Assessing Tactical Scheduler Options for Time-Based Surface Metering

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Time-Based Surface Metering

- Improve efficiency
- Improve predictability

 UNCERTAINTY

earliest pushback times

target pushback times

hold advisories

pushback clearance

ready for pushback

taxi and departure clearances

Pilot

Ramp Control

ATCT Control

Tactical Scheduler

Airline Ops
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
Tactical Scheduler

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

- Runway Scheduling
  - separation constraints

- Advisory Generation
  - taxi time
delay buffers

Flight state and intent

Earliest Runway Time

Earliest Pushback Time

Earliest Runway Time

Target Runway Time

Target Pushback Time
Advisory Generation

Target Pushback Time = Target Runway Time - Unimpeded Transit Time

Surface Congestion

Advisory Generation

A accounts for congestion along route
B accounts for congestion at runway

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)
Traffic Scenario

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

ops per 15-min

simulation time (min)
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

<table>
<thead>
<tr>
<th>taxi time buffer B (min)</th>
<th>delay (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
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<td>9</td>
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<td>10</td>
</tr>
</tbody>
</table>
Runway Time Prediction Results

- Departures are late on average
- Predictability (stdev) worsens quickly as taxi time buffer is increased

**Bar Chart**
- **Y-axis:** Runway Time Prediction Error (min)
- **X-axis:** Taxi time buffer B (min)
- **Legend:**
  - Late
  - Early
  - Avg
  - Stdev

**Graph:**
- The graph shows the increase in error and predictability (stdev) as the taxi time buffer increases, indicating a decline in predictability as buffer time increases.
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>
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

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

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

\[ q_{\text{line}} = 12 \]
Departure Queue Results

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>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>
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</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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