Assessing Tactical Scheduler Options for Time-Based Surface Metering

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Air Traffic Demonstration 2 (ATD-2)

Time-Based Surface Metering

- Improve efficiency
- Improve predictability

**Tactical Scheduler**

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

**UNCERTAINTY**

Airline Ops

ATCT Control

Ramp Control
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
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
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
Traffic Scenario

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

ops per 15-min

simulation time (min)

18L dep
18C dep
18R arr
23 arr
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 are input into the SOSS model, which then generates target pushback times. These times are then processed by the Tactical Scheduler, which updates the flight states every 10 seconds.
Departure Delay Results

Best job moving delay to gate without increasing total much.
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></td>
<td>Late</td>
</tr>
<tr>
<td></td>
<td>Early</td>
</tr>
<tr>
<td>0</td>
<td>avg</td>
</tr>
<tr>
<td>1</td>
<td>stdev</td>
</tr>
</tbody>
</table>

 taxi time buffer B (min)
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>
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
$B = 10$ min
$q_{AMA} = 11$
$q_{line} = 12$
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: 0 1 2 3 4 5 6 7 8 9 10

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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