Initial Data Analysis Results for ATD-2 ISAS HITL Simulation

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4th Joint Workshop for KARI-NASA ATM Research Collaboration
Korea Aerospace Research Institute, Daejeon, Korea
May 23-25, 2017
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

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

- Call Ready: 1400
- TOBT: 1402
- TTOT: 1421

\[
\begin{align*}
\text{Unimpeded Taxi Time} & : 10 \text{ min} \\
\text{Taxi Time Buffer} & : 10\% \text{ of } 10 \text{ min} = 1 \text{ min} \\
\text{Unimpeded Taxi Time} & : 10 \text{ min} \\
\text{Predicted Time in Queue} & : 11 \text{ min} \\
\text{Target Time in Queue} & : 8 \text{ min} \\
\end{align*}
\]

Gate hold: 2 min

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>
</tr>
</thead>
<tbody>
<tr>
<td>N_6</td>
<td>North flow</td>
<td>More hold 6</td>
<td>Yes</td>
<td>3536</td>
<td>35</td>
<td>34</td>
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<tr>
<td>N_8</td>
<td></td>
<td>8</td>
<td>Yes</td>
<td>3979</td>
<td>44</td>
<td>38</td>
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<tr>
<td>N_10</td>
<td></td>
<td>10</td>
<td>Yes</td>
<td>3014</td>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>N_12x</td>
<td></td>
<td>Less hold 12</td>
<td>No</td>
<td>4034</td>
<td>54</td>
<td>50</td>
</tr>
<tr>
<td>S_8</td>
<td>South flow</td>
<td>More hold 8</td>
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<td>3204</td>
<td>42</td>
<td>28</td>
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<tr>
<td>S_10</td>
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<td>41</td>
<td>34</td>
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<tr>
<td>S_12</td>
<td></td>
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<td>3332</td>
<td>49</td>
<td>39</td>
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<tr>
<td>S_12x</td>
<td></td>
<td>Less hold 12</td>
<td>No</td>
<td>3380</td>
<td>49</td>
<td>43</td>
</tr>
</tbody>
</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](image1)

![South flow](image2)
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.
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.

![Graph showing the relationship between run duration and gate hold time](image1)

![Graph showing the relationship between run duration and taxi-out time](image2)
Runway changes from schedule to actual assignment can impact the airport performance.

### Departure Runway Changes

#### North flow

<table>
<thead>
<tr>
<th>Runway Change</th>
<th>N_6</th>
<th>N_8</th>
<th>N_10</th>
<th>N_12x</th>
</tr>
</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>
</tr>
<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>
</tr>
<tr>
<td>36R -&gt; 36C</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>36C -&gt; 36R</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>12</td>
</tr>
</tbody>
</table>

#### South flow

<table>
<thead>
<tr>
<th>Runway Change</th>
<th>S_8</th>
<th>S_10</th>
<th>S_12</th>
<th>S_12x</th>
</tr>
</thead>
<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>
</tr>
<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>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
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<tr>
<td>Total</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>11</td>
</tr>
</tbody>
</table>
Departure Runway Throughput

- **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)

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

Count (ac)

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
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

![North flow graph](image)

<table>
<thead>
<tr>
<th>Dep No</th>
<th>15</th>
<th>20</th>
<th>17</th>
<th>27</th>
<th>14</th>
<th>13</th>
<th>20</th>
<th>34</th>
</tr>
</thead>
</table>

![South flow graph](image)

| Dep No | 24 | 18 | 20 | 21 | 28 | 21 | 28 | 21 |
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.
• 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.