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
• 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

Tactical Surface Metering Tool

Call Ready  TOBT  TTOT
1400     1402 1421

Unimpeded Taxi Time 10 min
Predicted Time in Queue 11 min
Target Time in Queue 8 min

Gate hold 2 min
Taxi Time Buffer 10% of 10 min = 1 min
Unimpeded Taxi Time 10 min

TOBT = max (EOBT, TTOT – X * taxi time – Y)

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

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>35</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 bar chart](chart1.png)

![South flow bar chart](chart2.png)
• 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

### North Flow
- **Dep No**:
  - 35
  - 44
  - 27
  - 54
- **Runway Change**:
  - 9
  - 9
  - 4
  - 12

### South Flow
- **Dep No**:
  - 42
  - 41
  - 49
  - 49
- **Runway Change**:
  - 8
  - 7
  - 8
  - 11
• Mean taxi-out times by runway
  – Longer taxi distance for Westbound flights

### North flow

<table>
<thead>
<tr>
<th>Runway</th>
<th>Eastbound</th>
<th>Westbound</th>
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<tbody>
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</tr>
<tr>
<td>N_12x</td>
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### South flow

<table>
<thead>
<tr>
<th>Runway</th>
<th>Eastbound</th>
<th>Westbound</th>
</tr>
</thead>
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<td>S_8</td>
<td>700</td>
<td>900</td>
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<tr>
<td>S_10</td>
<td>600</td>
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<td>700</td>
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<tr>
<td>S_12x</td>
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**Dep No**

| N_6 | 15 | 20 |
| N_8 | 17 | 27 |
| N_10| 14 | 13 |
| N_12x| 20 | 34 |

| S_8 | 24 | 18 |
| S_10| 20 | 21 |
| S_12| 28 | 21 |
| S_12x| 28 | 21 |
• 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.
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 graph]

![Run duration vs. Taxi-out time graph]
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>
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<tr>
<td>36C (Westbd)</td>
<td>35 -&gt; 44</td>
<td>35 -&gt; 44</td>
<td>35 -&gt; 39</td>
<td>35 -&gt; 41</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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<tr>
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<td>0</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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### South flow

<table>
<thead>
<tr>
<th></th>
<th>S_8</th>
<th>S_10</th>
<th>S_12</th>
<th>S_12x</th>
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<tbody>
<tr>
<td>18L (Eastbd)</td>
<td>41 -&gt; 39</td>
<td>41 -&gt; 36</td>
<td>41 -&gt; 39</td>
<td>41 -&gt; 34</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>
</tr>
<tr>
<td>18L -&gt; 18C</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>18C -&gt; 18L</td>
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<tr>
<td>Total</td>
<td>8</td>
<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
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)

Simulation time (minute)

Count (ac)
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
• 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>
<thead>
<tr>
<th>Dep No</th>
<th>N_6</th>
<th>N_8</th>
<th>N_10</th>
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<tbody>
<tr>
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<td>14</td>
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<table>
<thead>
<tr>
<th>Dep No</th>
<th>S_8</th>
<th>S_10</th>
<th>S_12</th>
<th>S_12x</th>
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<tr>
<td></td>
<td>24</td>
<td>20</td>
<td>28</td>
<td>28</td>
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<tr>
<td></td>
<td>18</td>
<td>21</td>
<td>21</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.
**APREQ/EDCT Flights vs. Other Flights**

- **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)

![Graphs showing mean taxi-out time comparison for North and South flows.

- North flow:
  - N_6: APREQ/EDCT 32 sec/ac, Other 6 | 32 sec/ac
  - N_8: APREQ/EDCT 37 sec/ac, Other 7 | 24 sec/ac
  - N_10: APREQ/EDCT 37 sec/ac, Other 7 | 47 sec/ac
  - N_12x: APREQ/EDCT 38 sec/ac, Other 7 | 42 sec/ac

- South flow:
  - S_8: APREQ/EDCT 35 sec/ac, Other 6 | 35 sec/ac
  - S_10: APREQ/EDCT 35 sec/ac, Other 6 | 43 sec/ac
  - S_12: APREQ/EDCT 35 sec/ac, Other 7 | 42 sec/ac

Dep No

<table>
<thead>
<tr>
<th>North flow</th>
<th>South flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>N_6</td>
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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.