Initial Data Analysis Results for ATD-2 ISAS HITL Simulation

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• Objectives
  – To evaluate operational procedures and information requirements for
    • Tactical Surface Metering Tool
    • APREQ procedures between ATC Tower and Center
    • Data exchange elements between Ramp and ATC Tower

• Scenarios
  – IFR rules in clear weather at Charlotte airport (CLT)
  – No GA / cargo flights
  – TMI flights included: APREQ/CFR, EDCTs, and MIT
  – North flow: 68 departures and 85 arrivals, with 3 turnaround
  – South flow: 63 departures and 89 arrivals, with 4 turnaround
Tactical Surface Metering Tool

- Provides pushback advisories to ramp controllers
- Departure demand control
  - Absorb delay in AMA and Ramp area by adding buffers in computing pushback time (TOBT)
    - Prevent runway over-saturation or starvation
    - Prevent too much or too little gate hold
  - Implement tunable parameters to maintain pressure on runway queue depending on demand/capacity

\[
TOBT = \max(EOBT, TTOT - X \times \text{taxi time} - Y)
\]

Call Ready 1400  \hspace{1cm} TOBT 1402  \hspace{1cm} TTOT 1421

- Unimpeded Taxi Time 10 min
- Predicted Time in Queue 11 min
- Target Time in Queue 8 min
- Taxi Time Buffer 10% of 10 min = 1 min
- Gate hold 2 min

Note) TOBT: Target Off-Block Time, EOBT: Earliest Off-Block Time, TTOT: Target Take-Off Time

X: Taxi time buffer (e.g., X=1.1)
Y: Metering buffer (e.g., Y=8min)
HITL Simulation Runs

- Total eight runs having different runway configuration, metering buffer value, and MIT constraint conditions
  - Different durations, leading to different numbers of flights

<table>
<thead>
<tr>
<th>Run Name</th>
<th>Runway Configuration</th>
<th>Metering Value (min)</th>
<th>MIT Restriction</th>
<th>Duration (sec)</th>
<th>Dep No (OFF)</th>
<th>Arr No (IN)</th>
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<tbody>
<tr>
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<td>North flow</td>
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</table>
Performance Metrics

- Gate hold time
- Taxi times
  - Ramp area and AMA
  - Eastbound and Westbound
- Runway throughput
  - Accumulated takeoffs
- Surface congestion
  - Number of departures in AMA and ramp area
  - Departure queue length and average queue time
- Traffic Management Initiatives (TMI)
  - APREQ and EDCT flights
Gate Hold Time

- Mean gate hold times by runway
  - Based on the given EOBT times and actual out times
  - All departures taken off, including TMI flights
  - More holding with the lower metering value for Eastbound

**North flow**

<table>
<thead>
<tr>
<th>Dep No</th>
<th>N_6</th>
<th>N_8</th>
<th>N_10</th>
<th>N_12x</th>
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<tr>
<td></td>
<td>15</td>
<td>17</td>
<td>14</td>
<td>20</td>
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<td></td>
<td>20</td>
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**South flow**

<table>
<thead>
<tr>
<th>Dep No</th>
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<th>S_10</th>
<th>S_12</th>
<th>S_12x</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>24</td>
<td>20</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
</tbody>
</table>
• Mean taxi-out times by metering value
  – No significant impact by metering value
  – Affected by other factors such as run duration, runway changes, and TMI constraints
Taxi-Out Time by Runway

- Mean taxi-out times by runway
  - Longer taxi distance for Westbound flights
• Mean taxi-in times by metering value
  – All arrivals that reached gates
  – More holding at gate can increase taxi-in times due to gate conflicts.
• Mean taxi-in times by runway
  – Affected by other factors such as run duration, runway changes, and interaction with departures
Effects of Run Durations

- Mean values of gate hold times and taxi-out times look proportional to run durations.
Runway changes from schedule to actual assignment can impact the airport performance.

### North flow

<table>
<thead>
<tr>
<th></th>
<th>N_6</th>
<th>N_8</th>
<th>N_10</th>
<th>N_12x</th>
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</thead>
<tbody>
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<td>33 -&gt; 24</td>
<td>33 -&gt; 29</td>
<td>33 -&gt; 27</td>
</tr>
<tr>
<td>36C (Westbd)</td>
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<td>35 -&gt; 44</td>
<td>35 -&gt; 39</td>
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<tr>
<td>Total</td>
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<td>4</td>
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### South flow

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<th>S_12</th>
<th>S_12x</th>
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<tbody>
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<td>41 -&gt; 36</td>
<td>41 -&gt; 39</td>
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<tr>
<td>18C (Westbd)</td>
<td>22 -&gt; 24</td>
<td>22 -&gt; 27</td>
<td>22 -&gt; 24</td>
<td>22 -&gt; 29</td>
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<tr>
<td>18L -&gt; 18C</td>
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<td>6</td>
<td>5</td>
<td>9</td>
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<tr>
<td>18C -&gt; 18L</td>
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<td>1</td>
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<tr>
<td>Total</td>
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<td>7</td>
<td>8</td>
<td>11</td>
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</table>
• Accumulated takeoffs
  – Similar takeoff rates, except for No MIT cases

Accumulated takeoffs - North flow

Accumulated takeoffs - South flow
Runway Throughput by Runway

Accumulated takeoffs on 36R - North flow

Accumulated takeoffs on 36C - North flow

Accumulated takeoffs on 18L - South flow

Accumulated takeoffs on 18C - South flow
Queue Size from Gate/Spot to Runway

Surface count - North flow

Simulation time (minute)

Surface count - South flow

Simulation time (minute)

AMA count - North flow

Simulation time (minute)

AMA count - South flow

Simulation time (minute)

N_6  N_8  N_10  N_12x

S_8  S_10  S_12  S_12x
Queue Size by Runway

AMA count to 36R - North flow

AMA count to 18L - South flow

AMA count to 36C - North flow

AMA count to 18C - South flow

Simulation time (minute)

Count (ac)

N_6  N_8  N_10  N_12x

S_8  S_10  S_12  S_12x
Time Spent in Departure Queue

- Mean queue time per aircraft by runway
  - (Sum of waiting times in queue during simulation run) / (Number of departures taken off)
  - Expected longer queue time with the higher metering value

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<th>28</th>
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<th>28</th>
<th>21</th>
</tr>
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</table>
APREQ/EDCT Flights vs. Other Flights

- Mean gate hold time comparison
  - TMI flights try to meet Controlled Takeoff Time (CTOT), whereas other flights follow pushback advisories (TTOT).
  - Different number of TMI flights for each run can affect.

![North flow graph](chart1)

![South flow graph](chart2)

<table>
<thead>
<tr>
<th>Dep No</th>
<th>APREQ/EDCT flights</th>
<th>Other flights</th>
</tr>
</thead>
<tbody>
<tr>
<td>N_6</td>
<td>3</td>
<td>32</td>
</tr>
<tr>
<td>N_8</td>
<td>7</td>
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<td>24</td>
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<tr>
<td>N_12x</td>
<td>7</td>
<td>47</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Dep No</th>
<th>APREQ/EDCT flights</th>
<th>Other flights</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_8</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>S_10</td>
<td>6</td>
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<td>S_12</td>
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<td>43</td>
</tr>
<tr>
<td>S_12x</td>
<td>7</td>
<td>42</td>
</tr>
</tbody>
</table>
• Mean taxi-out time comparison
  – Longer taxi time for TMI flights, compared to other flights
  – For South flow, longer taxi time for TMI flights along with the higher metering value (less hold, longer queue)
A HITL simulation was conducted to evaluate a tactical surface metering tool for ramp controllers at CLT. As the metering value increases, less gate holding and longer taxi times in departure queues were expected, but the simulation results might be affected by other factors:

- Runway changes
- Run duration
- TMI flights

APREQ/EDCT flights tends to have longer taxi times to meet the given takeoff times.