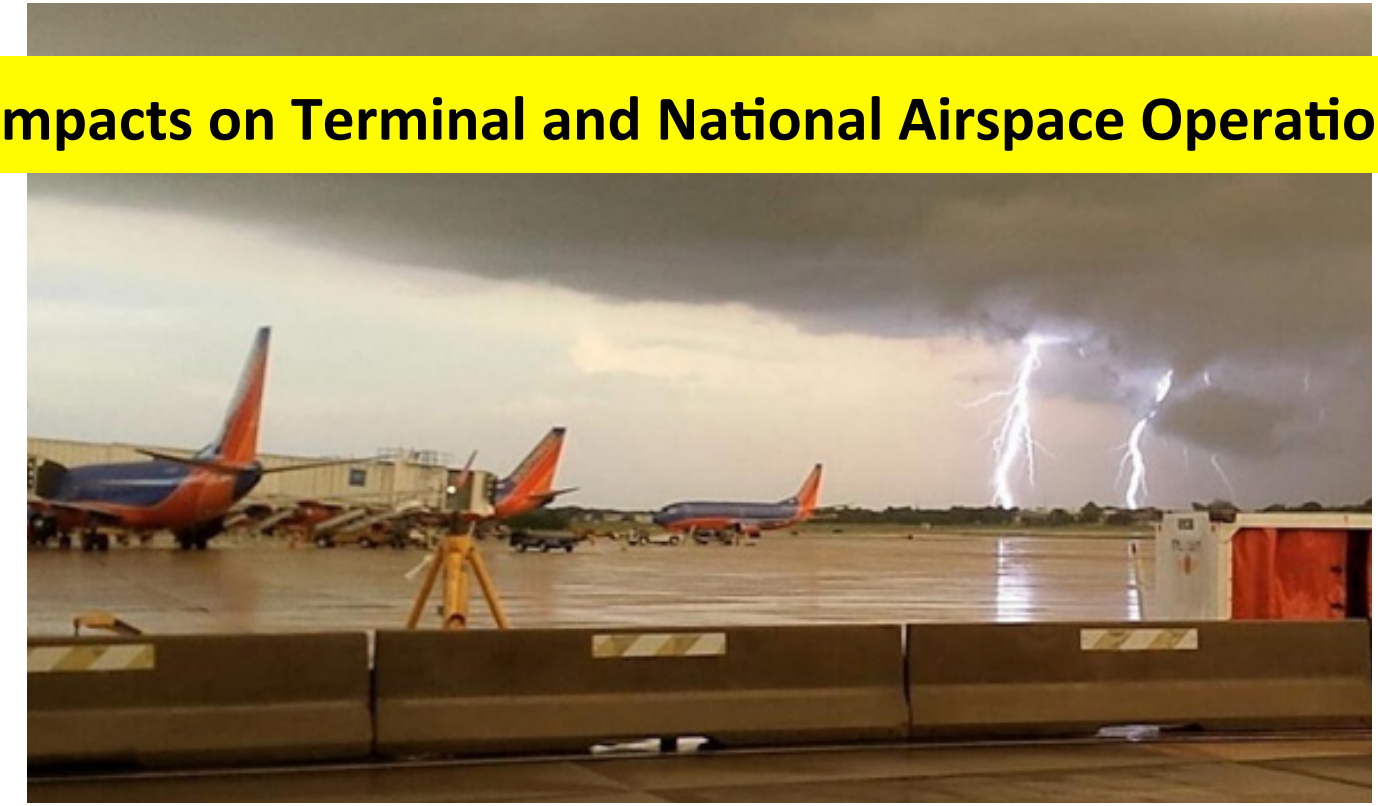
Lightning Impacts on Terminal and National Airspace Operations



Paper 11.3

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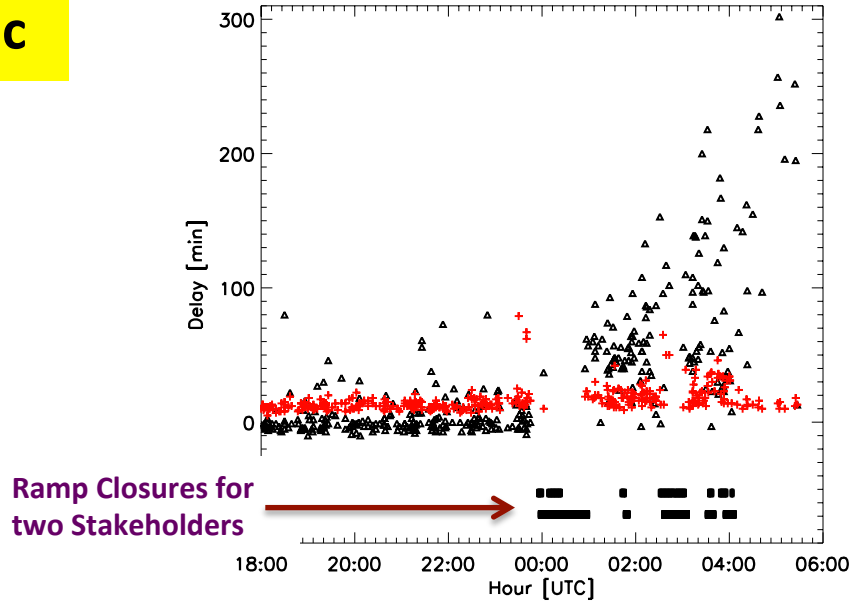
17th Aviation, Range, and Aerospace Meteorology Conference
7 January 2015 in Phoenix, AZ

The Problem in a Nutshell

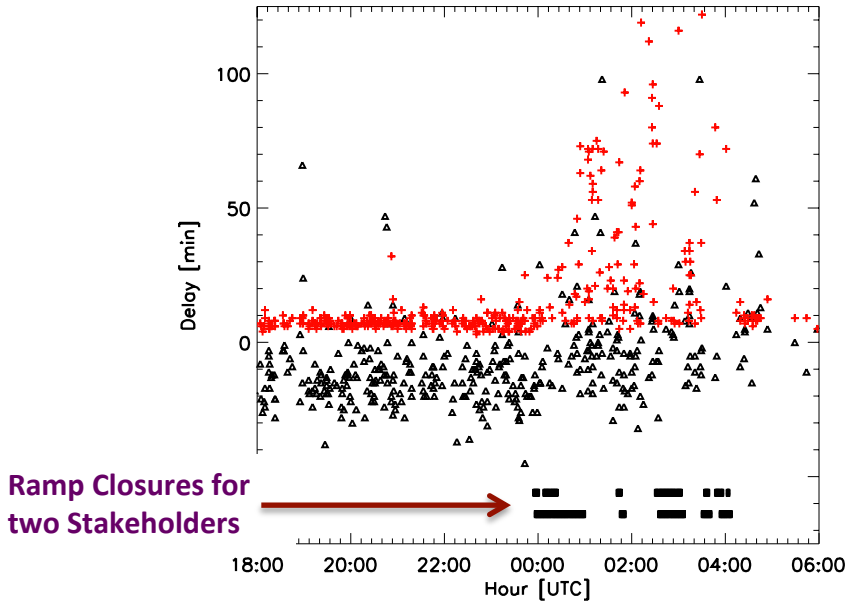
Ramp Closure Impacts on Air Traffic

- **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

Departures – Pushback (black) & Taxi-out (red)

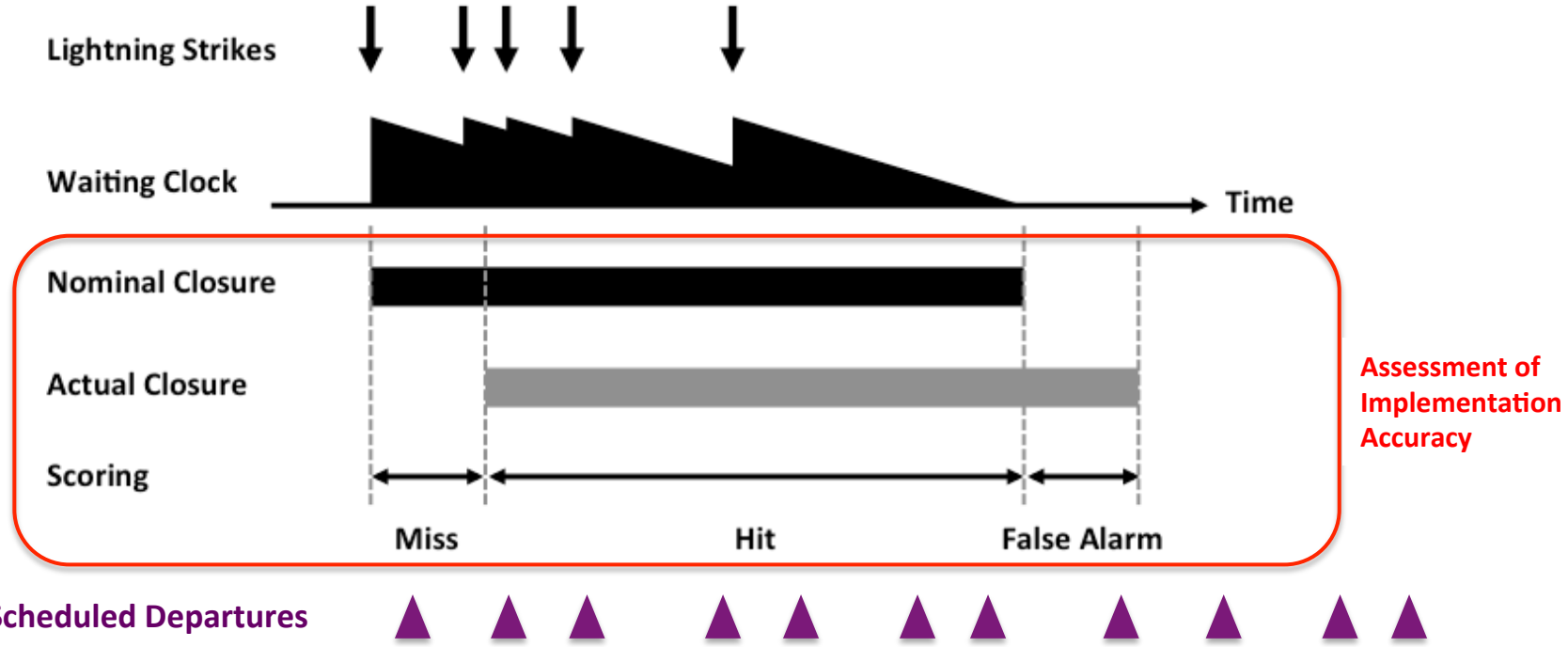


Arrivals – Touchdown (black) & Taxi-in (red)

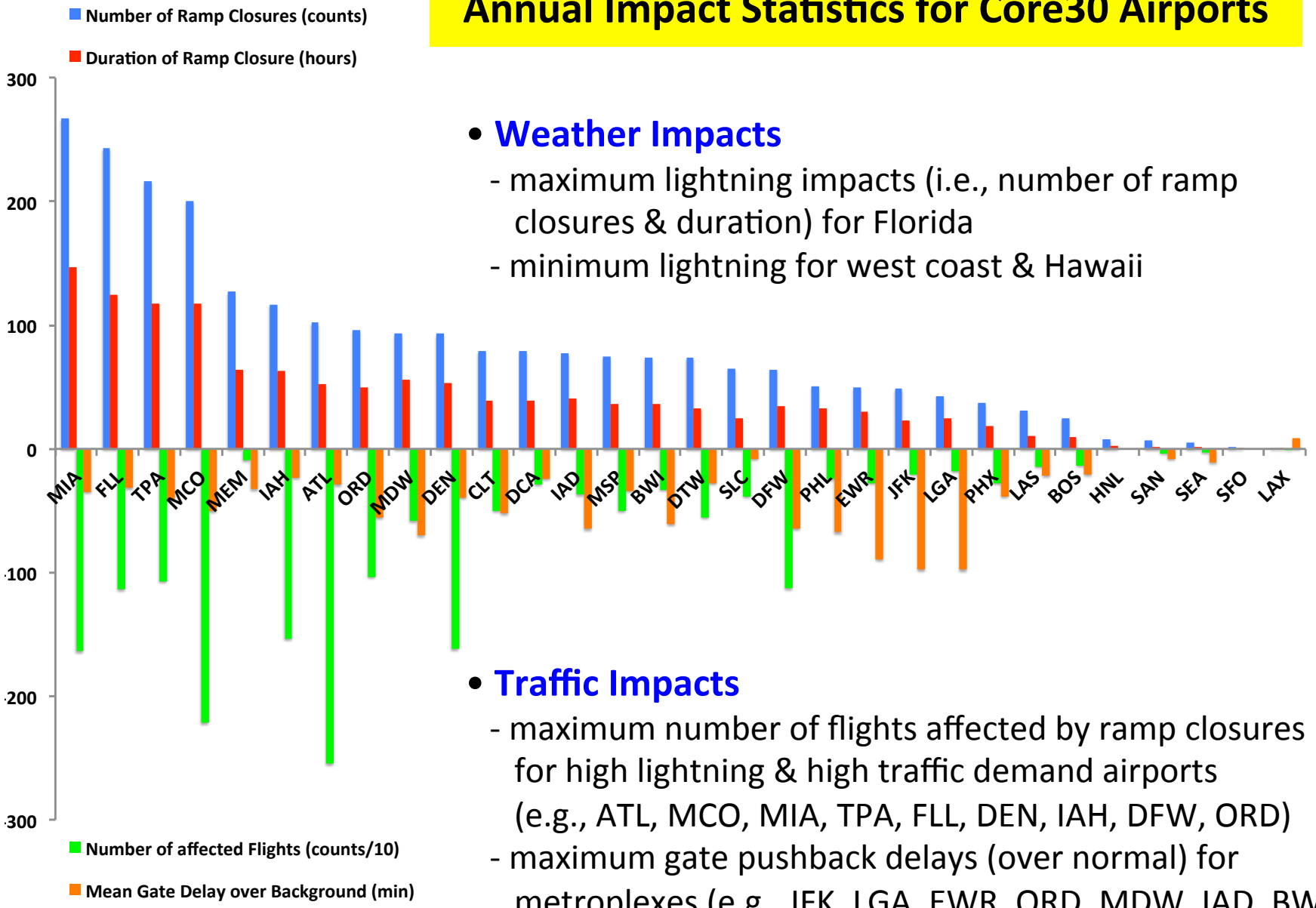


Estimation of Annual Impacts

- **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



Annual Impact Statistics for Core30 Airports



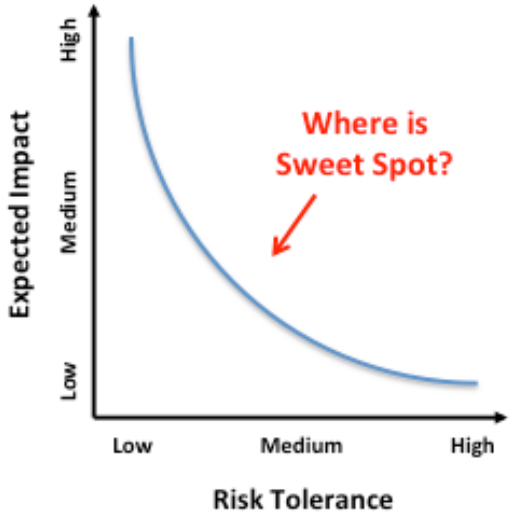
- **Weather Impacts**
  - maximum lightning impacts (i.e., number of ramp closures & duration) for Florida
  - minimum lightning for west coast & Hawaii

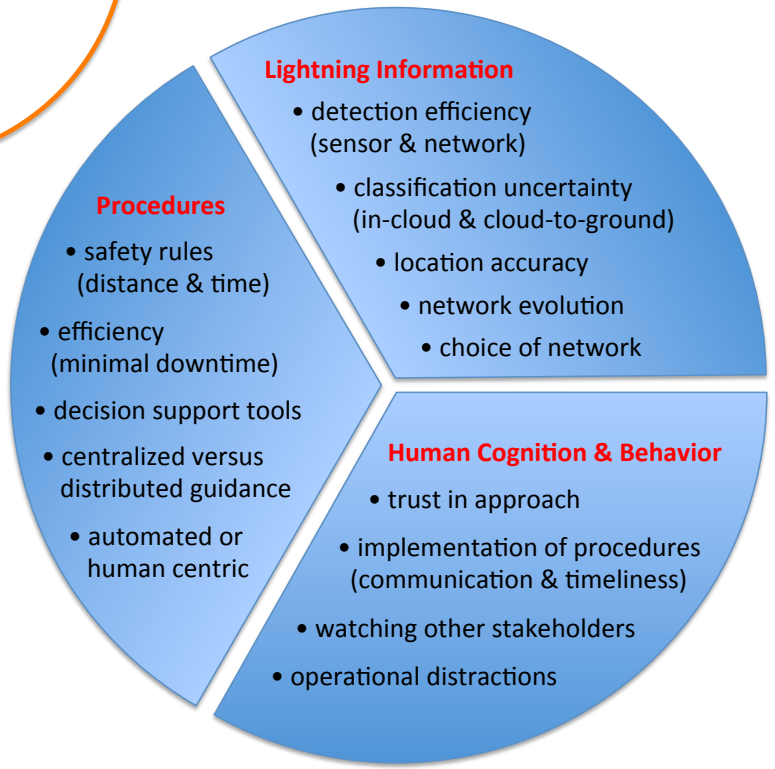
- **Traffic Impacts**
  - maximum number of flights affected by ramp closures for high lightning & high traffic demand airports (e.g., ATL, MCO, MIA, TPA, FLL, DEN, IAH, DFW, ORD)
  - maximum gate pushback delays (over normal) for metroplexes (e.g., JFK, LGA, EWR, ORD, MDW, IAD, BWI)

Ramp Closure Decisions

Challenge – Personnel Safety & Minimal Downtime

- **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

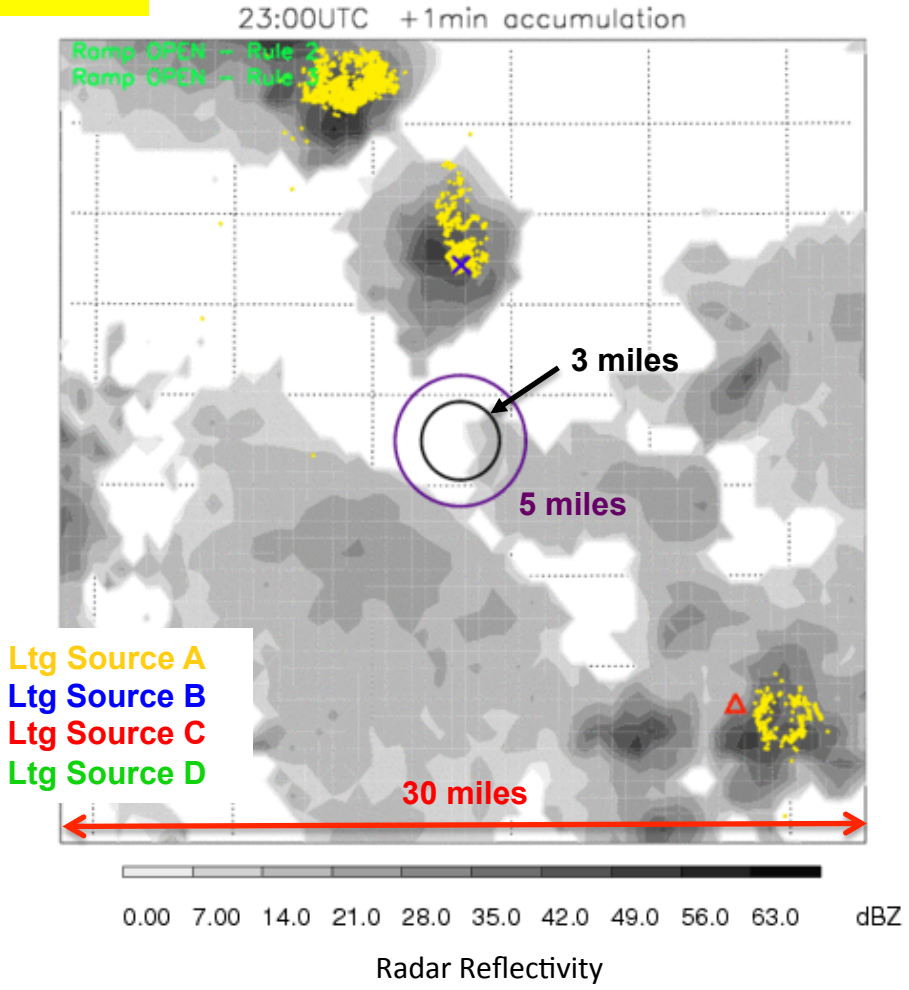




Challenge – Uncertainties Everywhere

Uncertainties with Lightning Networks

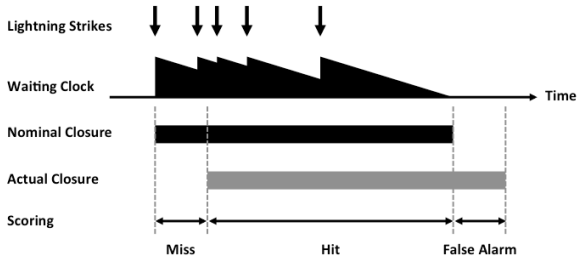
- **Measurement**
  - sensor (partial measure of spectrum)
  - network (station density & placement)
  - detection efficiency
- **Processing**
  - classification (IC & CG; stroke & flash)
  - spatial extent & location accuracy
  - data transmission & dissemination
- **Other Factors**
  - multiple national, 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

Stakeholder		*Closures (#)*	*Duration (min)*	*Hits (min)*	*False Alarms (min)*	*Misses (min)*
1	Actual	37	1357	1201	156	1937
	Nominal	125	3138			
2	Actual	96	2721	1799	922	366
	Nominal	129	2165			
3	Actual	22	1191	891	300	713
	Nominal	78	1604			

Actual = recorded ramp closures
Nominal = perfect implementation of procedures

Good **Inefficiency** **Safety Risk**

Summary

Steiner et al. (Air Traffic Control Quarterly, accepted for publication)

- **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
- **Acknowledgments**
  - airport & airline partners in this research
  - use of Earth Networks, Vaisala, WSI, & NMT total lightning mapping array data

This research is in response to requirements and funding by the Federal Aviation Administration (FAA). The views expressed are those of the authors and do not necessarily represent the official policy or position of the FAA.