

Lightning Impacts on Flight Operations



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The Problem in a Nutshell

Concern – Personnel Safety



Hazard – Lightning



Impact – Operational Efficiency



**When
Thunder
Roars,
Go Indoors!**

STOP all activities.

Seek shelter in a substantial building
or hard-topped vehicle.

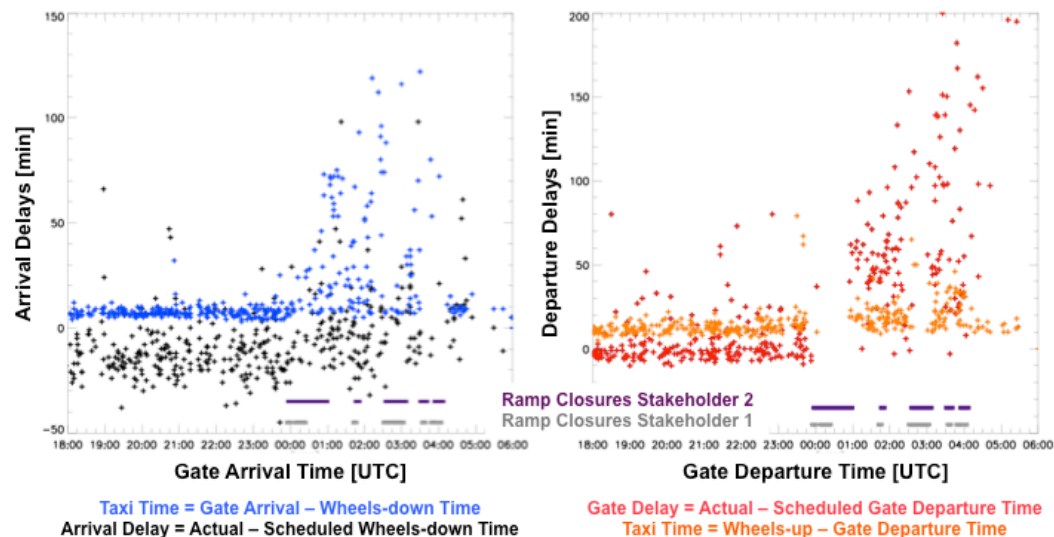
www.lightningsafety.noaa.gov

Mitigation – Ramp Closure

Ramp Closure Impacts on Air Traffic

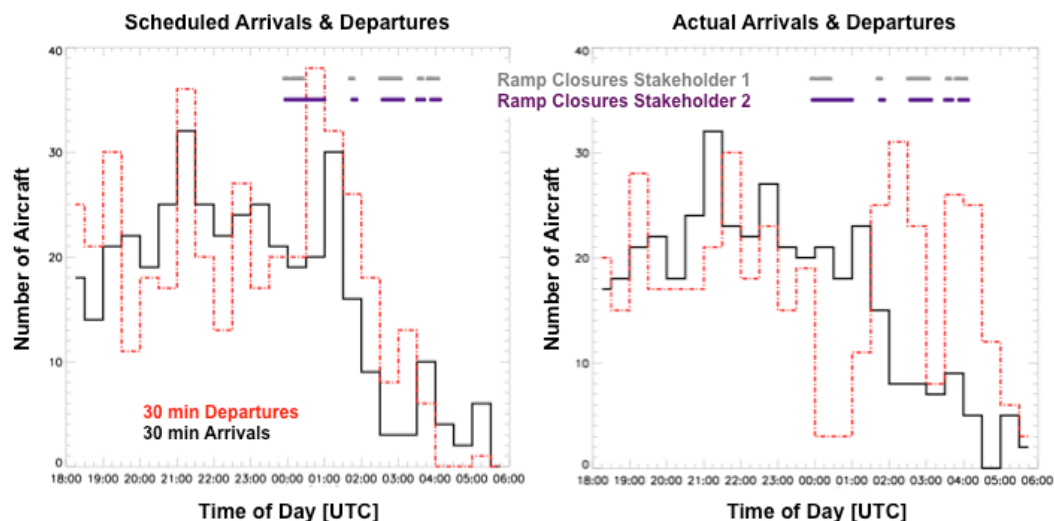
• Ramp Closure Impacts

- gate pushback delay (no service)
- taxi-out queuing (backlog)
- taxi-in delay (gate availability)
- delayed deplaning of passengers
- delayed turn-around times



• Airport Balance

- aircraft landing, but no departures
- potential for gridlock
- impact ripple effects into national airspace system



Annual Impact Statistics

Uncertainty related to procedures
& lightning data is substantial

• Direct Impacts

- gate pushback delays are substantial (on average **several tens of minutes** per affected flight)
- dependent on weather, demand, & airport complexity

• Indirect Impacts

- taxi-out queuing delays as part of backlog recovery (on **average 5 – 15 minutes**)
- taxi-in delays caused by unavailable gates (on average **5 – 20 minutes**)
- ripple effects beyond airport

• Other Lessons

- weather alone is not good proxy for measuring traffic impacts

Average delays, taxi times & range of uncertainty for several major airports

Airport	Metric	Ramp Closures min – max	No Closures min – max	Average Impact Minutes/Flight
ATL	Gate Departure Delay	59.11 – 83.48	9.27 – 10.07	61.6
	Taxi Out	29.37 – 35.20	17.91 – 18.06	14.3
	Gate Arrival Delay	36.41 – 45.02	5.58 – 6.31	34.8
	Taxi In	13.14 – 21.68	8.98 – 9.02	8.4
DEN	Gate Departure Delay	44.95 – 77.28	12.86 – 13.76	47.8
	Taxi Out	21.47 – 25.75	14.72 – 14.87	8.8
	Gate Arrival Delay	25.31 – 41.63	6.93 – 7.76	26.1
	Taxi In	11.78 – 24.92	8.62 – 8.69	9.7
EWR	Gate Departure Delay	60.11 – 70.17	14.96 – 15.79	49.8
	Taxi Out	24.46 – 44.98	20.22 – 20.36	14.4
	Gate Arrival Delay	36.18 – 65.89	11.81 – 12.63	38.8
	Taxi In	11.26 – 14.74	8.56 – 8.61	4.4
IAD	Gate Departure Delay	61.17 – 98.20	12.47 – 13.20	66.9
	Taxi Out	15.87 – 32.47	16.55 – 16.76	7.5
	Gate Arrival Delay	37.29 – 63.52	6.26 – 6.69	43.9
	Taxi In	11.59 – 24.54	6.71 – 6.75	11.3
IAH	Gate Departure Delay	35.23 – 55.28	10.47 – 11.10	34.5
	Taxi Out	21.45 – 28.82	15.51 – 15.64	9.6
	Gate Arrival Delay	16.23 – 24.42	4.05 – 4.40	16.1
	Taxi In	9.34 – 13.36	7.38 – 7.42	4.0
MCO	Gate Departure Delay	42.65 – 70.06	9.08 – 10.19	46.7
	Taxi Out	16.52 – 18.14	13.36 – 13.47	3.9
	Gate Arrival Delay	17.65 – 29.20	4.46 – 5.16	18.6
	Taxi In	13.52 – 22.70	7.43 – 7.60	10.6
MIA	Gate Departure Delay	25.99 – 45.70	8.39 – 9.14	27.1
	Taxi Out	22.22 – 23.56	16.17 – 16.46	6.6
	Gate Arrival Delay	11.07 – 17.01	2.59 – 3.22	11.1
	Taxi In	9.68 – 15.17	7.82 – 7.91	4.6
ORD	Gate Departure Delay	70.61 – 104.01	15.06 – 16.02	71.8
	Taxi Out	21.50 – 30.57	16.15 – 16.41	9.8
	Gate Arrival Delay	48.79 – 71.77	8.85 – 9.90	50.9
	Taxi In	18.78 – 42.91	9.32 – 9.43	21.5

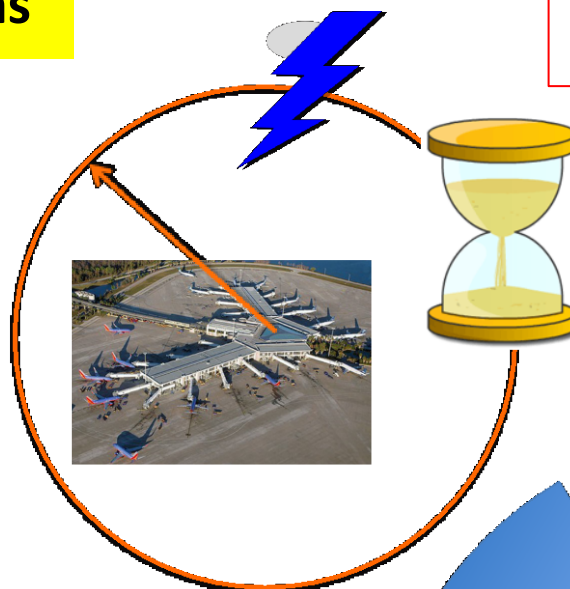
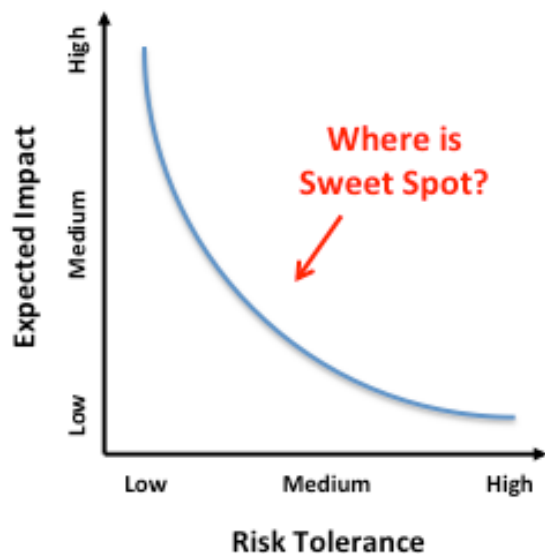
Ramp Closure Decisions

• Today's Approach

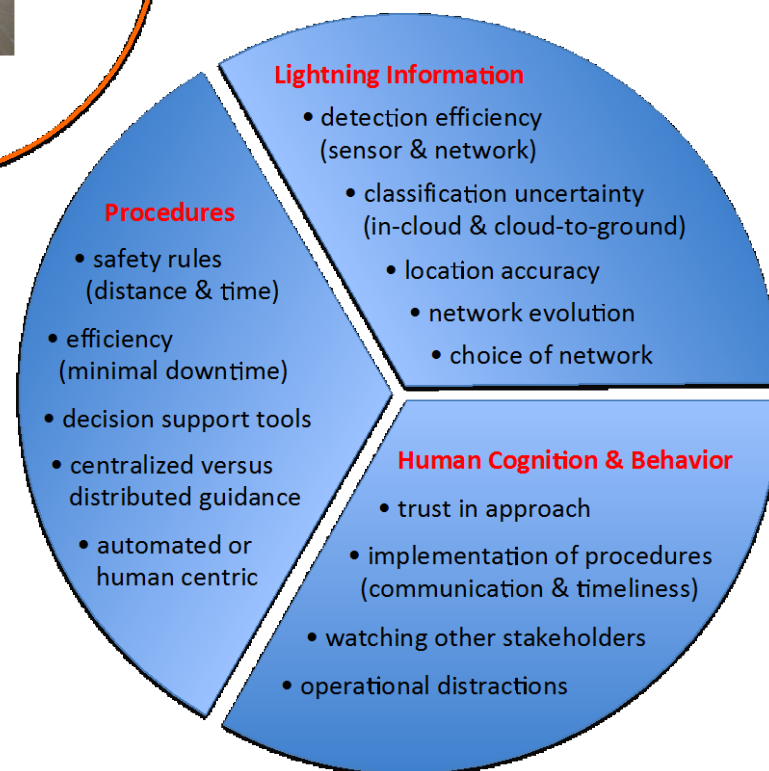
- reactive based on lightning within critical distance
- reset waiting period with each lightning strike
- commercial decision support

• Dilemma

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



Challenge – Personnel Safety & Minimal Downtime



Challenge – Uncertainties Everywhere

Uncertainties with Lightning Networks

- **Measurement**

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

- **Processing**

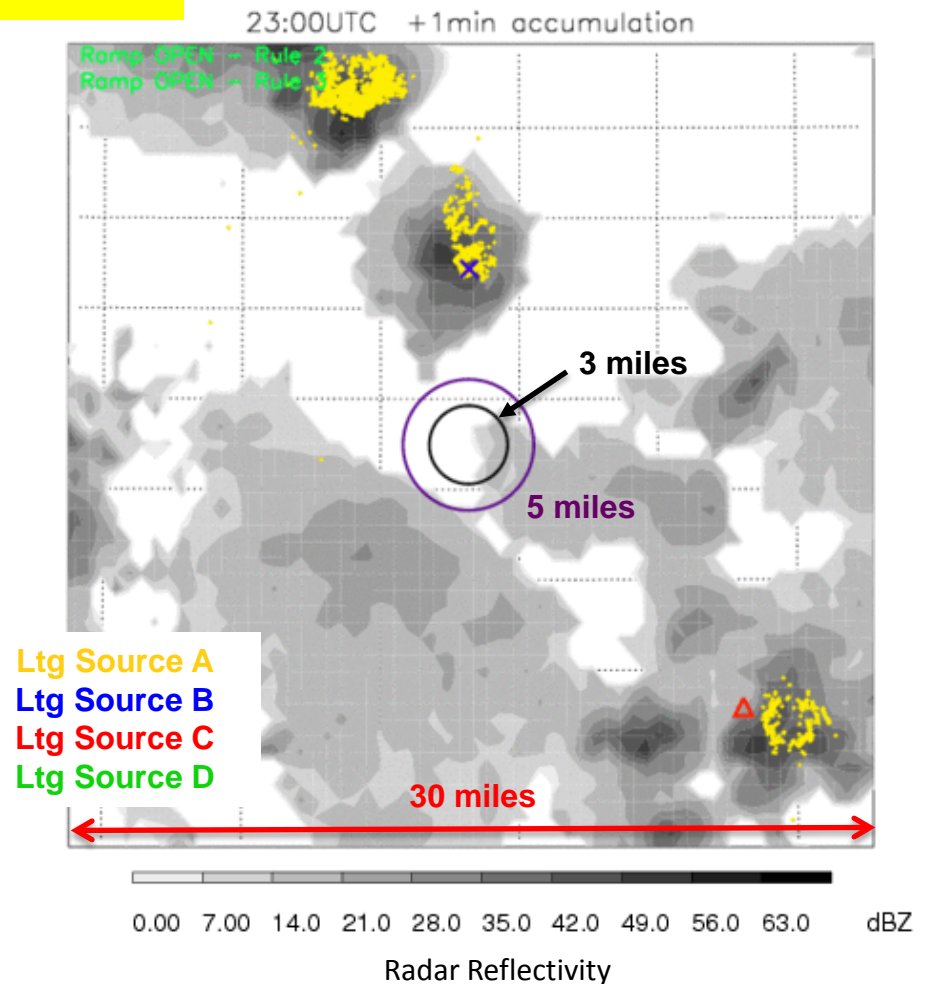
- classification (IC & CG; stroke & flash)
- spatial extent & location accuracy
- data transmission & dissemination

- **Other Factors**

- multiple national networks
- regional total lightning networks
- 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
- uncertainties cause confusion, potential safety risks & inefficiencies



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 established procedures varies by operator, time of impact, supervisor, 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

- **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

- **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 => appropriate procedures
- trust in safety procedures & sources of lightning data (human cognition & behavior)
- weather is “nuisance” distracting from focus on operations

- **Acknowledgements**

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