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

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

Note) TOBT: Target Off-Block Time, EOBT: Earliest Off-Block Time, TTOT: Target Take-Off Time
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>
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<td>Less hold 12</td>
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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
Taxi-Out Time

- 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.

![Graph showing taxi-in times for North and South flows with Arr No 34, 38, 26, 50, 28, 34, 39, 43]
Taxi-In Time by Runway

- Mean taxi-in times by runway
  - Affected by other factors such as run duration, runway changes, and interaction with departures
• Mean values of gate hold times and taxi-out times look proportional to run durations.

![Run duration vs. Gate hold time](image1)

![Run duration vs. Taxi-out time](image2)
Departure Runway Changes

- Runway changes from schedule to actual assignment can impact the airport performance.

<table>
<thead>
<tr>
<th>North flow</th>
<th>N_6</th>
<th>N_8</th>
<th>N_10</th>
<th>N_12x</th>
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</thead>
<tbody>
<tr>
<td>36R (Eastbd)</td>
<td>33 -&gt; 24</td>
<td>33 -&gt; 24</td>
<td>33 -&gt; 29</td>
<td>33 -&gt; 27</td>
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<tr>
<td>36C (Westbd)</td>
<td>35 -&gt; 44</td>
<td>35 -&gt; 44</td>
<td>35 -&gt; 39</td>
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<tr>
<td>36R -&gt; 36C</td>
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<td>9</td>
<td>4</td>
<td>9</td>
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<td>0</td>
<td>0</td>
<td>3</td>
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<tr>
<td>Total</td>
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<td>9</td>
<td>4</td>
<td>12</td>
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<th>S_8</th>
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<th>S_12x</th>
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<tbody>
<tr>
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<td>41 -&gt; 39</td>
<td>41 -&gt; 34</td>
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<td>18C (Westbd)</td>
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<td>22 -&gt; 27</td>
<td>22 -&gt; 24</td>
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<tr>
<td>18L -&gt; 18C</td>
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<td>5</td>
<td>9</td>
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<tr>
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<td>2</td>
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<tr>
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Accumulated takeoffs
- Similar takeoff rates, except for No MIT cases
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

 AMA count - North flow

Surface count - South flow

 AMA count - South flow

Legend:
- 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 36C - North flow

AMA count to 18L - South flow

AMA count to 18C - South flow
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

<table>
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<tr>
<th>Dep No</th>
<th>15</th>
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<th>17</th>
<th>27</th>
<th>14</th>
<th>13</th>
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<th>34</th>
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<tbody>
<tr>
<td>North flow</td>
<td>N_6</td>
<td>N_8</td>
<td>N_10</td>
<td>N_12x</td>
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<tr>
<td>(sec/ac)</td>
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<td>200</td>
<td>300</td>
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<table>
<thead>
<tr>
<th>Dep No</th>
<th>24</th>
<th>18</th>
<th>20</th>
<th>21</th>
<th>28</th>
<th>21</th>
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<th>21</th>
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<tbody>
<tr>
<td>South flow</td>
<td>S_8</td>
<td>S_10</td>
<td>S_12</td>
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</table>
• 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

<table>
<thead>
<tr>
<th>Dep No</th>
<th>APREQ/EDCT flights</th>
<th>Other flights</th>
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<tr>
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<td>32</td>
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### South flow

<table>
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<tr>
<th>Dep No</th>
<th>APREQ/EDCT flights</th>
<th>Other flights</th>
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<tbody>
<tr>
<td>S_8</td>
<td>7</td>
<td>35</td>
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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.