

Lightning Safety at Airports

Material for Thunder



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Motivation

- **Lightning Threat for Airports**
 - safety of personnel working outdoors
 - efficiency of gate, ramp & airport operations
 - safety of approaching/departing aircraft & airport infrastructure
- **Lack of detailed Information**
 - stakeholder safety procedures
 - ramp closure data
- **Objective of our Research**
 - document operational procedures & decision support tools
 - document & evaluate available lightning data sources
 - field observations to document ramp closures
 - assessment of impacts, identification of **inefficiencies or safety risks**, & potential for improved procedures or decision support



Lightning strikes airplane on ground

Storm Electrification & Lightning

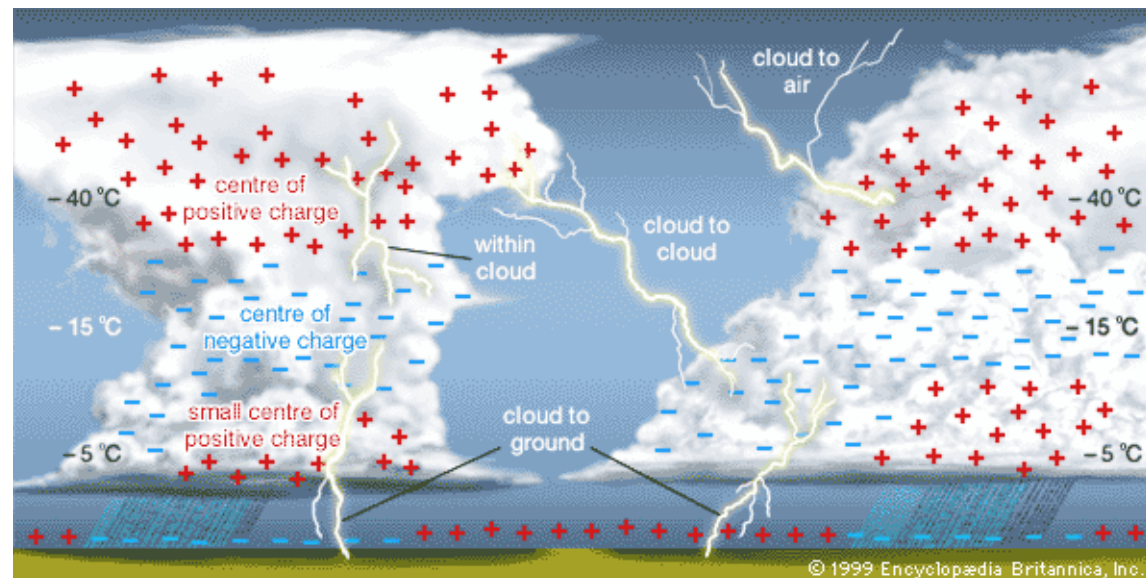
- **Precipitation-based charging Mechanism**

- substantial evidence from field, laboratory & modeling studies
- charging occurs in strong updrafts within mixed-phased region
- rebounding collisions between riming ice particles & crystals in presence of supercooled liquid
- sign and magnitude of charge transfer depends on liquid water content, temperature, size of ice crystals, impact velocity, growth regime, etc.
- charge separation due to gravitational sorting of hydrometeors



- **Lightning**

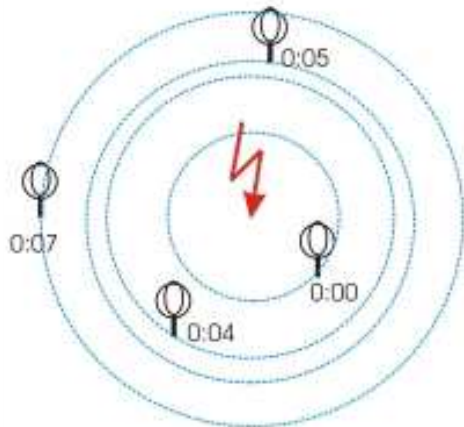
- **natural** lightning originates frequently in thunderstorm cores & occasionally in anvils; it may also occur in winter storms
- lightning can be **triggered** by rockets & aircraft passing through clouds with lower electric fields



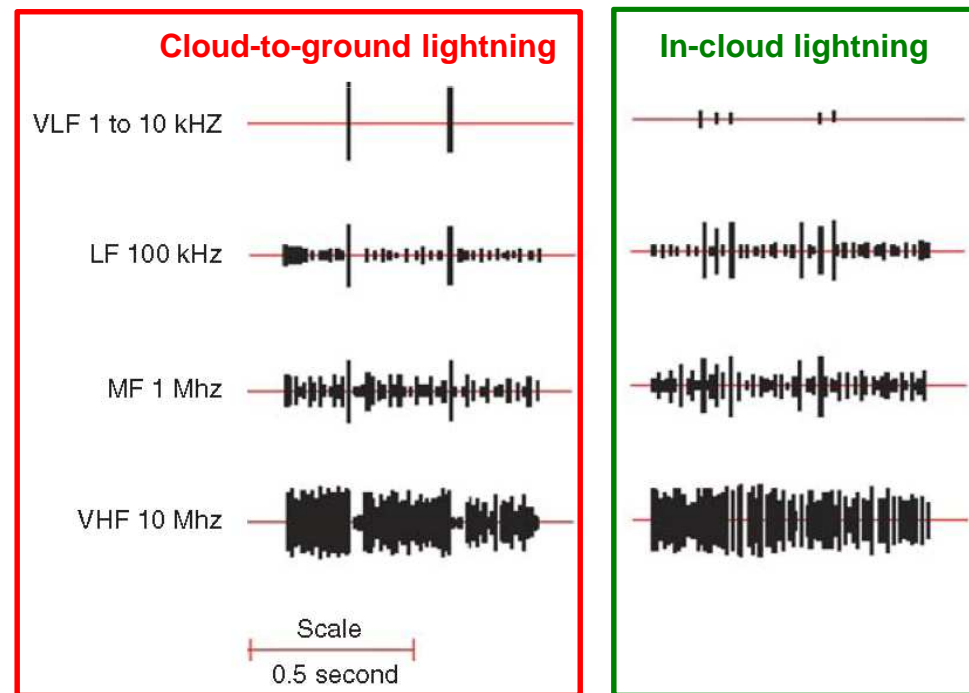
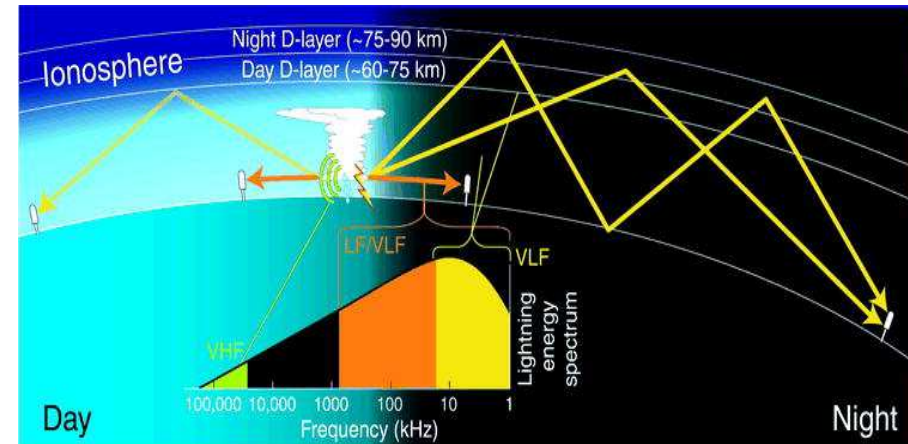
Types of lightning

Lightning Detection

- **Methods**
 - electromagnetic (most ground systems)
 - optical (e.g., spaceborne instruments)
 - acoustic (thunder)
- **Lightning Signal**
 - lightning emits spectrum of electromagnetic radiation
 - components of lightning discharges radiate at different wavelengths
- **Measurement**
 - time of arrival (TOA) & direction
 - peak current & polarity



Pessi et al. (2009)



Uman (1969)

Ground-based Lightning Networks

Sources of Lightning Data (in USA)

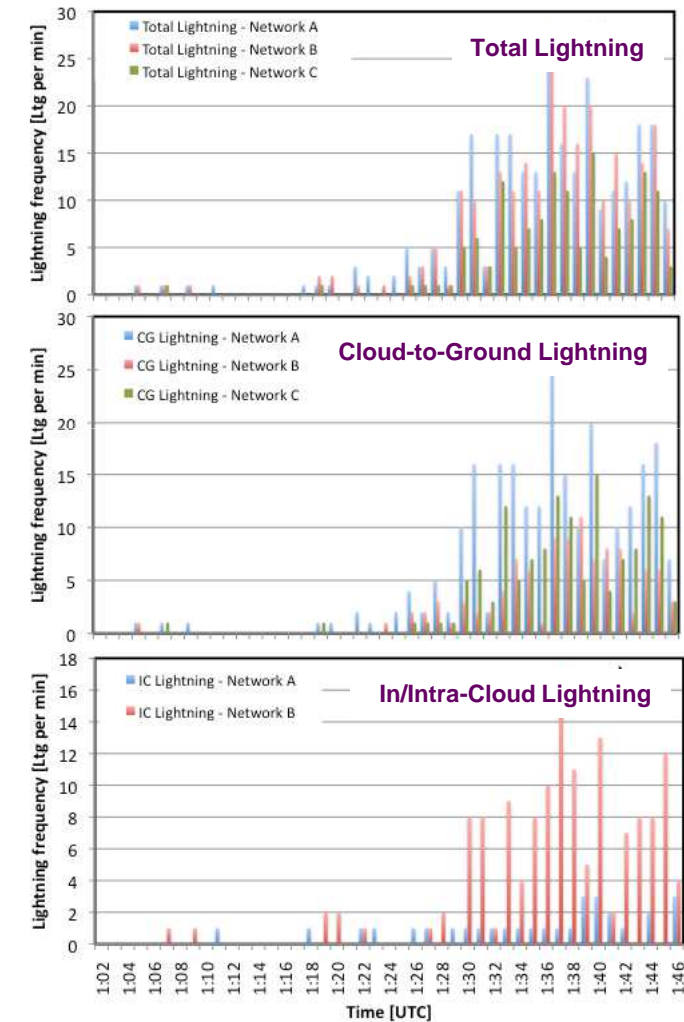
- National Lightning Detection Network (NLDN)
- US Precision Lightning Network (USPLN)
- WeatherBug Total Lightning Network (WTLN)
- Lightning Mapping Array (LMA), regional only

Uncertainty

- sensors measure only part of lightning spectrum
- network detection efficiency & location accuracy
- processing algorithm for location & type (IC, CG)

	NLDN	USPLN	WTLN	LMA
Detection frequency	LF 1 kHz – 350 kHz	LF 1.5 kHz – 450 kHz	LF & HF 1 Hz – 12 MHz	VHF around 60 MHz
Detect CG strikes & IC events	yes	yes	yes	yes
CG detection efficiency	>95% flash 70% - 80% stroke	>95% flash	>98%	100% flash
IC detection efficiency	10% - 30% flash	10% - 15% stroke	up to 95% (varies by region)	100% flash
2D location accuracy	better than 250 m	better than 250 m	better than 500 m	6 – 12 m (20 – 30 m vert.)

Lightning differences near airport (5 miles)



Lightning Safety Procedures

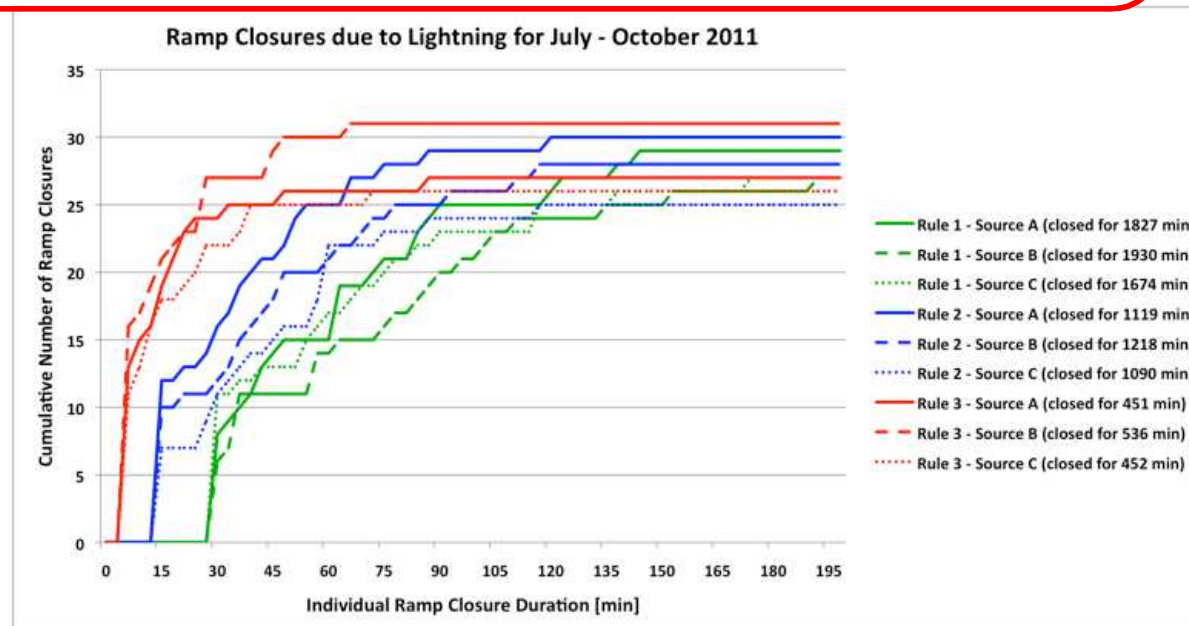
- **Safety Rules**

- typical distance & time thresholds for stopping & resuming outdoor work
- some use multiple distances for stepwise reduction of type of work performed

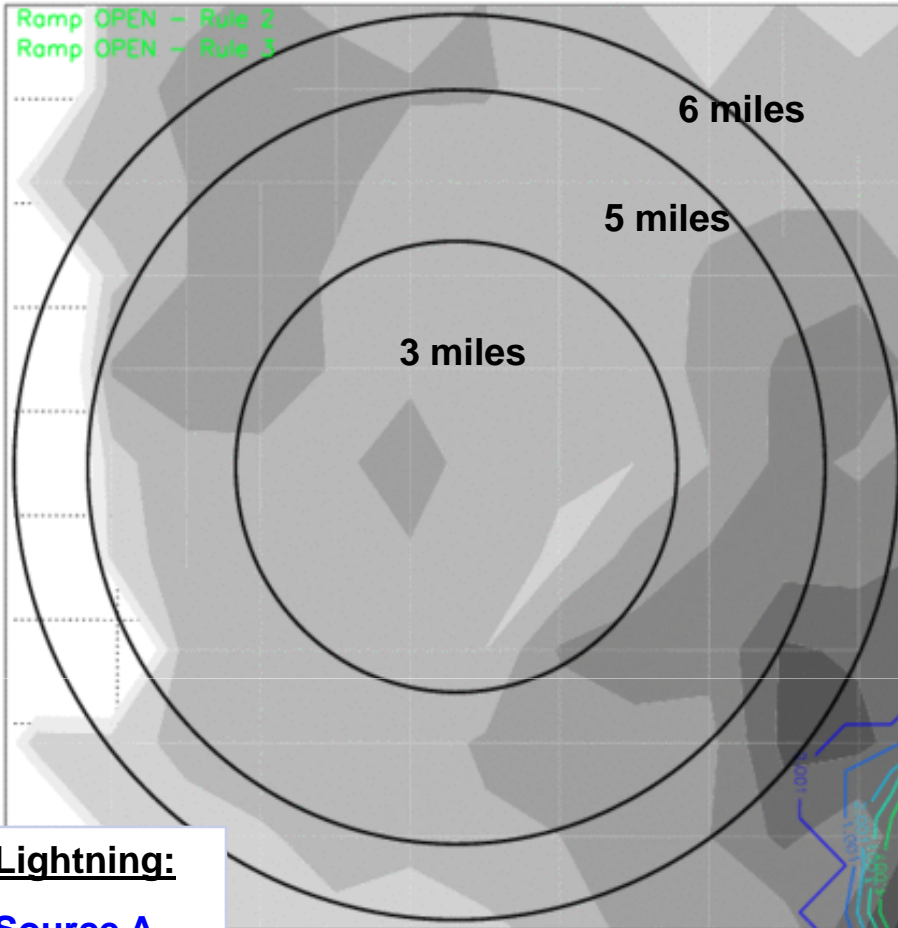
	Distance	Time
Rule 1	6 miles	30 min
Rule 2	5 miles	15 min
Rule 3	3 miles	6 min

- **Uncertainty**

- stakeholders may be using their own safety procedures based on possibly different lightning sources (each airport may be different)
- practical application of procedures (human aspects)



01:40UTC +1min accumulation

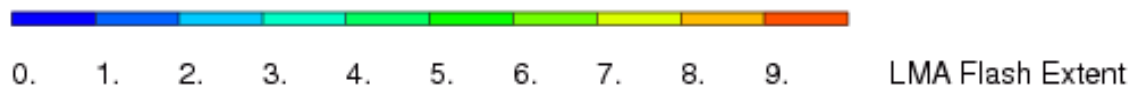


Lightning:

Source A

Source B

Source C



Field Observations

Monitoring & Documenting

- watch range of stakeholders
- document decision making process & ramp closure times
- collect lightning data from different sources

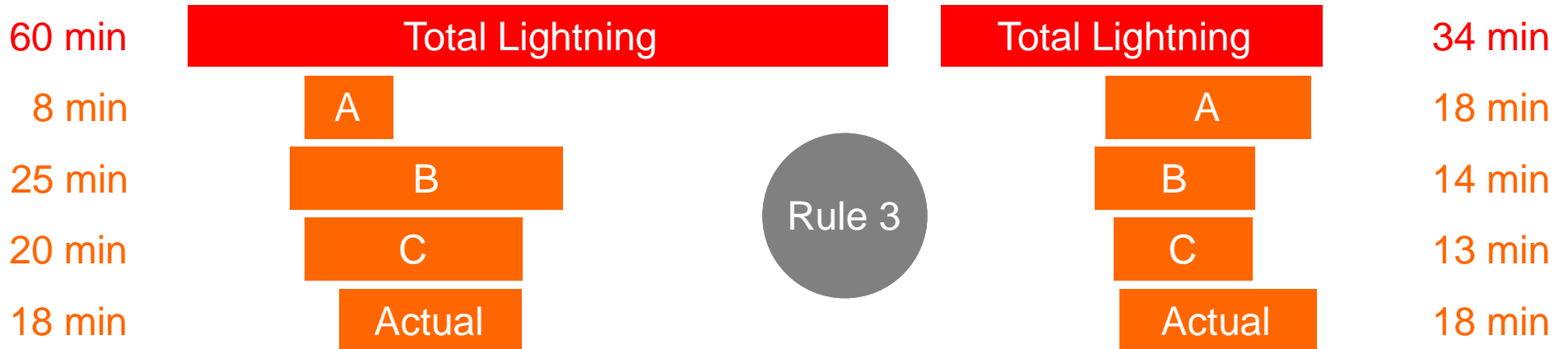
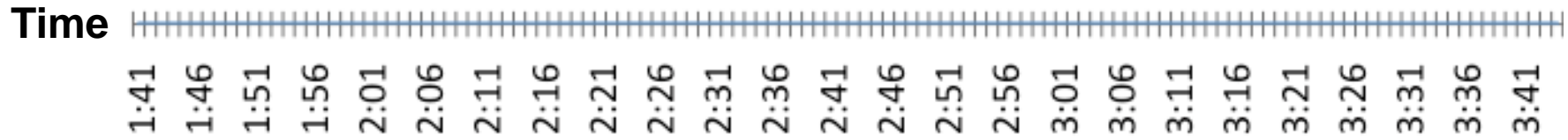
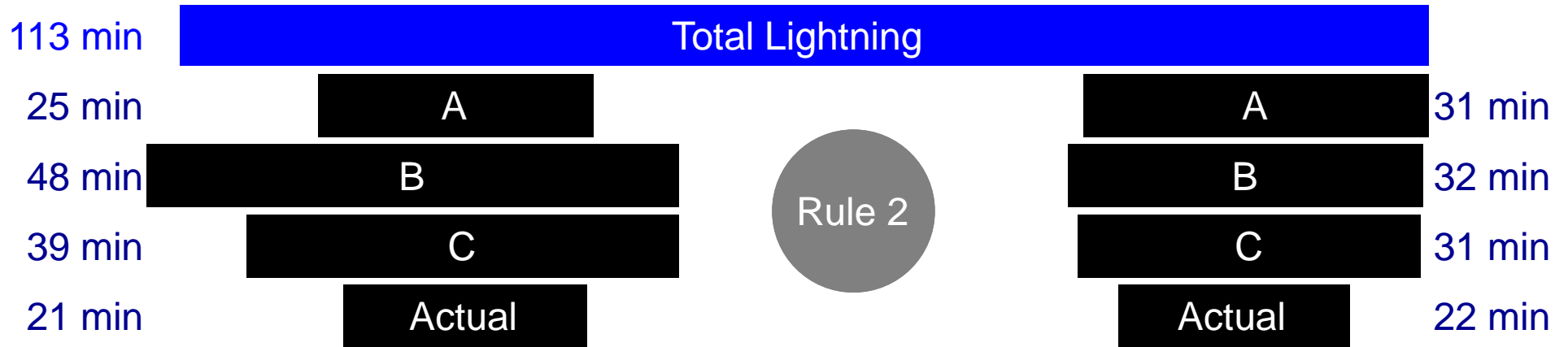
Analyses

- case studies & climatologies
- assess combinations of rules & lightning sources
- offline lightning nowcasting

Evaluation

- ramp closure impacts on airport & terminal airspace
- identification of uncertainties, safety risks & inefficiencies
- ripple effects to national airspace

Ramp Closures – Nominal vs Observed



Summary & Outlook

- **Preliminary Findings**

- airports fall in two categories – some provide centralized guidance, while others don't (liability issue)
- stakeholders may use their own lightning safety procedures & different sources of lightning information (including commercial decision support tools)
- **large uncertainties** related to procedural differences & lightning data (including false alarms & location inaccuracies)
- field observations also reveal varied adherence to safety rules (stakeholders are watching each other as well)
- closing & reopening ramps can take up to several minutes
- **other factors** play role in airport overall efficiency

- **Future Work**

- ongoing field observations & in-depth analysis of field observations (case studies)
- **identification of potential safety risks & inefficiencies**
- development of improved decision support (procedural or use of tools)
- **education of stakeholders** about measurement & procedural uncertainties, identified potential safety risks & inefficiencies

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The views expressed are those of the authors and do not necessarily represent the official policy or position of the FAA.