Capacity and delays at Newark Airport, theoretical and experimental approaches

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Objectives

• Review and apply essential notions studied in class:
  – Theoretical capacity
  – Actual capacity (based on maximum throughput)
  – Delay estimates based on queuing theory
  – Actual delays
• Compare and understand the differences between theory and reality.
Newark Airport

- 443,000 movements
- 36 million passengers
- 13th busiest airport in the United States
- 22 minutes mean arrival delay, congested
- EWR-JFK-LGA metroplex:
  - 1,276,000 movements
  - 110,000,000 passengers
  - busiest multi-airport system in the world

*figures for 2007*

Experimental approach to capacity [1]

Pareto Envelope EWR 2007

26.7 mov per 15 min
Experimental approach to capacity [2]

Experimental approach to capacity [3]
Experimental approach to capacity [4]
Theoretical approach to capacity

- Run the MACAD* capacity simulation program
- Treat the simple case of 2 close parallel runways (4R|4L or 22L|22R)
- Data needed:
  - aircraft mix: ASPM
  - IFR separation standards: FAA AC’s
  - VFR separation estimates**
  - approaching speeds, runway occupancy times

* Odoni, Stamatopoulos  
** Trani

RESULTS:
- IFR theoretical capacity: 18 movements per 15 minutes
- VFR theoretical capacity: 20 movements per 15 minutes

Theoretical capacities are slightly lower than capacities yielded by theoretical approaches

* Odoni, Stamatopoulos  
** Trani
All capacities

<table>
<thead>
<tr>
<th>Method / Source</th>
<th>arrivals+departures in 15 minutes capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>98th percentile</td>
<td>22</td>
</tr>
<tr>
<td>Pareto envelope (&gt;100 obs)</td>
<td>22</td>
</tr>
<tr>
<td>Scheduled demand</td>
<td>23</td>
</tr>
<tr>
<td>FAA benchmark report</td>
<td>21-23</td>
</tr>
<tr>
<td>Macad Model (VFR)</td>
<td>20</td>
</tr>
</tbody>
</table>

Experimental approach to delays [1]
Experimental approach to delays [2]

<table>
<thead>
<tr>
<th>Time</th>
<th>Average Delay</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>8am-9am</td>
<td>-0.2 min</td>
<td>29.0 min</td>
</tr>
<tr>
<td>12pm-1pm</td>
<td>8.1 min</td>
<td>38.1 min</td>
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<tr>
<td>4pm-5pm</td>
<td>30.1 min</td>
<td>55.0 min</td>
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</tbody>
</table>

Experimental approach to delays [3]
Experimental approach to delays [4]

Runway configurations

Performance of different runway configurations during peak hour (4pm – 8pm)

<table>
<thead>
<tr>
<th>Runway configuration</th>
<th>All</th>
<th>22L</th>
<th>22R</th>
<th>11, 22L</th>
<th>22R</th>
<th>4R</th>
<th>4L</th>
<th>4R, 11</th>
<th>4L</th>
<th>4R, 29</th>
<th>4L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>100%</td>
<td>30.5%</td>
<td>27.8%</td>
<td>14.4%</td>
<td>13.9%</td>
<td>8.0%</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Arrival delay</td>
<td>31.2</td>
<td>43.9</td>
<td>14.5</td>
<td>48.0</td>
<td>18.4</td>
<td>25.4</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Departure delay</td>
<td>27.1</td>
<td>35.1</td>
<td>16.8</td>
<td>37.5</td>
<td>20.0</td>
<td>23.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>+ Taxi out delay</td>
<td>20.8</td>
<td>17.7</td>
<td>20.6</td>
<td>19.9</td>
<td>28.2</td>
<td>23.2</td>
<td></td>
<td></td>
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</table>
Theoretical approach to delays

- Run a queuing model program: *DELAYS*
- For different levels of capacity
- For a particular day of demand (Feb 4 2007), **NOT** average demand

![Demand profile on Feb 4 2007 and delay forecasts](image)

*Odoni, Kivestu

Conclusions

- **Capacity:**
  - theoretical and experimental approach within 15% of each other, a good match
  - can assist with the choice of runway configuration, comparing airports, etc.
- **Delays:**
  - theoretical estimates much lower than reality
  - delays cannot be explained by the limited capacity of 1 single airport
  - must consider the entire network of airport to include delay propagation