Initial Data Analysis Results for ATD-2 ISAS HITL Simulation

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ATD-2 ISAS HITL Simulation

• 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

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

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

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>
</tr>
</thead>
<tbody>
<tr>
<td>N_6</td>
<td>North flow</td>
<td>More hold</td>
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<td>35</td>
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<td>No</td>
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<td>No</td>
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<td>43</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

![Graph showing gate hold times for North and South flows with dep no and holding times]
• 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.

<table>
<thead>
<tr>
<th>Arr No</th>
<th>North flow</th>
<th>South flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ramp Taxi Time</td>
<td>Ramp Taxi Time</td>
</tr>
<tr>
<td></td>
<td>AMA Taxi Time</td>
<td>AMA Taxi Time</td>
</tr>
<tr>
<td>Arr No</td>
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<td>(sec/ac)</td>
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<tr>
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<td>50</td>
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<td>S_12x</td>
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<table>
<thead>
<tr>
<th>Arr No</th>
<th>28</th>
<th>34</th>
<th>39</th>
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<td>Ramp Taxi Time</td>
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<tr>
<td></td>
<td>AMA Taxi Time</td>
<td>AMA Taxi Time</td>
<td>AMA Taxi Time</td>
<td>AMA Taxi Time</td>
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</table>
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
Effects of Run Durations

- Mean values of gate hold times and taxi-out times look proportional to run durations.

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

![Run duration vs. Taxi-out time](image2.png)
Runway changes from schedule to actual assignment can impact the airport performance.

### North flow

<table>
<thead>
<tr>
<th>Eastbd Runway</th>
<th>N_6</th>
<th>N_8</th>
<th>N_10</th>
<th>N_12x</th>
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<tbody>
<tr>
<td>36R</td>
<td>33 - 24</td>
<td>33 - 24</td>
<td>33 - 29</td>
<td>33 - 27</td>
</tr>
<tr>
<td>36C (Westbd)</td>
<td>35 - 44</td>
<td>35 - 44</td>
<td>35 - 39</td>
<td>35 - 41</td>
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<tr>
<td>36R -&gt; 36C</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>9</td>
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<tr>
<td>36C -&gt; 36R</td>
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<td>0</td>
<td>0</td>
<td>3</td>
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<tr>
<td>Total</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>12</td>
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</table>

### South flow

<table>
<thead>
<tr>
<th>Eastbd Runway</th>
<th>S_8</th>
<th>S_10</th>
<th>S_12</th>
<th>S_12x</th>
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<tbody>
<tr>
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<td>41 - 39</td>
<td>41 - 36</td>
<td>41 - 39</td>
<td>41 - 34</td>
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<tr>
<td>18C (Westbd)</td>
<td>22 - 24</td>
<td>22 - 27</td>
<td>22 - 24</td>
<td>22 - 29</td>
</tr>
<tr>
<td>18L -&gt; 18C</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>9</td>
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<tr>
<td>18C -&gt; 18L</td>
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<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
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

Simulation time (minute)
Queue Size from Gate/Spot to Runway

Surface count - North flow

Surface count - South flow

AMA count - North flow

AMA count - South flow

Simulation time (minute)

Count (ac)

Simulation time (minute)

Count (ac)

Simulation time (minute)

Count (ac)

Simulation time (minute)

Count (ac)

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

Simulation time (minute)

Count (ac)

N_6  N_8  N_10  N_12x

S_8  S_10  S_12  S_12x
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

**Time Spent in Departure Queue**

![Graph showing time spent in departure queue for North and South flow with dep No values: 15 | 20, 17 | 27, 14 | 13, 20 | 34, 24 | 18, 20 | 21, 28 | 21, 28 | 21]
• 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.
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)
Summary

- 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.