L 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

flight states

target pushback times
Departure Delay Results

Best job moving delay to gate without increasing total much

<table>
<thead>
<tr>
<th>delay (min)</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>
<tbody>
<tr>
<td>taxi time buffer B (min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

AMA
Ramp
Gate
Total
Runway Time Prediction Results

Departures are late on average

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

<table>
<thead>
<tr>
<th>taxi time buffer B (min)</th>
<th>Runway Time Prediction Error (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>avg</td>
</tr>
<tr>
<td>1</td>
<td>stdev</td>
</tr>
<tr>
<td>2</td>
<td>Late</td>
</tr>
<tr>
<td>3</td>
<td>Early</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
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<td>7</td>
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<tr>
<td>9</td>
<td></td>
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<tr>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
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>Ramp</td>
<td>In ramp</td>
</tr>
<tr>
<td>AMA</td>
<td>In Active Movement Area (AMA)</td>
</tr>
<tr>
<td>Taxi = Ramp + AMA</td>
<td>In ramp and AMA</td>
</tr>
<tr>
<td>Queue</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

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

\( B = 10 \text{ min} \)

\( q_{\text{AMA}} = 11 \)

\( q_{\text{line}} = 12 \)
Departure Queue Results

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

Maximum queue lengths for 18L (0-120 min)
## Summary and Conclusion

<table>
<thead>
<tr>
<th></th>
<th>Move as much delay to gate without increasing total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runway Time</td>
<td>Keep buffers small for better predictability</td>
</tr>
<tr>
<td>Throughput</td>
<td>Under-predict slightly to maintain pressure on runways</td>
</tr>
<tr>
<td>Departure</td>
<td>Avoid saturating the Taxi and AMA queues</td>
</tr>
<tr>
<td>Departure Delay</td>
<td></td>
</tr>
<tr>
<td>Buffer B</td>
<td>0  1  2  3  4  5  6  7  8  9  10</td>
</tr>
</tbody>
</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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