Evaluating the Safety of Launch and Reentry Operations in the National Airspace System

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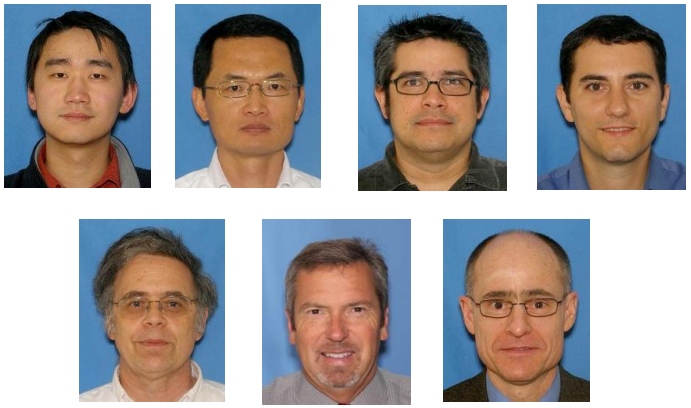
The MITRE Corporation



(authors clockwise)

FAA COE CST ATM6 Conference

October 2016

Las Cruces, NM

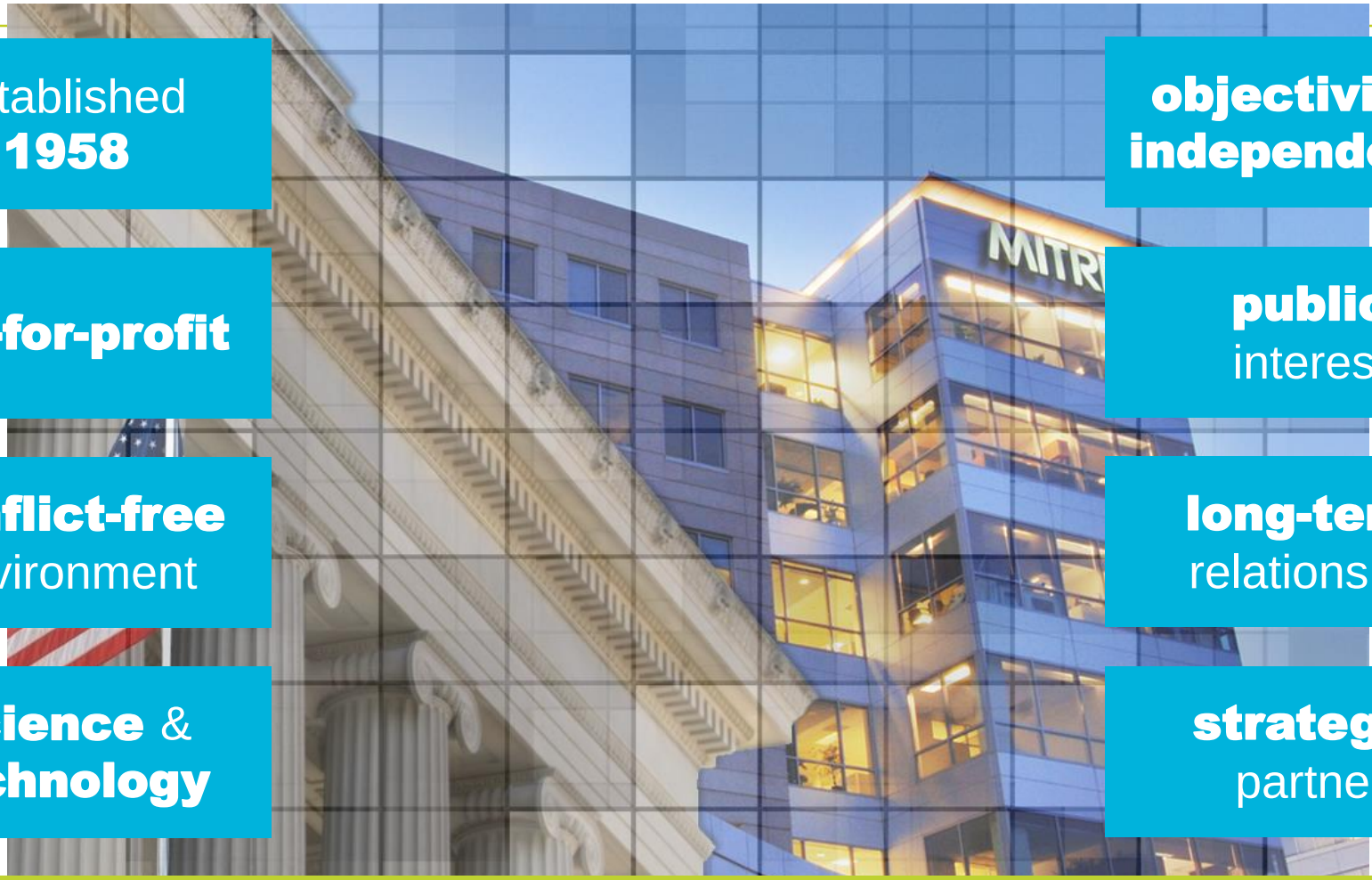
MITRE is Unique

established **1958**

not-for-profit

conflict-free environment

science & **technology**



objectivity & **independence**

public interest

long-term relationship

strategic partner

Serve as channels of expertise to advance government missions

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Only company with Federally Funded Research and Development Centers (FFRDCs) for both the **FAA** and **DoD**

…. bringing together capabilities and domain expertise from stakeholder communities to solve the nation's most critical challenges

- Air
- Space
- Missile Warning
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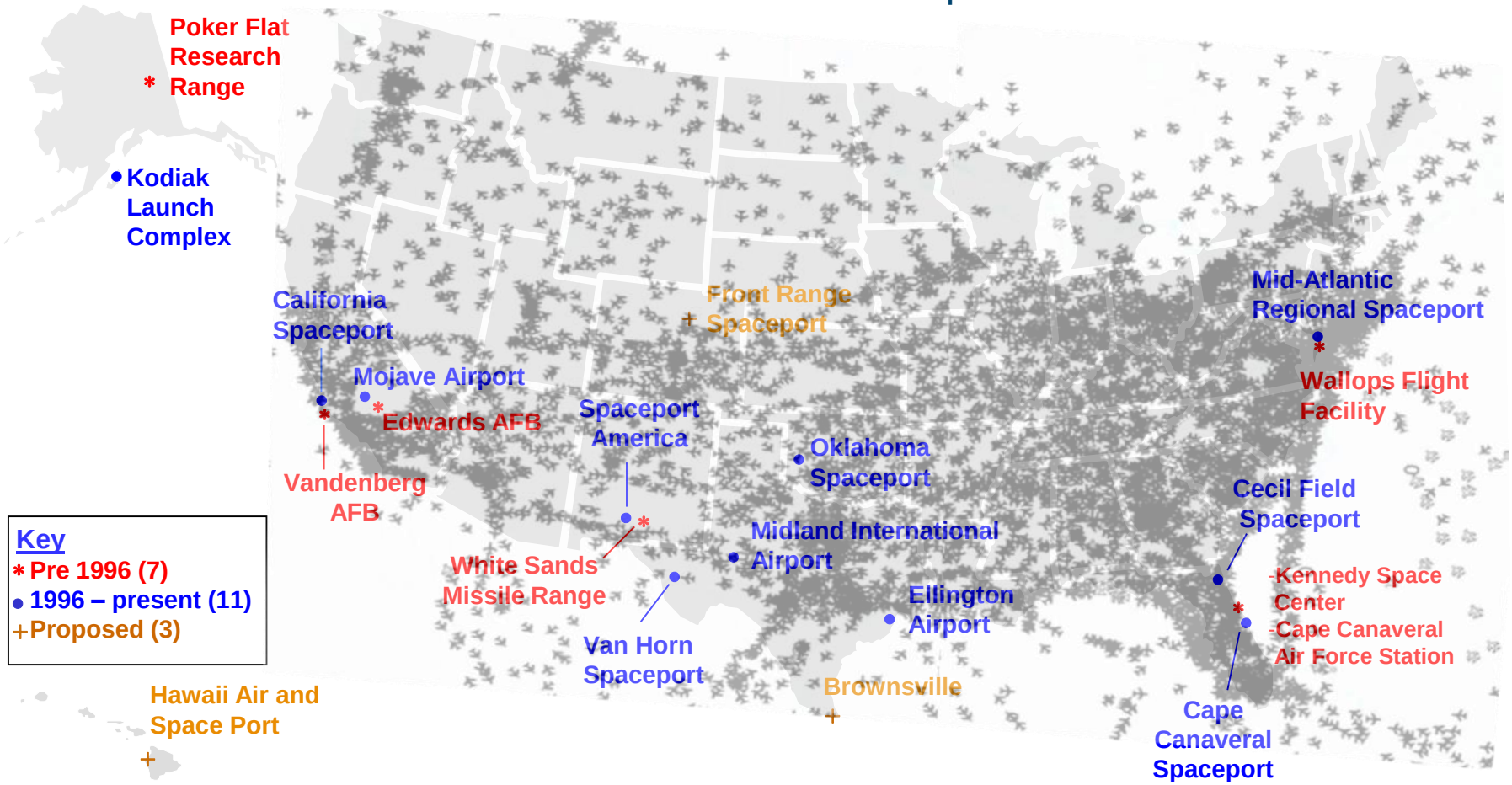
Private-Public Partnerships

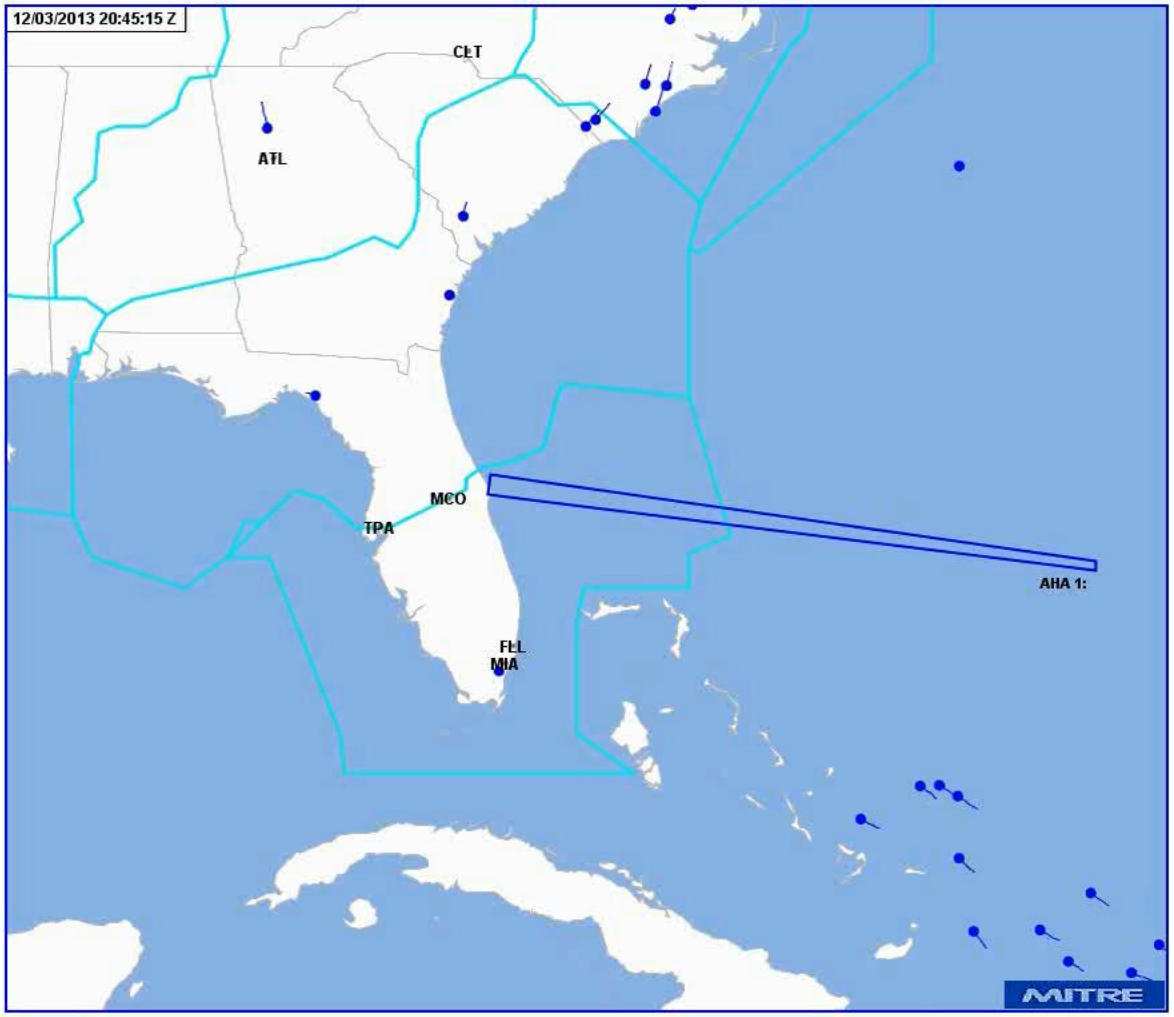
It is Getting Busier in the Airspace…

U.S. Launch Sites and Snapshot of Air Traffic



Source: https://www.faa.gov/about/office_org/headquarters_offices/ast/industry/media/Map_US_spaceports.pdf

Launch and Reentry Operations Affect Other NAS Users



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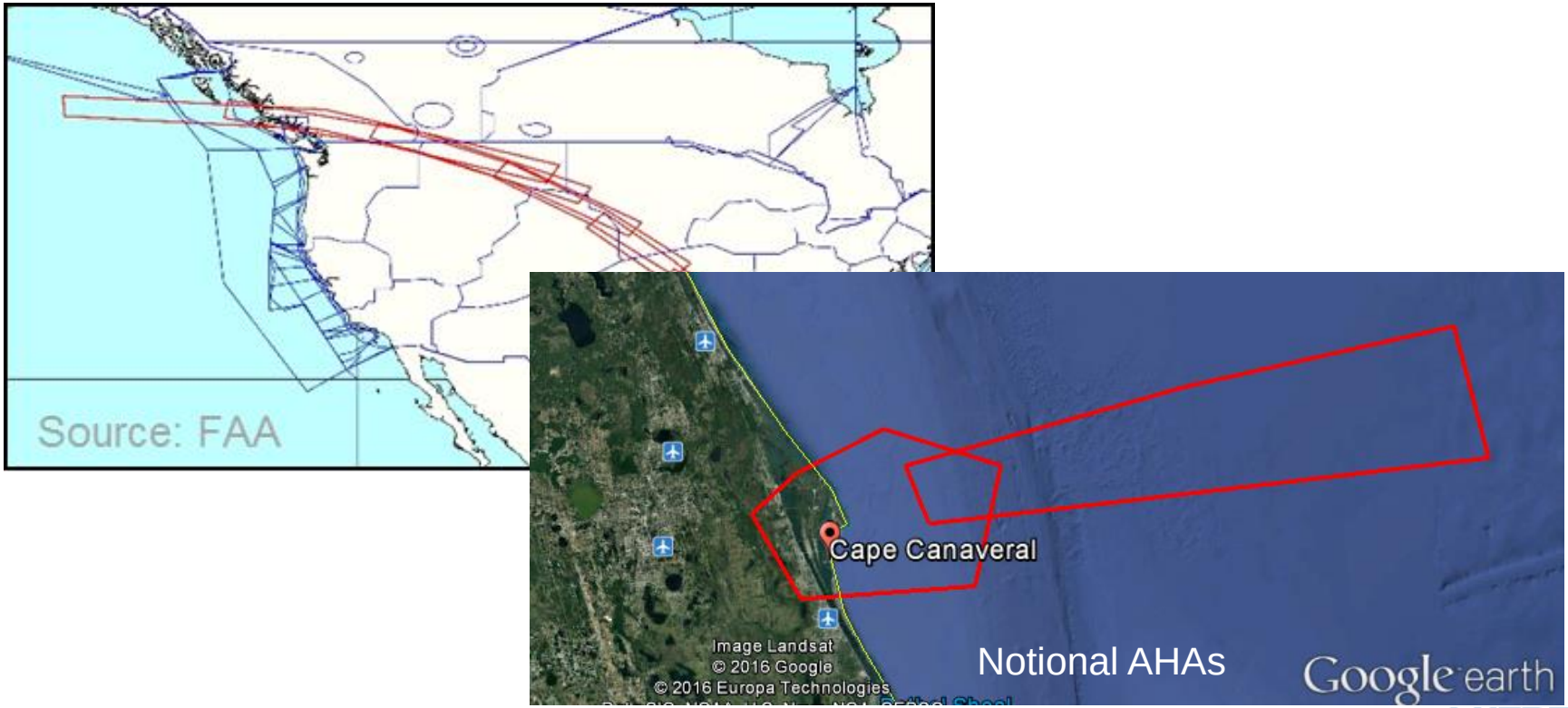
Contingent Aircraft Hazard Areas (AHAs)

- **Contingent (dynamic) AHAs is a method to efficiently integrate more frequent launch and reentry operations**
  - How safe are they?



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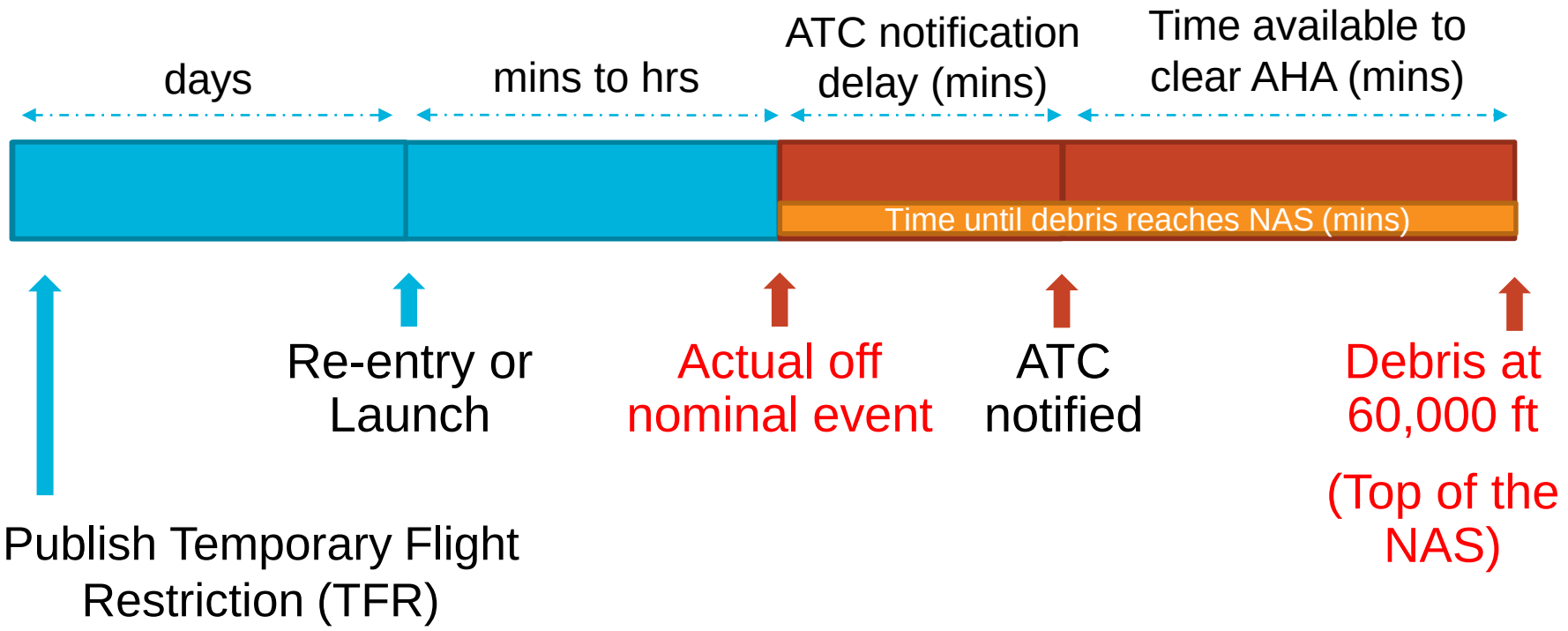
Air Traffic Control Timeline for Off-Nominal Case



Can aircraft clear the hazard area before debris reaches the NAS?
(Time to clear <= Time until debris reaches NAS)

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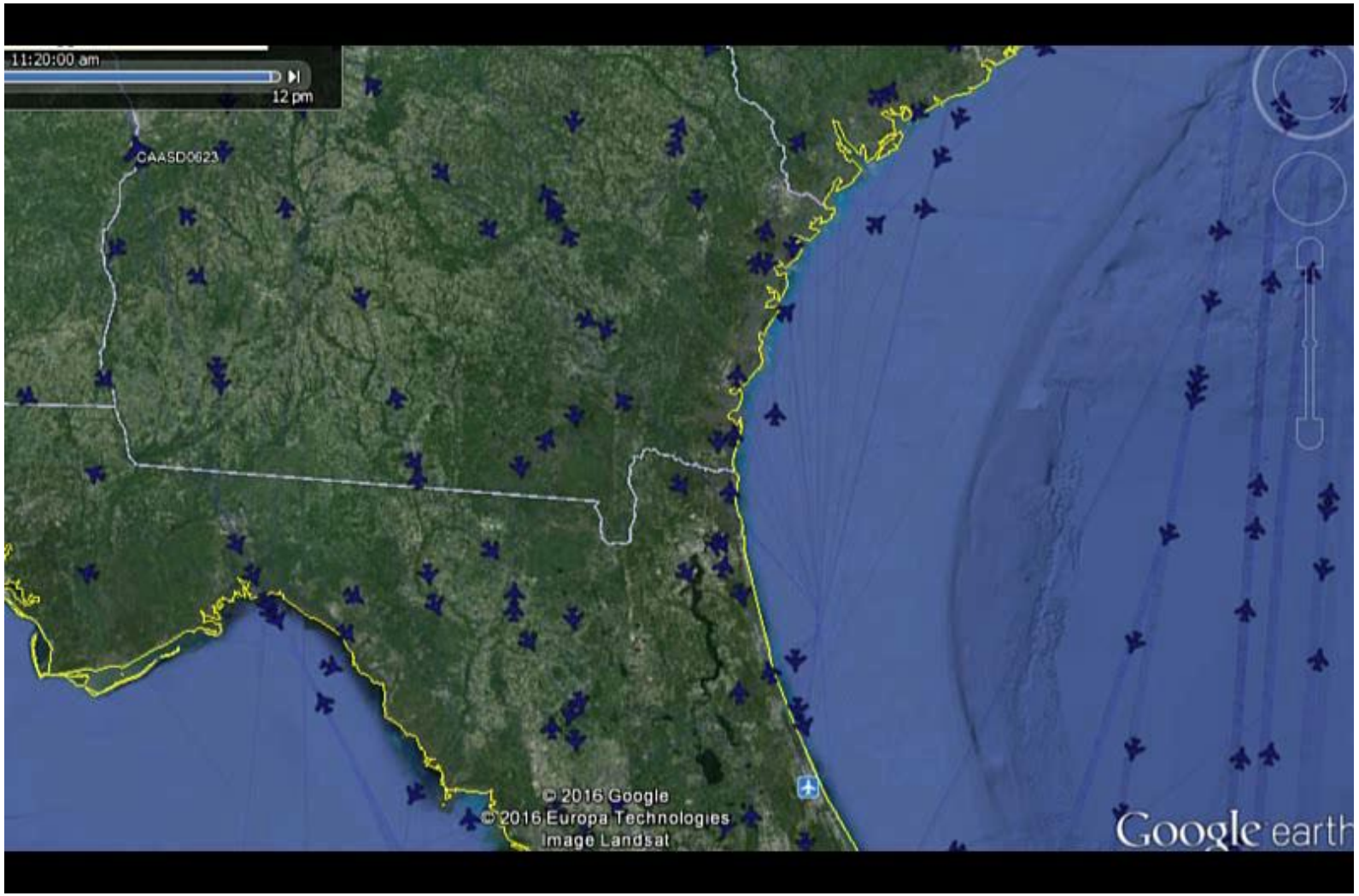
Evacuation Due to a Winged Re-entry from Orbit



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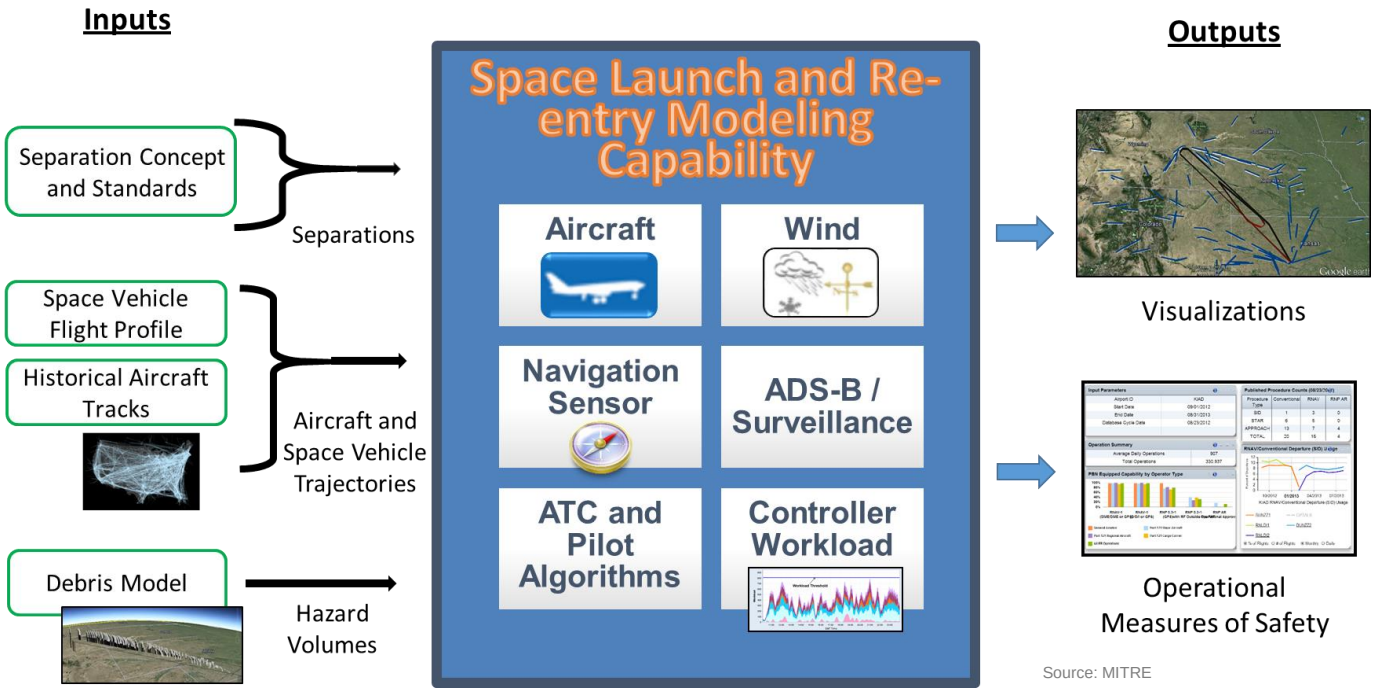
Approach

- **Develop a fast-time analysis capability to provide operational measures of safety for launch and reentry operations**



Source: MITRE

- **Prior versions of model used by FAA and DoD to assess algorithms and performance standards of different systems**

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Collaboration

Stanford University

– Debris modeling

FAA Center of Excellence for Commercial Space Transportation

– Research/Industry Member

Office of Comercial Space Transportation

– Scenario development and trajectories

NASA

– Trajectory modeling

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Research Question

- **Past MITRE research has shown that times to clear hazard areas are mostly dependent upon:**
  - Size of the hazard volume
  - Orientation of the flow of traffic to the hazard volume
  - Density of traffic in and around the hazard volume
  - ATC notification delay
- **How sensitive is the time to clear to these factors?**
- **Utilize MITRE's capability to evaluate these factors**

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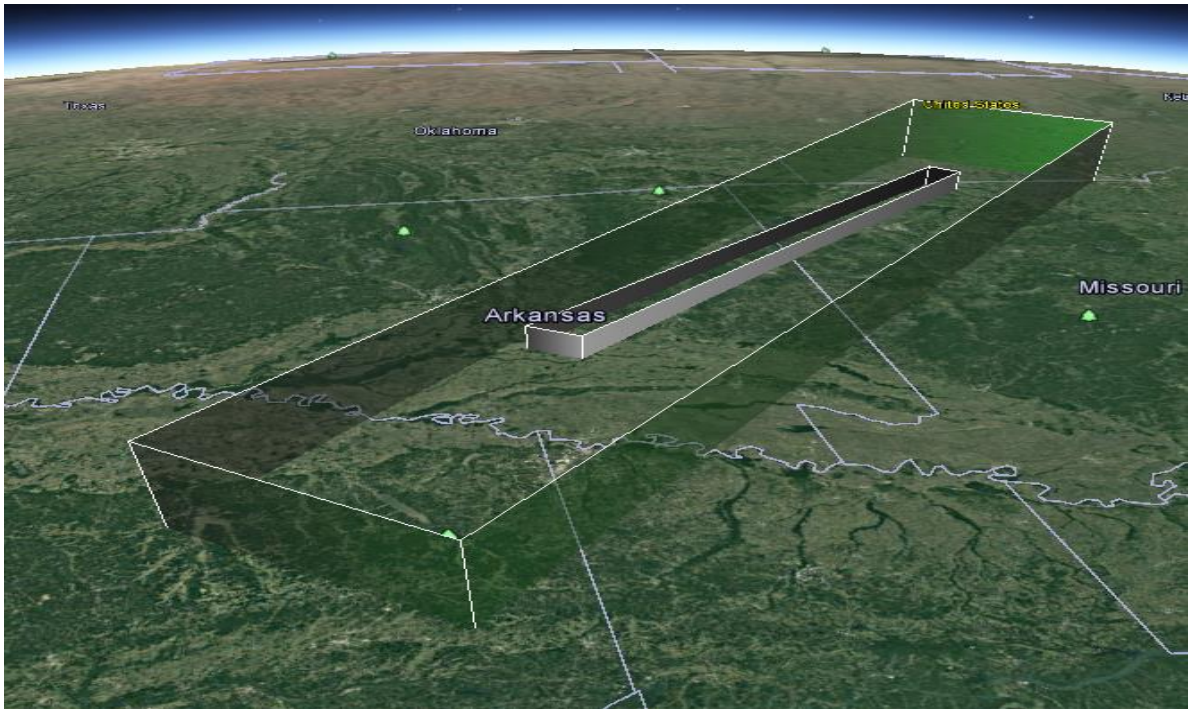
Use Case

- **Off nominal reentry over the continental US**



- **Examine: Traffic orientation, traffic density, ATC Notification Delay, and aircraft surveillance**

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Analysis

- **Examined sensitivity of metrics to the examined factors**
  - "time to clear a hazard area" – time it takes for all aircraft to exit a hazard area after an off nominal event
  - "time in hazard" – time each flight spends in the hazard area

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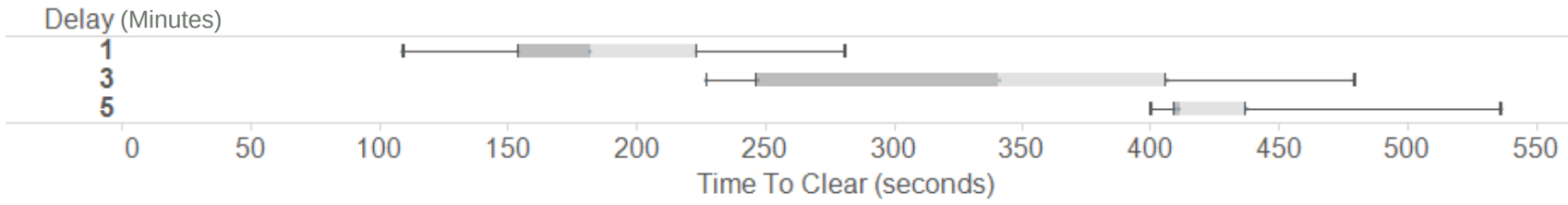
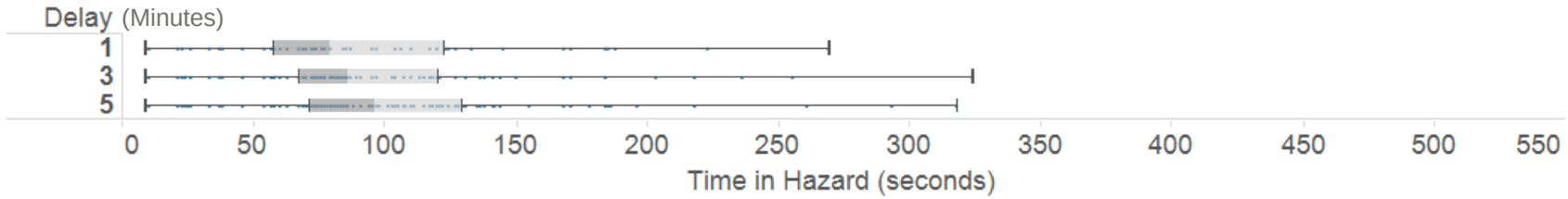
Findings: ATC Notification Delay

- **Large sensitivity to ATC notification delay**
  - Time it takes for ATC to be aware of an off-nominal
- **Not a linear relationship**



Sensitivity of Time to Clear to ATC notification delay (with ADS-B surveillance)



Sensitivity of Time in Hazard to ATC notification delay (with ADS-B surveillance)

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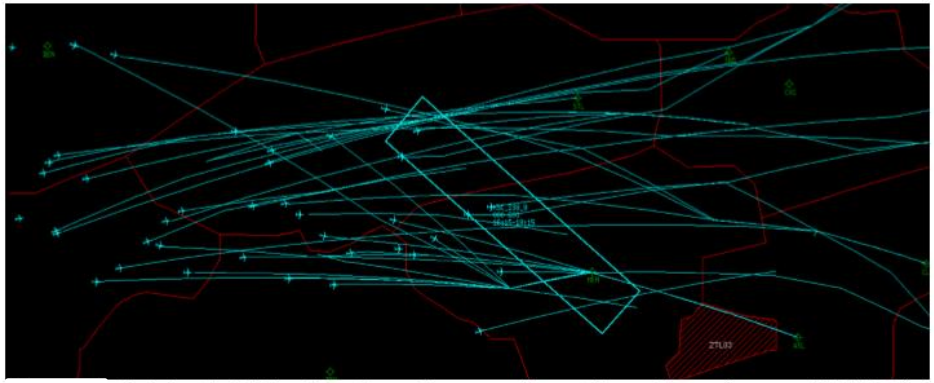
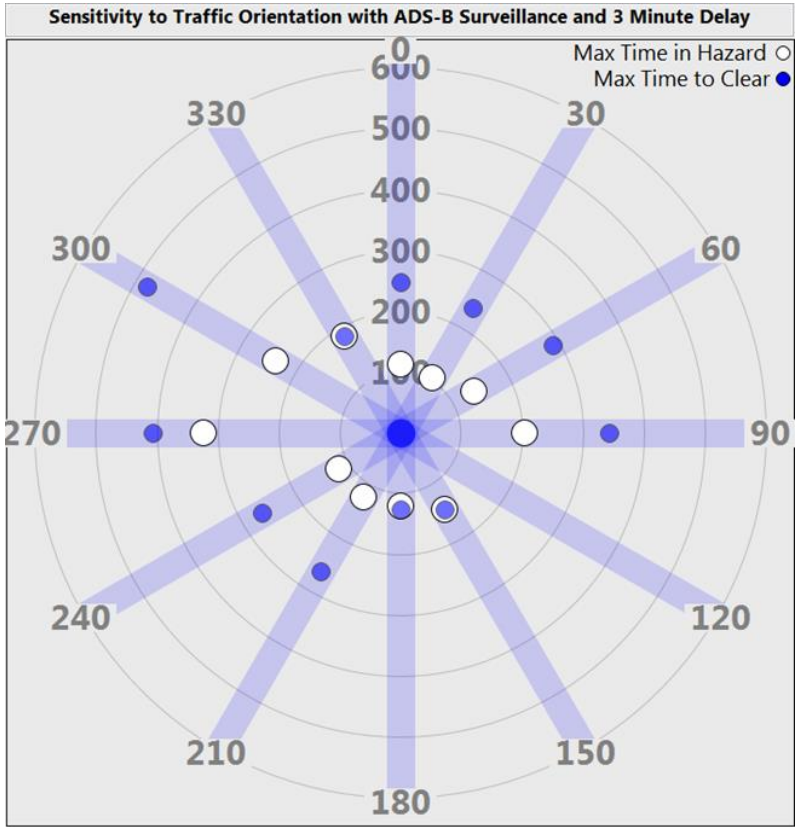
Findings: Traffic Orientation

- **Sensitive to traffic orientation**
- **Longer times generally coincide with the hazard area orientation (~310/130 degrees)**



Original AHA with aircraft on eastbound headings. *(source MITRE)*



Sensitivity to traffic orientation with ADS-B and 3-minute ATC notification delay

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Analysis Results Summary

- **“Time to clear a hazard area” is most sensitive to ATC notification delay, traffic orientation, and traffic density**
- **“Time in hazard” is less sensitive to the factors than “time to clear a hazard area”**

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Conclusion

- **MITRE's capability can assess if contingent (dynamic) AHAs are safe to use**
  - Can determine if aircraft can clear AHA before debris reaches the NAS
  - Detailed, parametric assessments of variety of vehicles and trajectories, ATC strategies, separation concepts and standards, and surveillance performance needs
- **FAA can utilize this sensitivity study to focus resources on factors that could most improve safety for these operations**

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Questions?

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