Federal Aviation Administration

Unified 4D Trajectory Approach for Integrated Traffic Management

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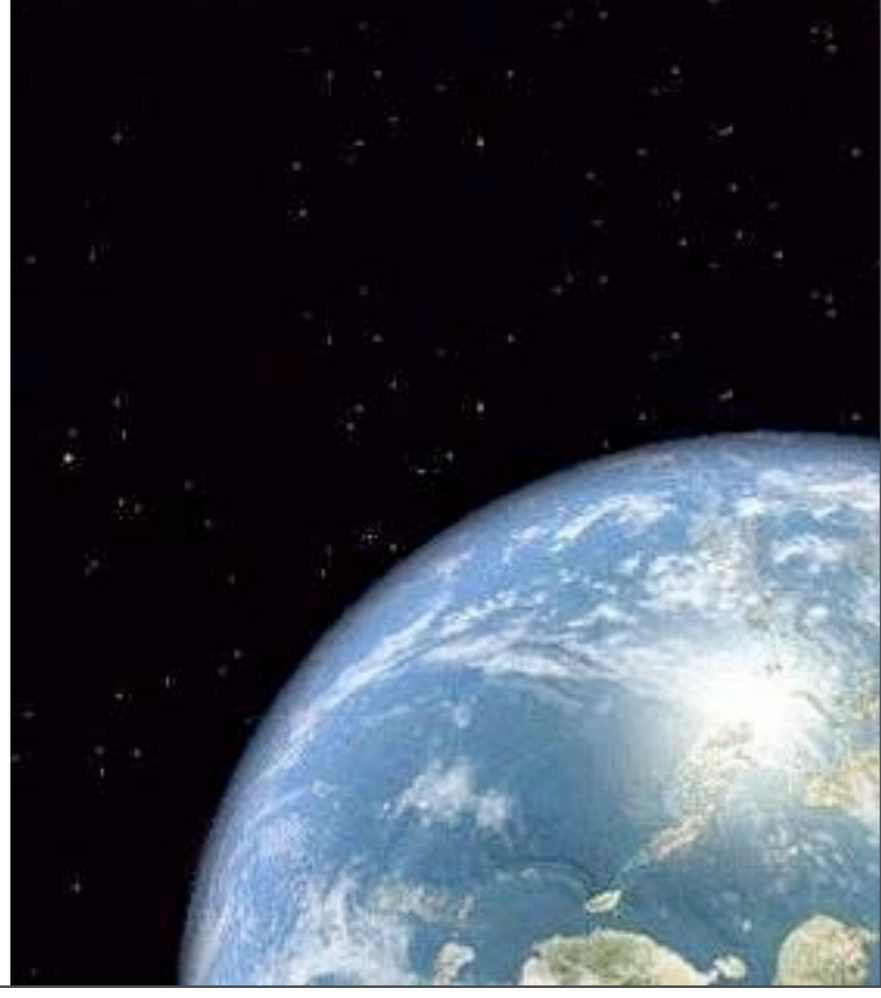
Stanford University



October 30 2014

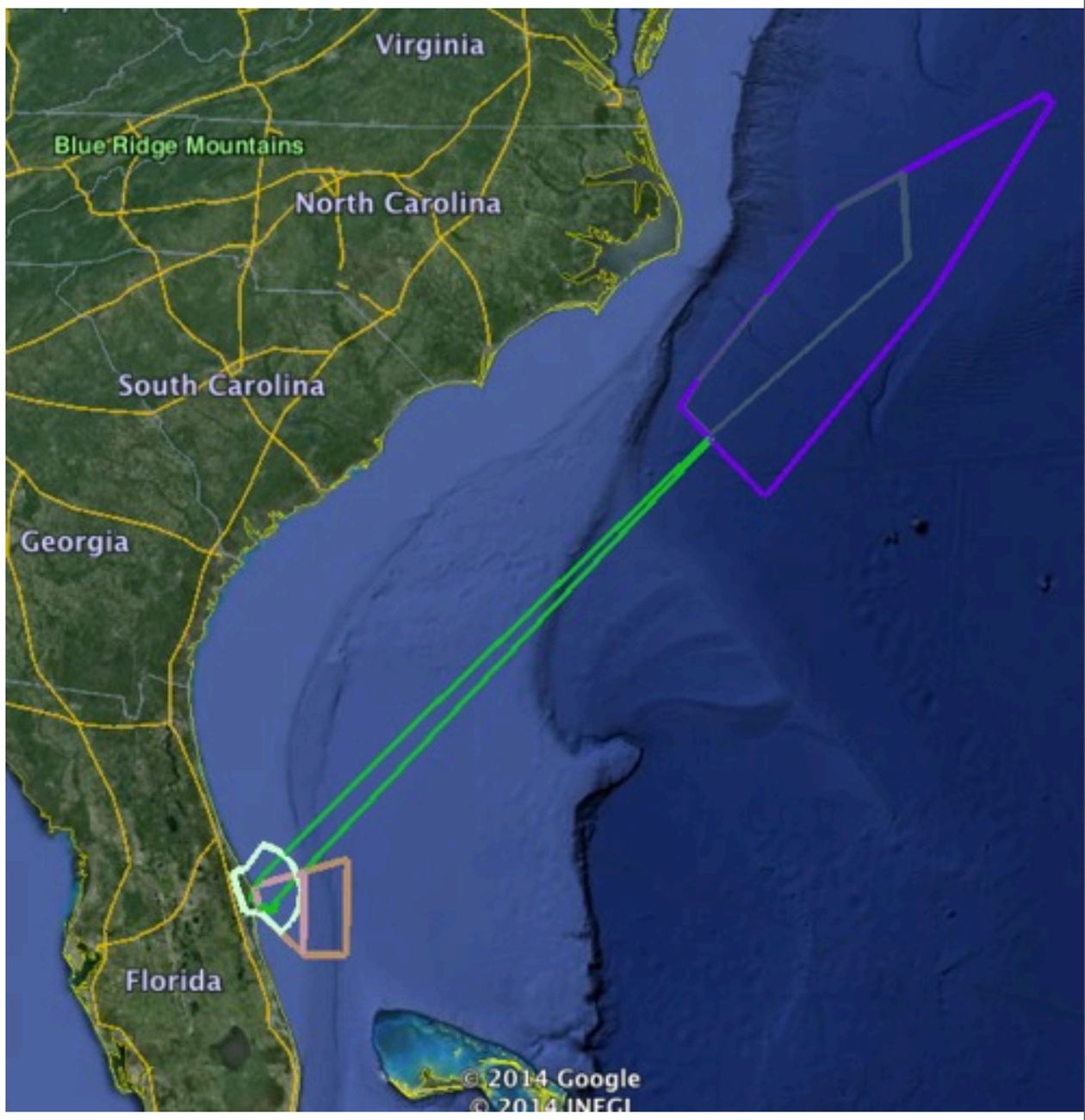
Outline

- **What's the problem we want to solve?**
- **Compact Envelopes to the rescue**
- **Some Examples**
- **Quantify how great compact envelopes are**
- **Concluding thoughts and papers**

What's The Problem?

- **Need launch architectures to ensure NAS users are safe.**
- **Current method uses SUAs, NOTAMs, etc and and is too big! Not altitude contoured, uses pre-existing shapes, conservative assumptions, range safety buffers, not dynamic.**
- **What level of safety?**
- **Unfair.**
- **Commercial space traffic in rising volume and launching from new ranges requires new ATM architectures.**

Falcon9 March 1st 2013



Compact Envelope Concept

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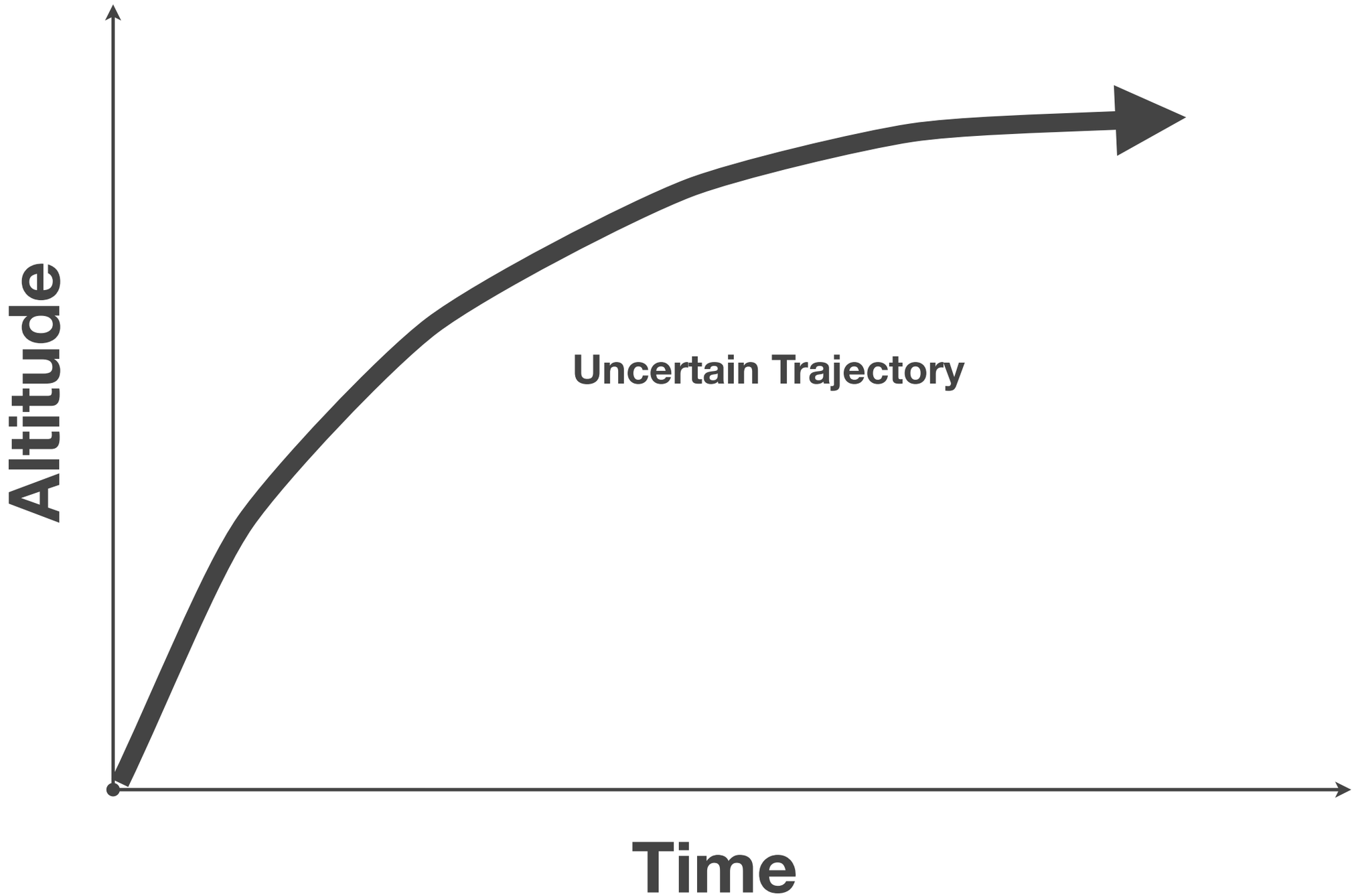

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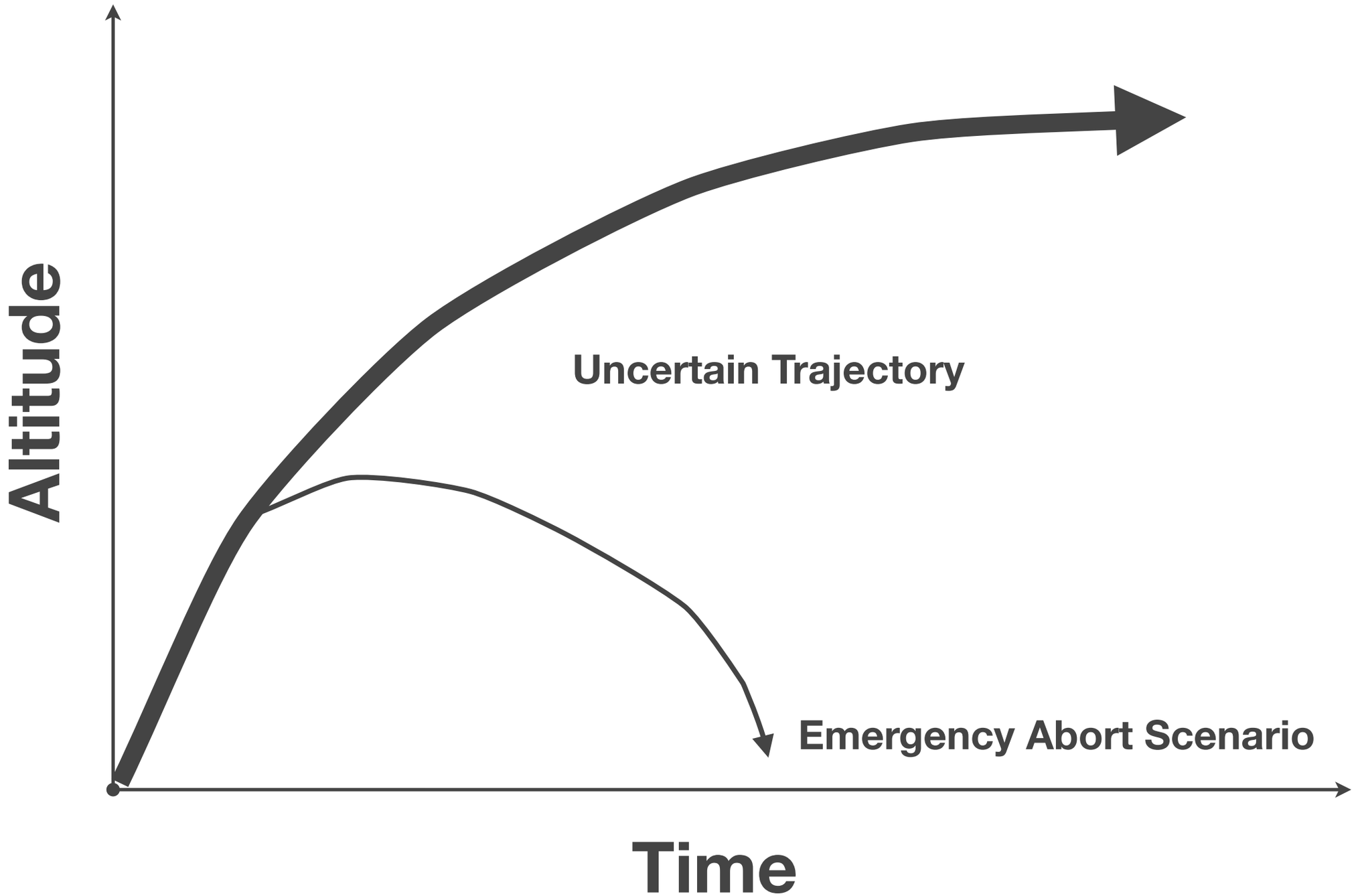

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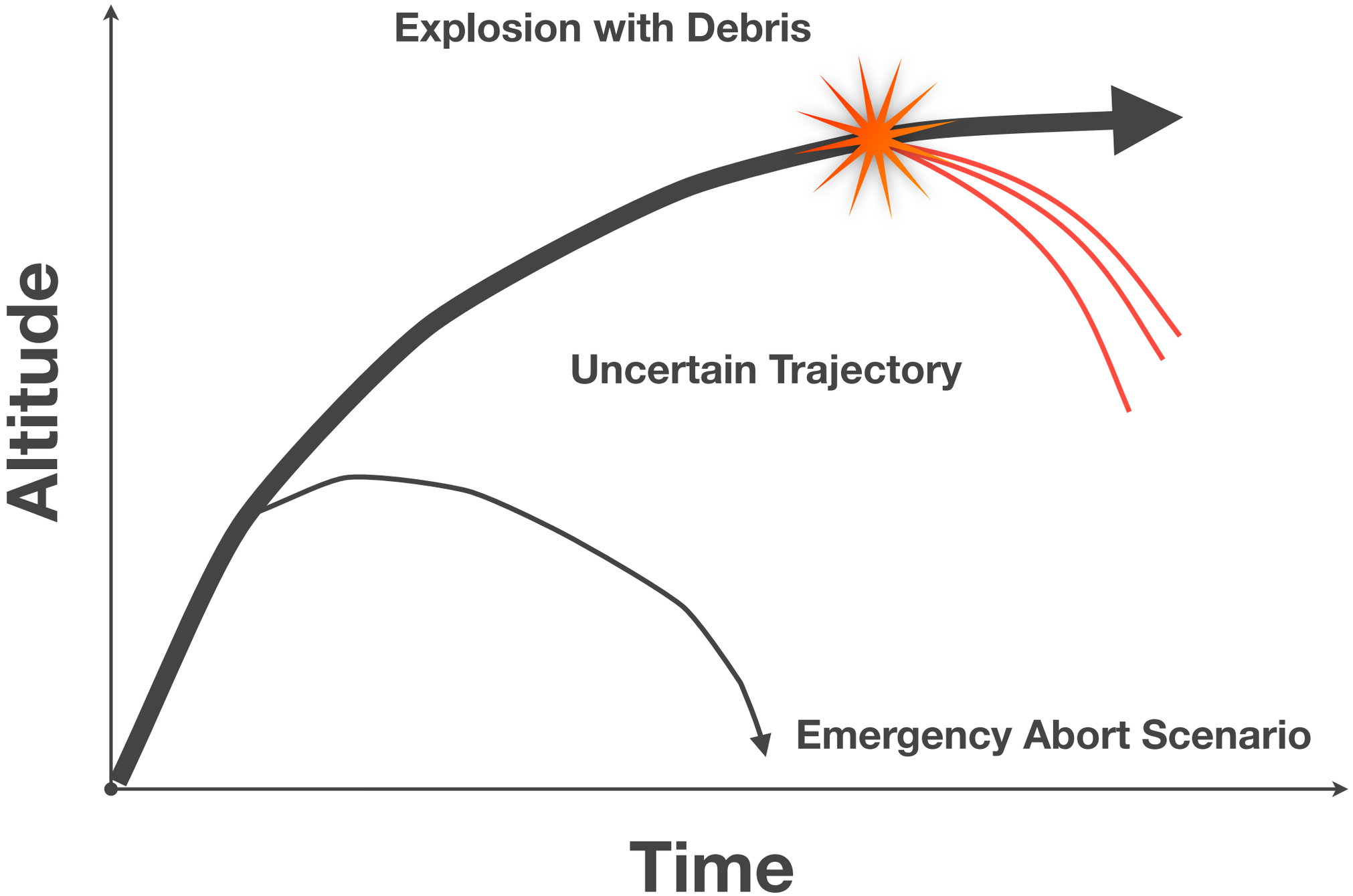

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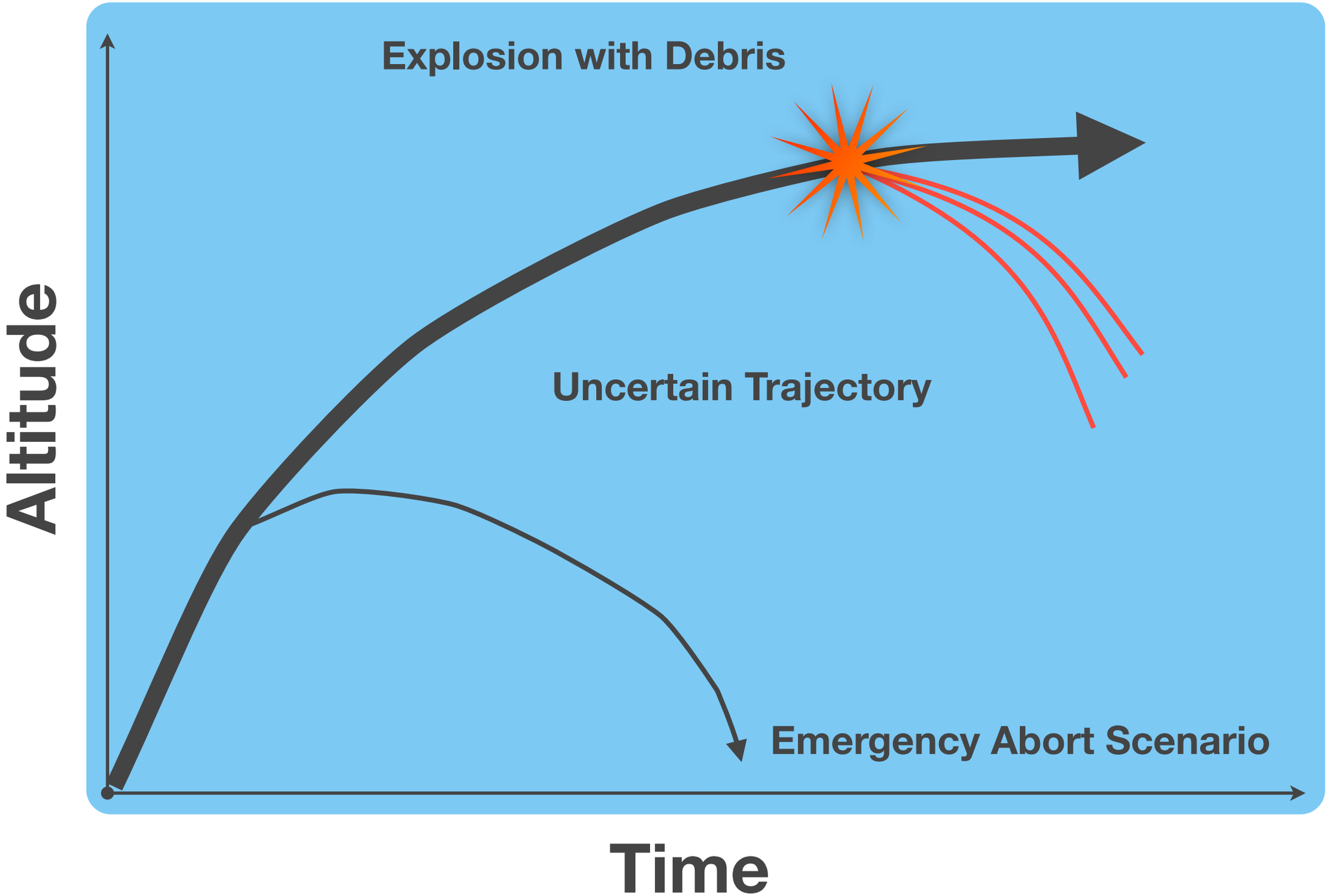

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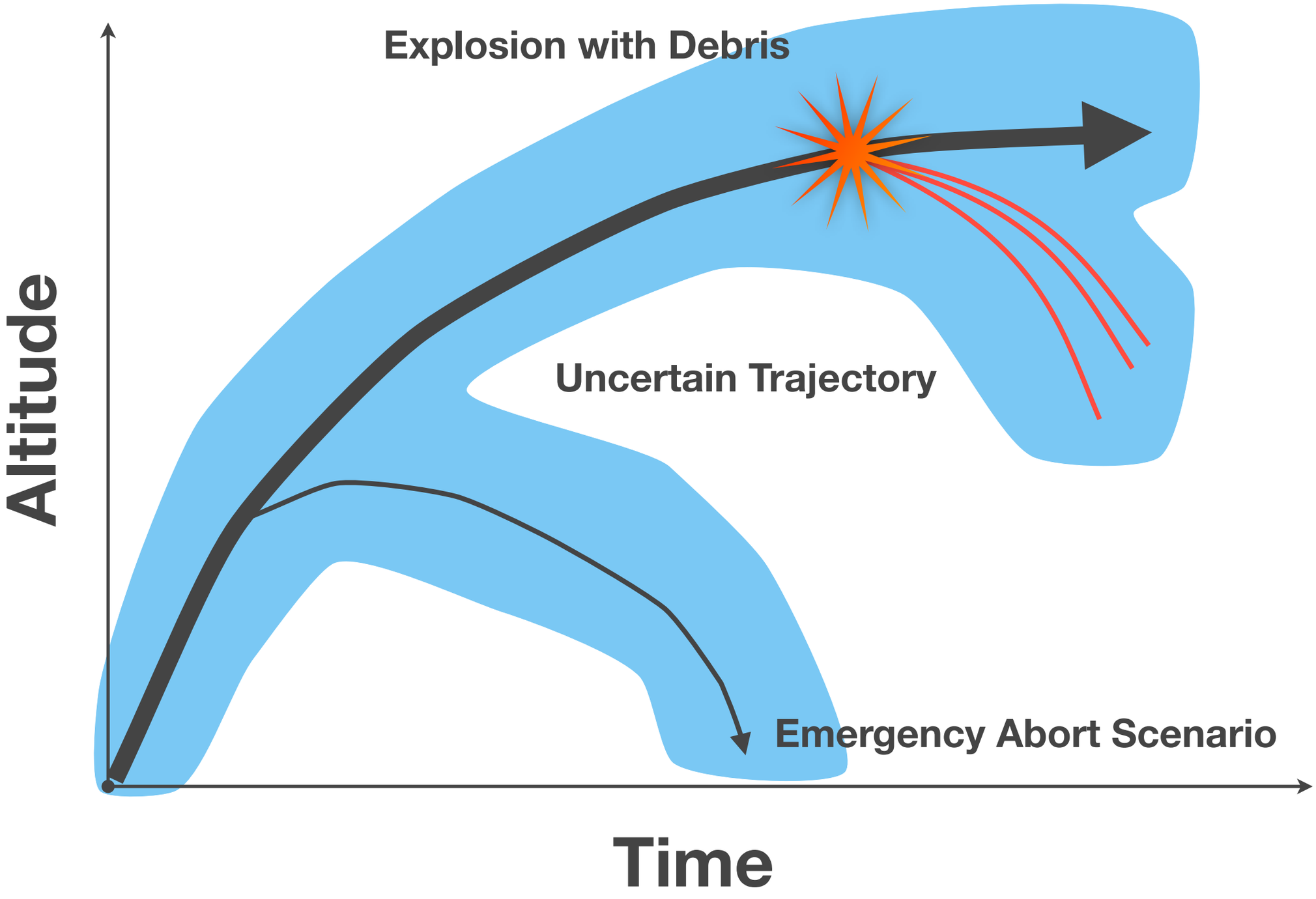

Suborbital Example: Lynx

- **Using NAS reaction time of five minutes.**
- **Using instantaneous vehicle health monitoring.**
- **Envelope corresponds to probability of casualty < 1e-7 (one in ten million)**
- **Calculation includes uncertainties due to winds, time of explosion, debris properties, etc.**

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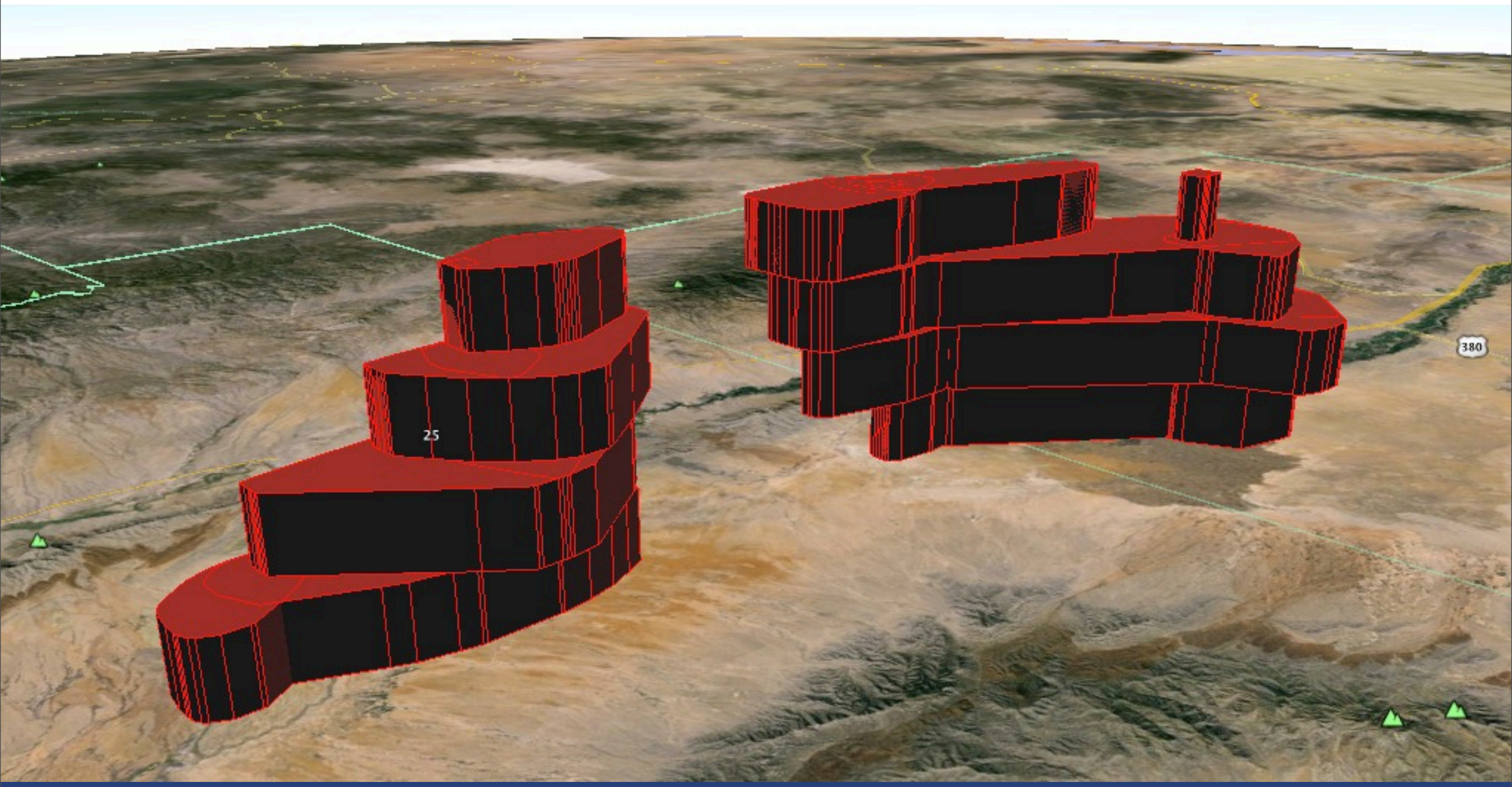
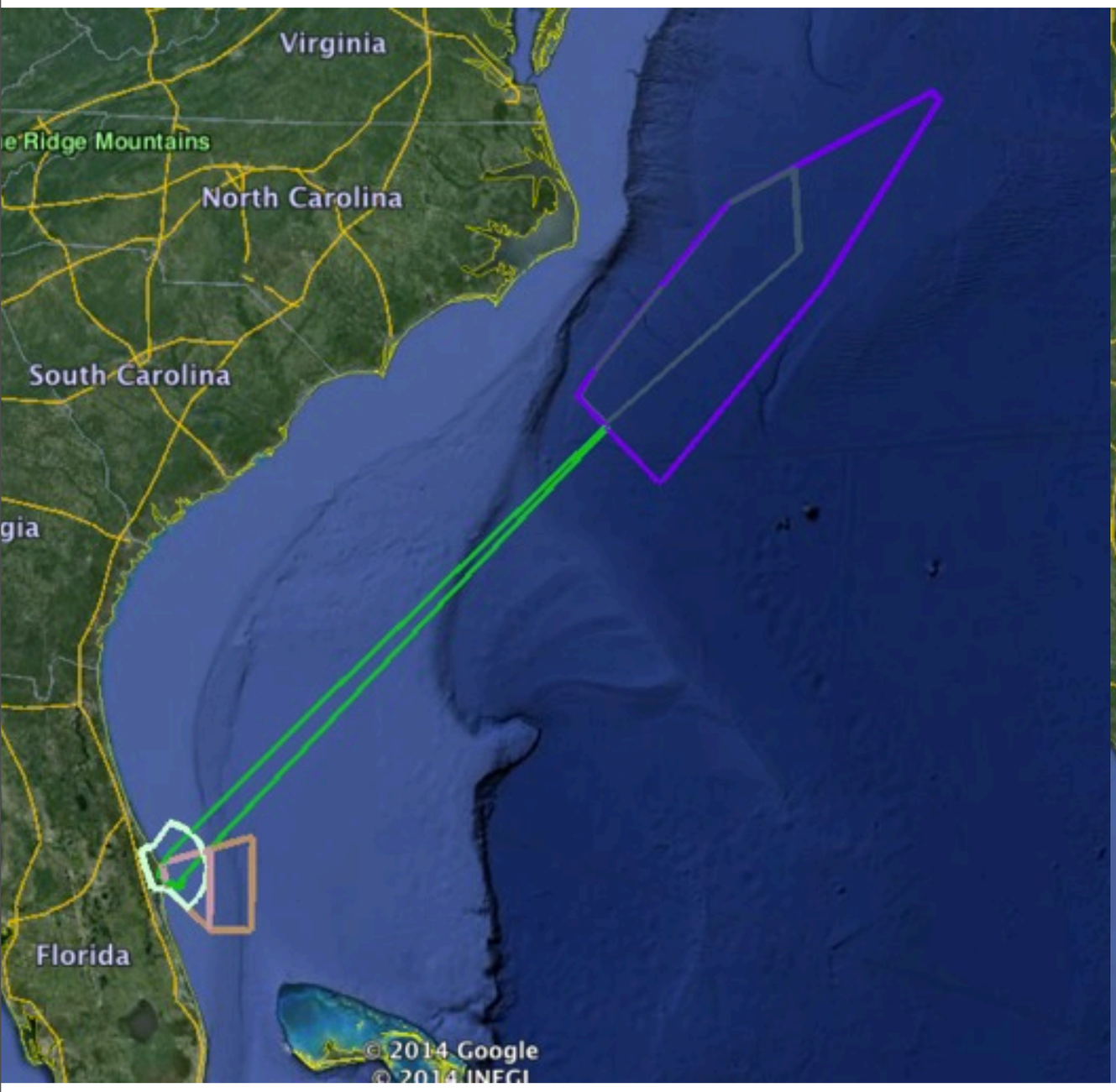
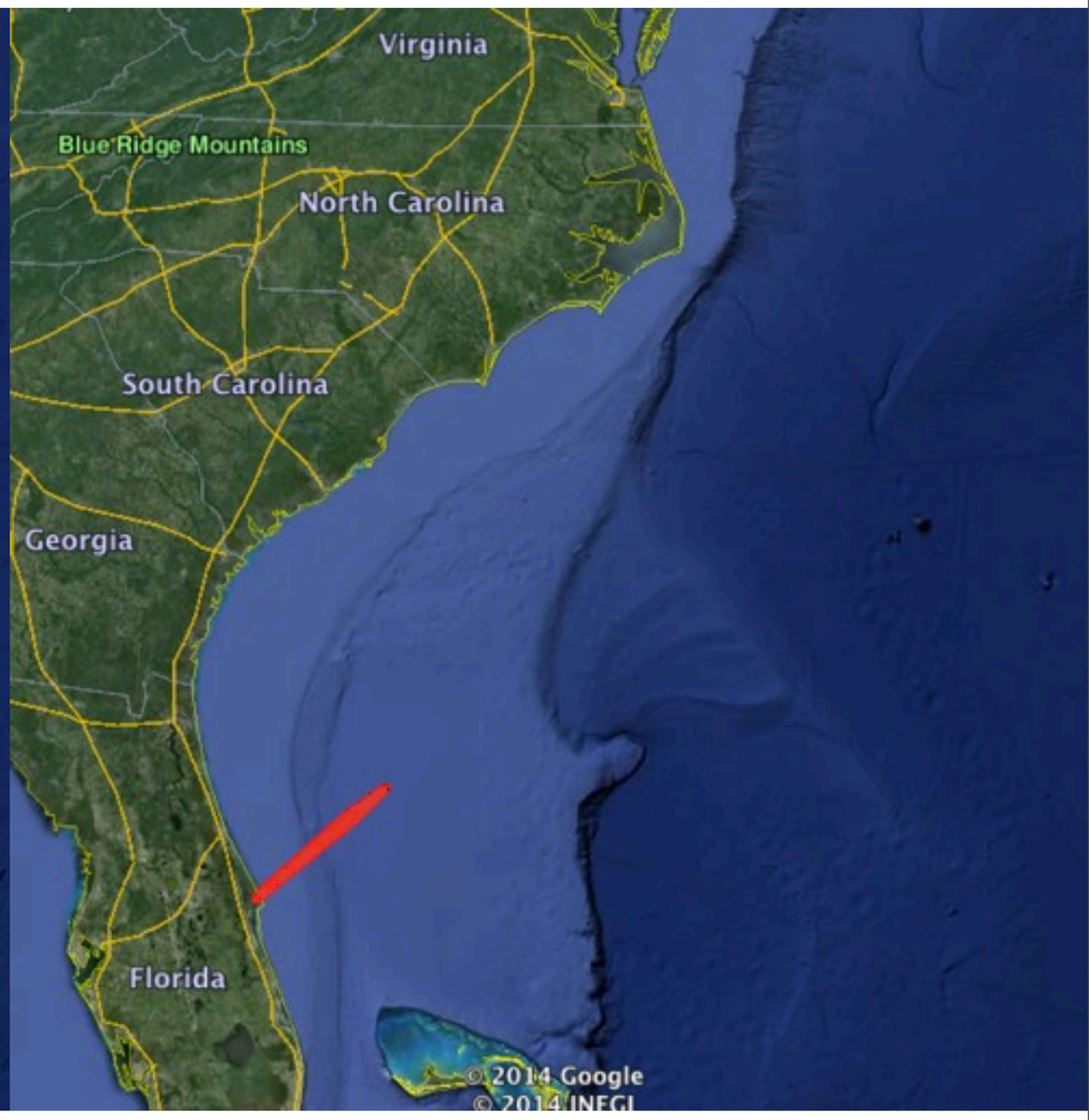
Suborbital Example: Lynx (Another View)



Orbital Example: Falcon9





Orbital Example: Falcon9

	Actual SUAs	Compact Envelopes	Units
Flights Rerouted			**#**
Added Flight Time			**Min**
Added Flight Distance			**N.M.**
Added Fuel Burn			**lbs**

Orbital Example: Falcon9

	Actual SUAs	Compact Envelopes	Units
Flights Rerouted	45		#
Added Flight Time	537		Min
Added Flight Distance	2110.773		N.M.
Added Fuel Burn	22641.262		lbs

Orbital Example: Falcon9

	Actual SUAs	Compact Envelopes	Units
Flights Rerouted	45	0	#
Added Flight Time	537	0	Min
Added Flight Distance	2110.773	0	N.M.
Added Fuel Burn	22641.262	0	lbs

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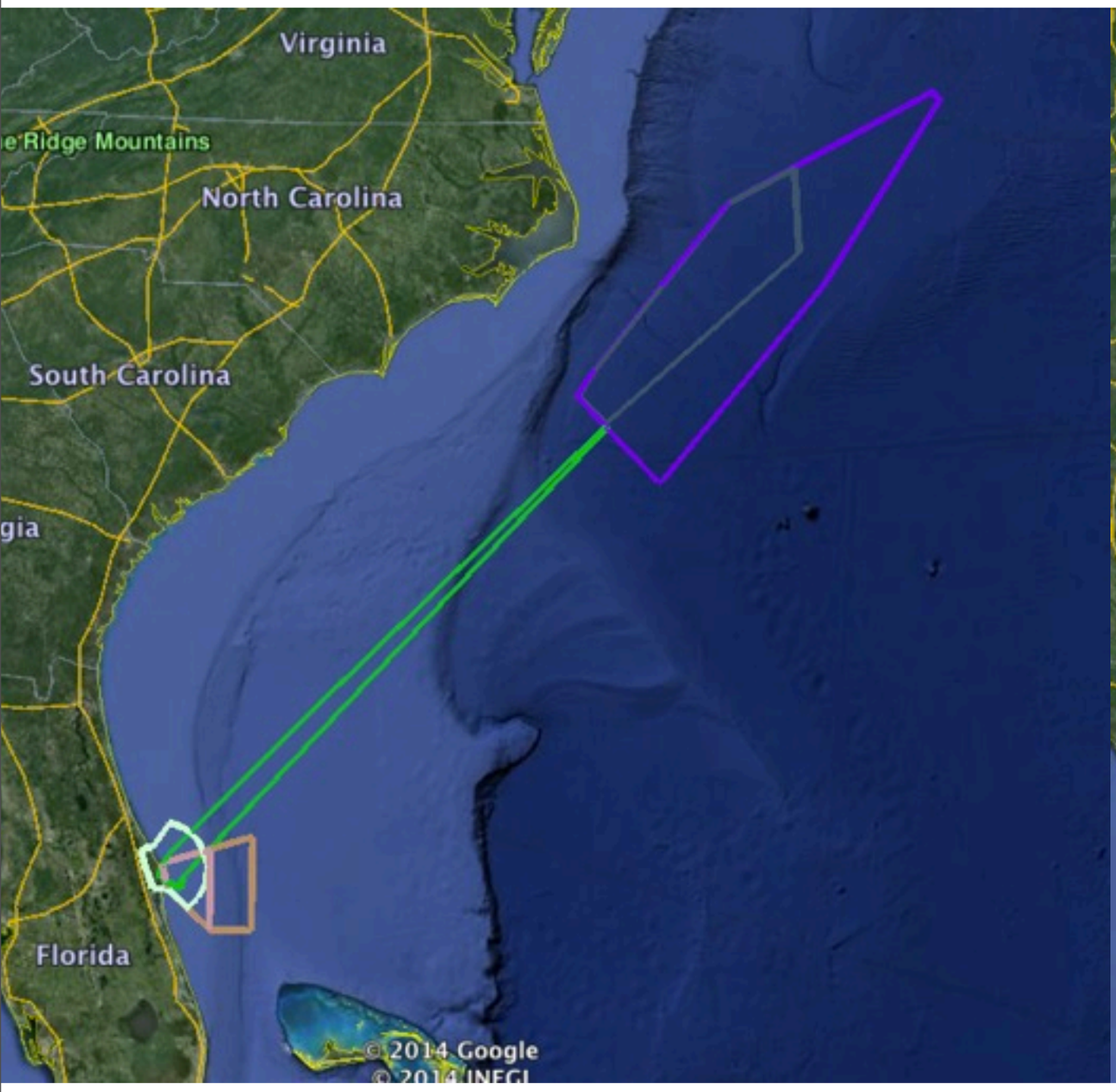

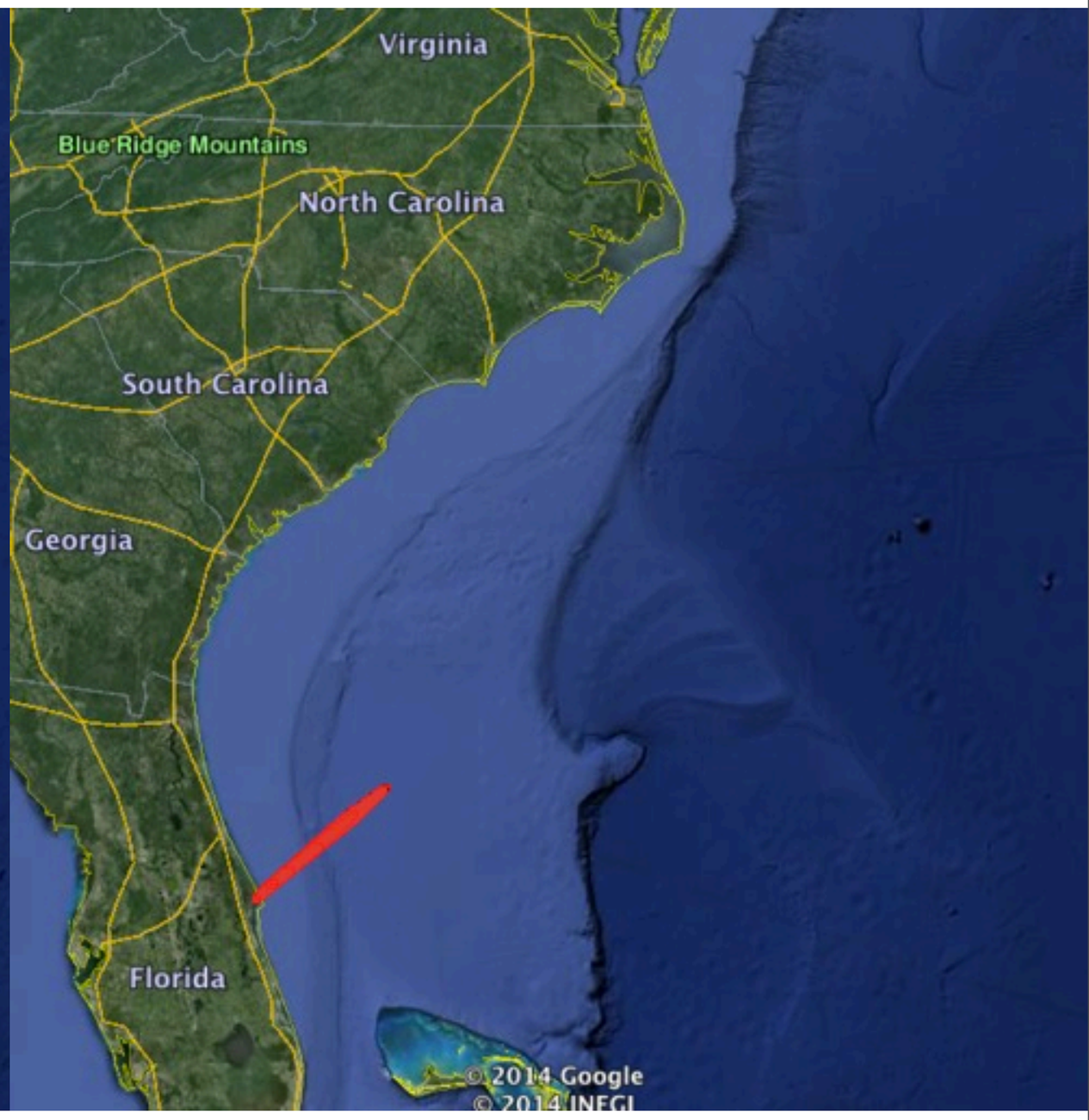

Reentry Example: Columbia

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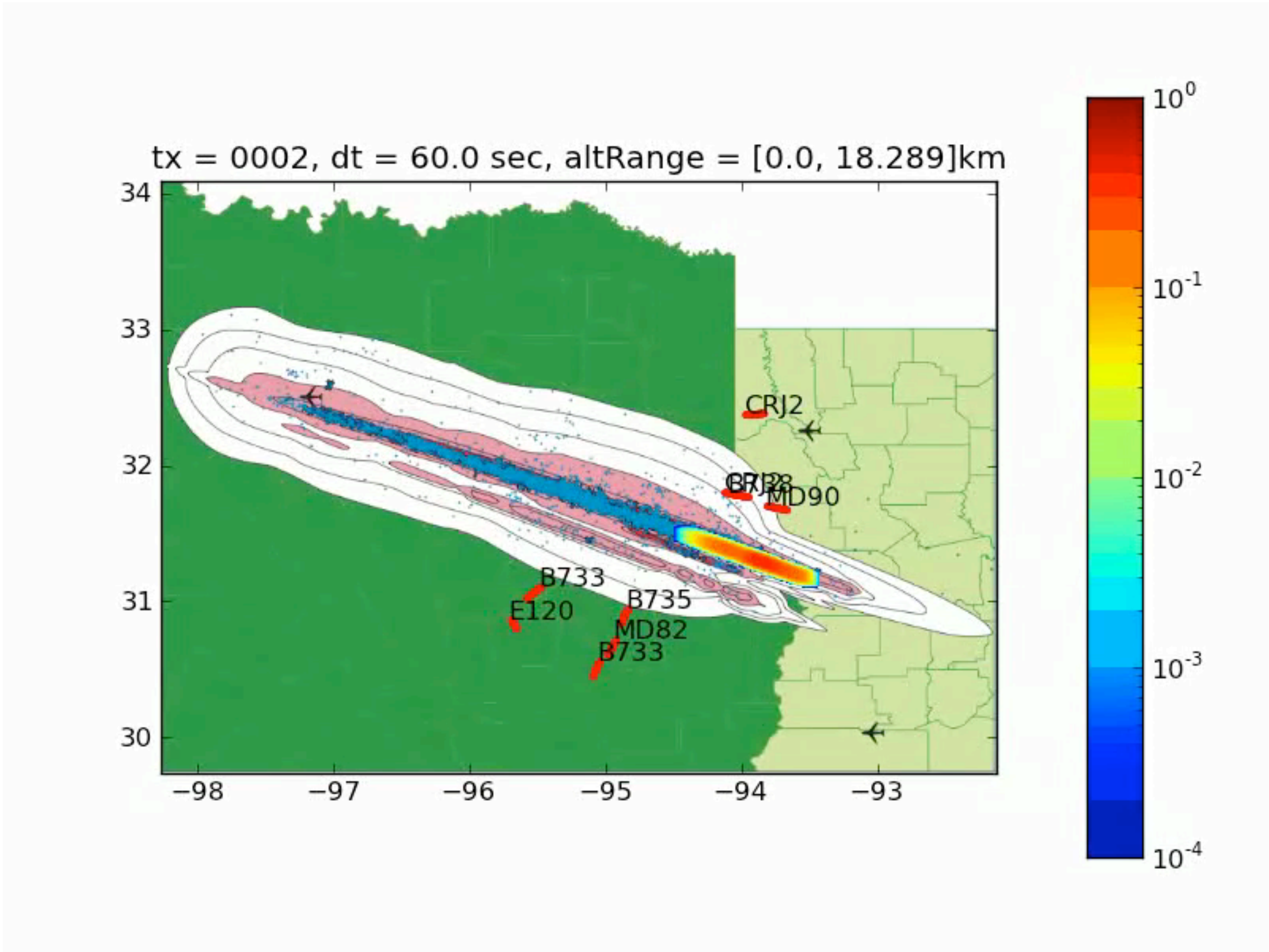

Conclusion

- **I am developing a novel method, called Compact Envelopes, for keeping launch and reentry traffic safely separated from traditional air traffic.**
- **I have created a software environment to assess risk to aircraft from debris hazards and to create Compact Envelopes.**
- **Compact Envelopes incorporate probabilistic risks to generate a no-fly zone boundary that is contoured in space, dynamic in time, and quantifiably safe. Leverages NextGen!**
- **Preliminary validation against Columbia disaster case.**
- **Paper and talk at SciTech 2015 (January!).**
- **NAS-wide simulation in close collaboration with FAA and NASA.**

Thanks!