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

Taxi and departure clearances

Ready for pushback

Pushback clearance

Pilot
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

- Runway Scheduling
  - Separation constraints
  - Flight state and intent

- Advisory Generation
  - Taxi time delay buffers
  - Surface congestion
Advisory Generation

Target Pushback Time = Target Runway Time – (Unimpeded Transit Time – B)

Surface Congestion

Advisory Generation

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

**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

Runway Time Prediction Error (min)

Late

Early

0

1

2

3

4

5

6

7

8

9

10

taxi time buffer B (min)

avg

stdev
Throughput Prediction Results

Predictability (stdev) independent of buffer

Throughput Prediction Error (dep per 15-min)

Under-predicted

Over-predicted

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 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
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**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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</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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