The Impact of Block Time Reliability on Scheduled Block Time Setting

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Outline

• Background and literature review
• Percentile model for SBT setting
• Impact Analysis
• Conclusion
Scheduled Block Time (SBT) Setting

(Gate delay)

Departure delay

Taxi-out

Air time

Arrival delay

Taxi-in

CRS departure time

Wheels on

Actual arrival time

Actual departure time

Wheels off

Actual block time

Scheduled block time

Effective flight time (EFT)

Background

• SBT is crucial in airline scheduling
• Airlines’ trade-off in setting SBT
  – Shorter SBT
    ▪ SBTs are expensive: crew cost, fuel cost
    ▪ Aircraft utilization
    ▪ More competitive in the market
  – Longer SBT
    ▪ Better on-time performance
    ▪ Less propagated delay
Literature Review

- Travel time reliability in ground transportation
- Analogy between ground and air

<table>
<thead>
<tr>
<th>Concept</th>
<th>Ground transportation</th>
<th>Air transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision</td>
<td>Departure time</td>
<td>Block-time</td>
</tr>
<tr>
<td>Scheduled travel time</td>
<td>Preferred arrival time – Selected departure time</td>
<td>Scheduled block-time</td>
</tr>
<tr>
<td>Actual travel time</td>
<td>Actual arrival time – Selected departure time</td>
<td>Actual block-time</td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>Historical travel times</td>
<td>Historical block-times</td>
</tr>
<tr>
<td>Cost of earliness/excessive SBTs</td>
<td>Lost utility from reduced time at origin</td>
<td>Excess labor expense, reduced aircraft utilization</td>
</tr>
<tr>
<td>Costs of lateness/insufficient SBTs</td>
<td>Late penalty, work constraints</td>
<td>Degraded on-time performance, traveler inconvenience, delay propagation</td>
</tr>
</tbody>
</table>
Background: Travel Time Reliability

• Widespread interest in travel time reliability in ground transportation
  – Measurement and valuation of travel time reliability
  – Departure time scheduling with uncertain travel time
    (Vickrey, 1973; Small, 1982; Jenelius, et.al., 2011; Fosgerau, 2010)

• New concept and metric for flight predictability
  – Delay and capacity used to be the only metrics for measuring customer service
  – Reliability metrics have not been considered in SBT setting analysis (Coy, 2006; Mayer, 2003; Chiraphadhanakul, 2011)
Outline

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Capturing Predictability?

• Past experience: variance
  – Counter-intuitive estimation results
  – Outliers pull up measured predictability too much

• Learn from industry practice: capturing the distribution of block time
Percentile Model for SBT Setting

• Relate SBT to historical block time

• Treat different segment of block time distribution differently

• Allow for investigating the potential benefit from improved predictability
Percentile Model:

- Capture the distribution with piece-wise approximation
- 50th to 100th percentile of FT distribution
- Median and the difference every 10th percentiles:

\[ d_{56}(FT_{ay}^f) = p_{60}(FT_{ay}^f) - p_{50}(FT_{ay}^f) \]

**Flight time and its percentiles**
Percentile Model

- Capture the distribution with piece-wise approximation
- 50th to 100th percentile of BT distribution
- Median and the difference every 10th percentiles:
- Distinguish different component of block time: taxi-out time, non taxi-out time; gate delay

Flight time and its percentiles
Variables – OD level

- Flight distance
- Competitiveness of the OD pair: Herfindahl index (HHI)
- Load factor
- Flight fare
- Airport characteristic
  - OEP 35 airports
  - Airline operating hubs
Percentile Model: Data Aggregation

- Scheduled block-time (SBT)
  - Uniform for each individual flight over a quarter
  - Median SBT

- Data from three consecutive years
  - SBT: year 2011
  - Historical flight data: aggregated from year 2009 and 2010

- Individual flight defined by OD pair, departure time window (30 min), aircraft type, carrier and quarter, e.g., ATL BOS 20 B757 DL 1 (airline practice)
Estimation Results

- Effect of historical BT:
  - Median (left tail): strong
  - The “inner right tail”: moderate — airline’s BTR target
  - Additional flight time above the 70th percentile: not strong
- Effect of gate delay: negligible, insignificant
Outline

• Background and literature review

• Percentile model for SBT setting

• Impact Analysis

• Conclusion
Impact Analysis

• Percentile model confirms that different segments of the distribution have varying impacts on SBT setting
  – Left tail (median)
  – Inner right tail

• Is this happening in real life?
  – Observe the changes in block time distribution over a time period
  – Its contribution to SBT, schedule adherence metrics
Impact Analysis

- Two groups of data: 2006&2007; 2009&2010
- Two variables we control: median block time; inner right tail (75th percentile – median)
- Three “scenarios” for each variable: increase, decrease, remain the same

<table>
<thead>
<tr>
<th>Inner Right Tail of BT</th>
<th>Median BT</th>
<th>Increase</th>
<th>Average</th>
<th>Decrease</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase</td>
<td></td>
<td>226</td>
<td>598</td>
<td>142</td>
<td>966</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.027)</td>
<td>(0.072)</td>
<td>(0.017)</td>
<td>(0.116)</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>657</td>
<td>5125</td>
<td>733</td>
<td>6515</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.079)</td>
<td>(0.614)</td>
<td>(0.088)</td>
<td>(0.781)</td>
</tr>
<tr>
<td>Decrease</td>
<td></td>
<td>88</td>
<td>521</td>
<td>263</td>
<td>872</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.011)</td>
<td>(0.062)</td>
<td>(0.031)</td>
<td>(0.104)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>971</td>
<td>6244</td>
<td>1138</td>
<td>8353</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.117)</td>
<td>(0.748)</td>
<td>(0.136)</td>
<td>(1.00)</td>
</tr>
</tbody>
</table>
The Outcome

• Performance in the year after: 2008; 2011
  – Change in SBT
  – On-time performance: A0, A14
  – Block time deviation from schedule: positive, negative

• How changes in SBT affect schedule adherence metrics
  – Hypothetical scenario for 2011
  – SBT stays the same as in 2008
Results: Representative Flight for Each Scenario
Results: Change in SBT

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<td>5.834</td>
<td>6.323</td>
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<td>2 Med same, IRTail +</td>
<td>1.273</td>
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<td>3.638</td>
<td>6.513</td>
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<tr>
<td>5 Med same, IRTail same</td>
<td>-0.348</td>
<td>5.113</td>
</tr>
<tr>
<td>6 Med –, IRTail same</td>
<td>-4.909</td>
<td>6.637</td>
</tr>
<tr>
<td>7 Med +, IRTail –</td>
<td>2.267</td>
<td>7.995</td>
</tr>
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<td>8 Med same, IRTail –</td>
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- Greatest change of SBT happens when both measures change in the same direction: 1 & 9
Results: Change in SBT

- Greatest change of SBT happens when both measures change in the same direction: 1&9
- Inner right tail: around 3.3 minute difference when median changes in the same direction

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- Median: 9 minutes
## Results: Change in Schedule Adherence Metrics

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<th>SBT (min)</th>
<th>A0</th>
<th>A14</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Med +, IRTail +</td>
<td>150.6</td>
<td>156.4</td>
<td>0.53</td>
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<tr>
<td>9</td>
<td>Med –, IRTail –</td>
<td>184.3</td>
<td>177.0</td>
<td>0.49</td>
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### Analysis

<table>
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<tr>
<th>Scenario</th>
<th>Scenario Description</th>
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<th>Change</th>
<th>ND (min)</th>
<th>PD (min)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mean</td>
<td>s.t.d</td>
<td>2008</td>
<td>2011</td>
</tr>
<tr>
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<td>Med +, IRTail +</td>
<td>5.8</td>
<td>6.3</td>
<td>4.9</td>
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</tr>
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<td>9</td>
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**Results: Change in Schedule Adherence Metrics**

- Overall improvement from 2008 to 2011: resulted from combined effect of SBT change and operational performance change

- Isolating the effect of SBT (2011’): sizable impact
  - 1: improvement is due to 6 minute increase in SBT
  - 9: no substantial improvement because the reduction in SBT
  - Comparing magnitude: the impact of changes in SBT is at same level as the underlying operational performance changes
Conclusion

• SBT setting behavior
  – Segmenting the distribution is crucial in understanding how block time reliability affects SBT
  – Left and inner right tail has larger impacts on SBT setting
  – The far right tail of the distribution has small impacts

• Impact analysis
  – Significant adjustments in SBTs happen when there are changes in block time distribution
  – SBT has impacts on schedule adherence other than underlying operational performance

• Average block time is not enough information to understand the impacts on SBT, on-time performance, or deviation from schedule
Thank you!