Lightning Impacts on Terminal and National Airspace Operations

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The Problem in a Nutshell

Hazard – Lightning

Concern – Personnel Safety

Impact – Operational Efficiency

Mitigation – Ramp Closure
Ramp Closure Impacts on Air Traffic

- **Direct Impacts**
  - servicing of gate-side aircraft halted
  - gate pushback delays
  - dependent on weather, traffic demand, airport complexity & nearby airports, FAA, etc.

- **Indirect Impacts**
  - taxi-out queuing delays as part of backlog recovery after work resumes
  - taxi-in delays caused by unavailable gates
  - delayed turn-around times
  - potential for airport gridlock, if continued landing of aircraft
  - ripple effects beyond airport

- **Other Lessons**
  - weather alone is not good proxy for measuring traffic impacts
Estimation of Annual Impacts

- **Translating Lightning into Ramp Closures**
  - typical rule of lightning within 5 miles & 10 minute wait period
  - lightning data courtesy of one major CONUS lightning network

- **Traffic Data Analysis**
  - airline on-time data courtesy of RITA Bureau of Transportation Statistics
  - flagging flights that fall inside nominal ramp closures based on above rules
• **Weather Impacts**
  - maximum lightning impacts (i.e., number of ramp closures & duration) for Florida
  - minimum lightning for west coast & Hawaii

• **Traffic Impacts**
  - maximum number of flights affected by ramp closures for high lightning & high traffic demand airports (e.g., ATL, MCO, MIA, TPA, FLL, DEN, IAH, DFW, ORD)
  - maximum gate pushback delays (over normal) for metroplexes (e.g., JFK, LGA, EWR, ORD, MDW, IAD, BWI)
Ramp Closure Decisions

- **Today’s Approach**
  - reactive based on lightning within critical distance
  - reset waiting period with each lightning strike
  - commercial decision support

- **Dilemma**
  - balancing safety & efficiency
  - definition & quantification of risk
  - risk tolerance

**Challenge – Personnel Safety & Minimal Downtime**

- Lightning Information
  - detection efficiency (sensor & network)
  - classification uncertainty (in-cloud & cloud-to-ground)
    - location accuracy
    - network evolution
    - choice of network

- Procedures
  - safety rules (distance & time)
  - efficiency (minimal downtime)
  - decision support tools
  - centralized versus distributed guidance
  - automated or human centric

- Human Cognition & Behavior
  - trust in approach
  - implementation of procedures (communication & timeliness)
    - watching other stakeholders
    - operational distractions

- Challenge – Uncertainties Everywhere

**Where is Sweet Spot?**
Uncertainties with Lightning Networks

• **Measurement**
  - sensor (partial measure of spectrum)
  - network (station density & placement)
  - detection efficiency

• **Processing**
  - classification (IC & CG; stroke & flash)
  - spatial extent & location accuracy
  - data transmission & dissemination

• **Other Factors**
  - multiple national, regional & local lightning detection systems
  - notable differences in detection efficiency & location accuracy
  - evolution of networks & algorithms

• **Implications**
  - missed lightning threats yield no ramp closures => people at risk of getting hurt
  - unnecessary ramp closures (closed too long or no closure needed due to false alarm) => inefficient operations
Effectiveness of Ramp Closure Implementation

- **Procedures**
  - reflecting varied degrees of risk tolerance
  - increased pressures for operational efficiency
  - tight rules may not necessarily yield smaller impacts
  - source of lightning matters

- **Human Cognition & Behavior**
  - effectiveness of implementing procedures varies by operator, time of impact, etc.
  - sometimes closing ramp early, but most often late, & occasionally ignoring lightning altogether
  - watching other operators using different rules causes confusion & distrust

### Ramp closures for June, July & August at one Core30 airport

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Closures (#)</th>
<th>Duration (min)</th>
<th>Hits (min)</th>
<th>False Alarms (min)</th>
<th>Misses (min)</th>
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</thead>
<tbody>
<tr>
<td>Actual</td>
<td>37 125</td>
<td>1357 3138</td>
<td>1201</td>
<td>156</td>
<td>1937</td>
</tr>
<tr>
<td>Nominal</td>
<td>96 129</td>
<td>2721 2165</td>
<td>1799</td>
<td>922</td>
<td>366</td>
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<tr>
<td>Actual</td>
<td>22 78</td>
<td>1191 1604</td>
<td>891</td>
<td>300</td>
<td>713</td>
</tr>
<tr>
<td>Nominal</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Actual = recorded ramp closures
Nominal = perfect implementation of procedures

Good: Inefficiency: Safety Risk
Summary

• **Lightning Impacts on Aviation**
  - personnel safety concerns necessitate ramp closures
  - lightning-induced ramp closures cause substantial impacts on aviation
  - impacts quantifiable for both departures & arrivals
  - some impacts may be avoidable => need to focus on that (collaboration with AvMet)

• **Uncertainties in Lightning Data**
  - detection efficiency, location & classification accuracy affect safety decisions
  - understand & quantify uncertainty => yields buffers for decision support
  - lightning networks are evolving => beneficial for reducing uncertainty

• **Challenges from User Perspective**
  - balancing safety concerns with operational efficiency => next talk 11.4 on procedures
  - trust in safety procedures & sources of lightning data (human cognition & behavior)
  - weather is “nuisance” distracting from focus on operations

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  - airport & airline partners in this research
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