Assessing Tactical Scheduler Options for Time-Based Surface Metering

Shannon Zelinski
Robert Windhorst

NASA Ames Research Center
Time-Based Surface Metering

Tactical Scheduler

- earliest pushback times
- target pushback times

UNCERTAINTY

- Improve efficiency
- Improve predictability

Airline Ops

ATCT Control

Pilot

Ramp Control

taxi and departure clearances

ready for pushback

hold advisories

pushback clearance
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

- 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

Target Pushback Time = Target Runway Time - Unimpeded Transit Time - Surface Congestion

- 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

Fast-Time Simulation

Arrivals

Departures

18R 18C 18L

Active Movement Area (AMA)

Gates

Ramp

23
Traffic Scenario

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

ops per 15-min

ops per 15-min

simulation time (min)

18L dep

18C dep
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
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

[Bar chart showing taxi time buffer B (min) vs. delay (min) with legend for AMA, Ramp, Gate, and 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>Late avg 1.3</td>
</tr>
<tr>
<td>1</td>
<td>Late avg 1.5</td>
</tr>
<tr>
<td>2</td>
<td>Late avg 1.7</td>
</tr>
<tr>
<td>3</td>
<td>Late avg 2.0</td>
</tr>
<tr>
<td>4</td>
<td>Late avg 2.3</td>
</tr>
<tr>
<td>5</td>
<td>Late avg 2.6</td>
</tr>
<tr>
<td>6</td>
<td>Late avg 3.0</td>
</tr>
<tr>
<td>7</td>
<td>Late avg 3.5</td>
</tr>
<tr>
<td>8</td>
<td>Late avg 4.0</td>
</tr>
<tr>
<td>9</td>
<td>Late avg 4.5</td>
</tr>
<tr>
<td>10</td>
<td>Late avg 5.0</td>
</tr>
</tbody>
</table>

- **avg**: Average prediction error
- **stdev**: Standard deviation of prediction error
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
$B = 10 \text{ min}$
$q_{AMA} = 11$
$q_{line} = 12$
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

<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>
<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

Shannon.j.zelinski@nasa.gov