



Federal Aviation
Administration

Near-Elimination of Airspace Disruption from Commercial Space Traffic Using Compact Envelopes

Thomas Colvin & Juan Alonso
Stanford University

Task 185

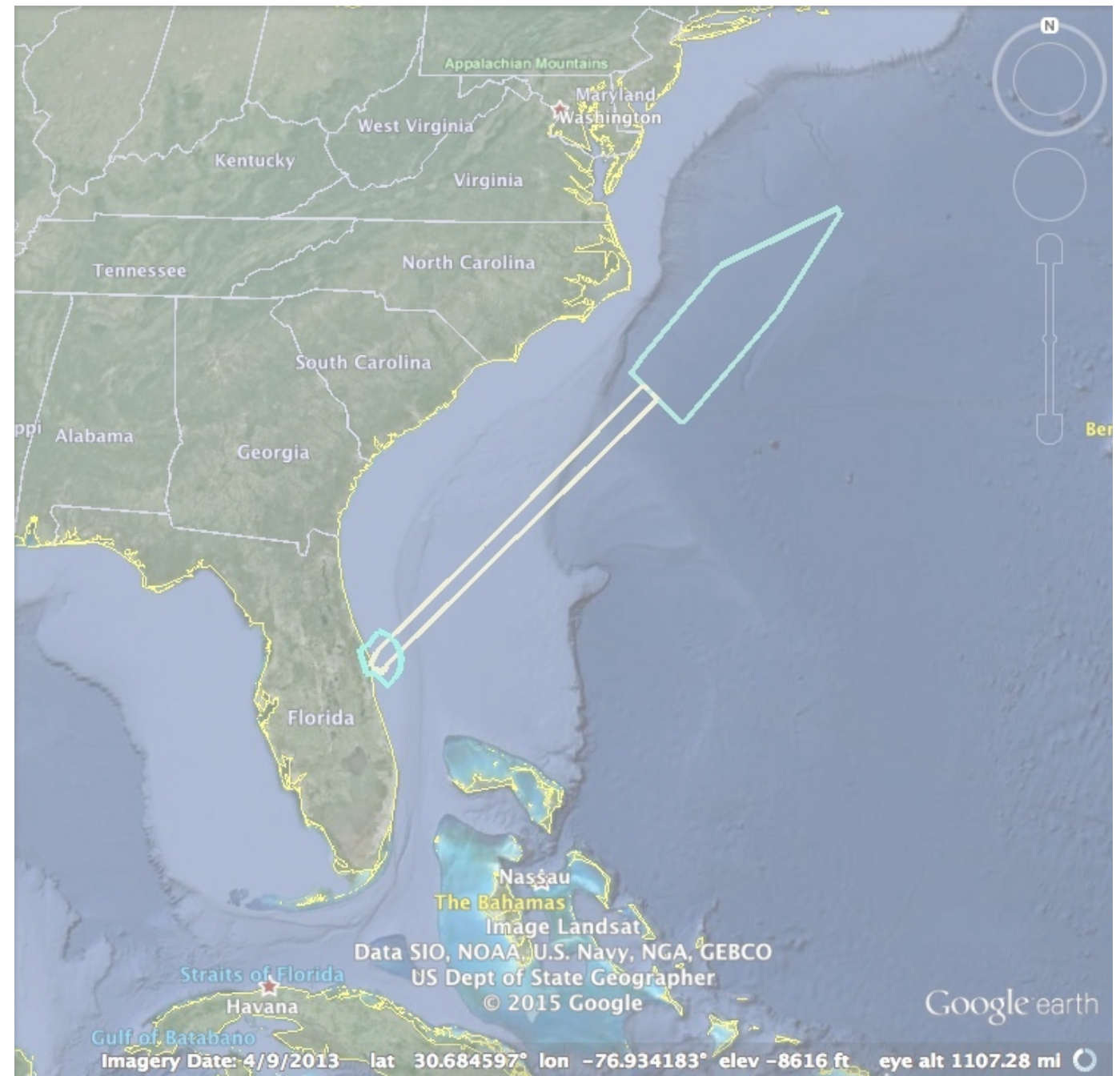
Oct 28, 2015



Space Operations Disrupt The NAS

March 1st 2013
Falcon9 from Cape Canaveral

- **Need To Ensure Safety**
- **Traditional Methods Inefficient**
- **Large Cost To Airlines**
- **Commercial Space Traffic Volume Increasing**
- **New Launch Ranges**



Compact Envelope Assumptions



Reaction Time

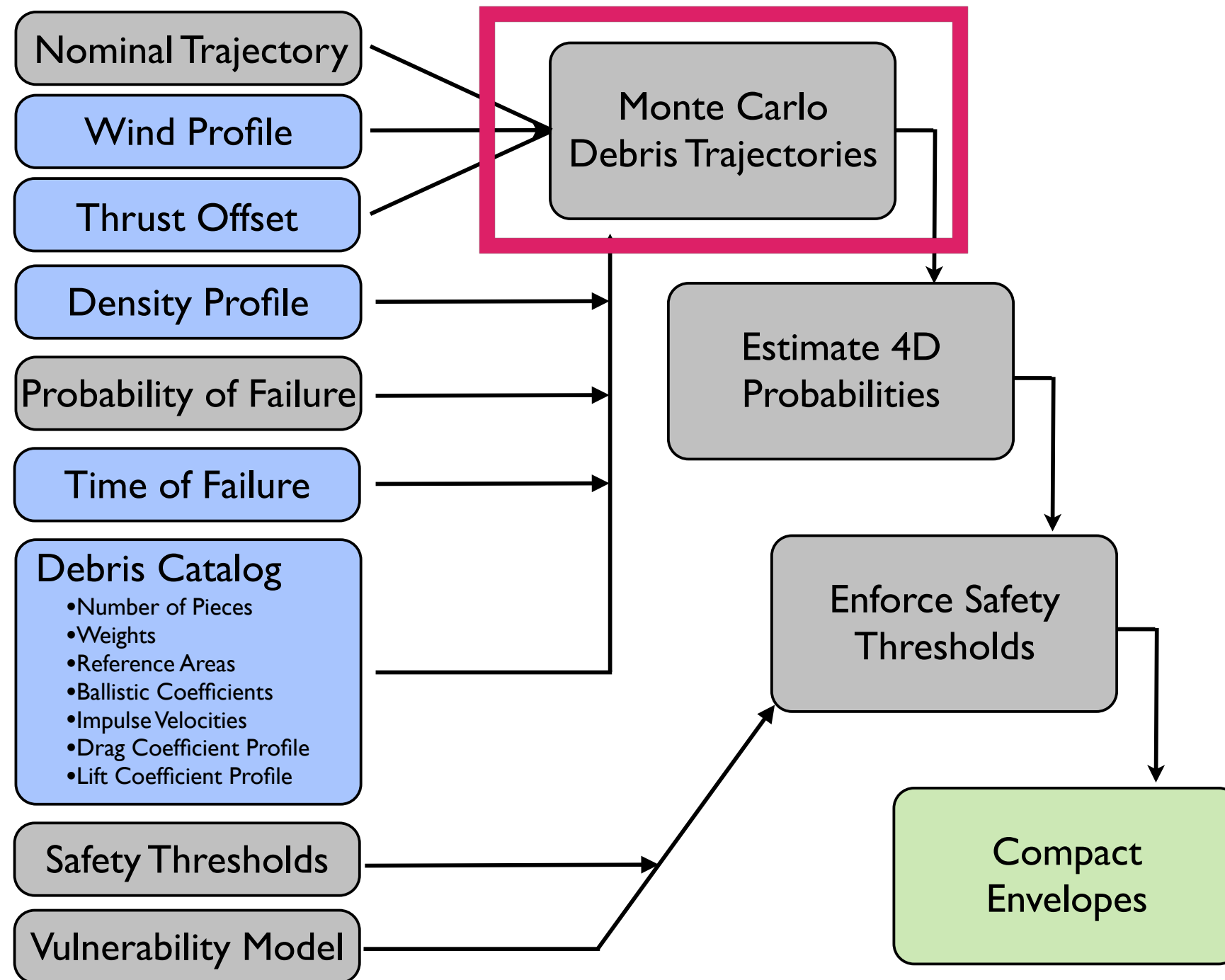


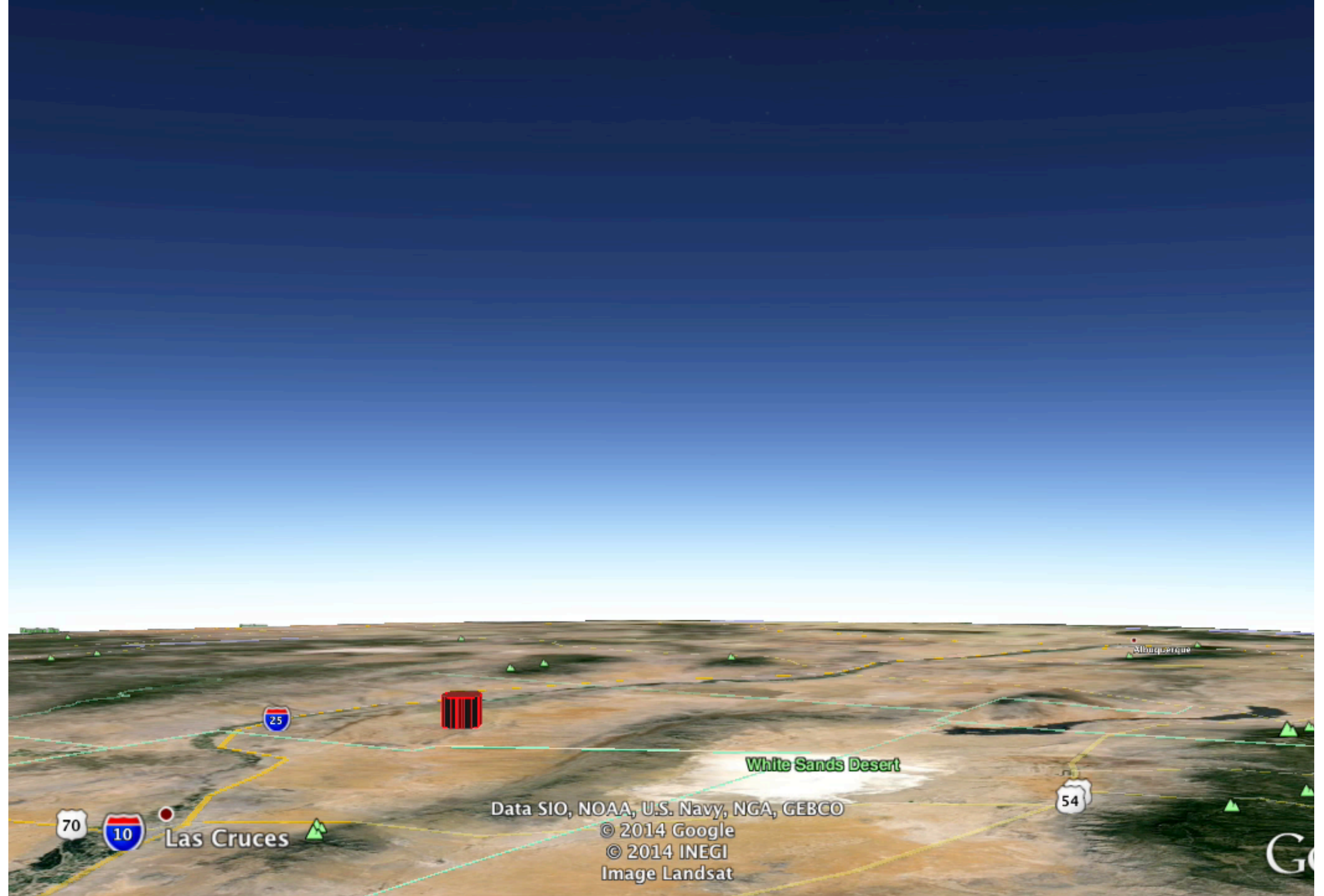
**Vehicle Health
Monitoring**



Data Comm

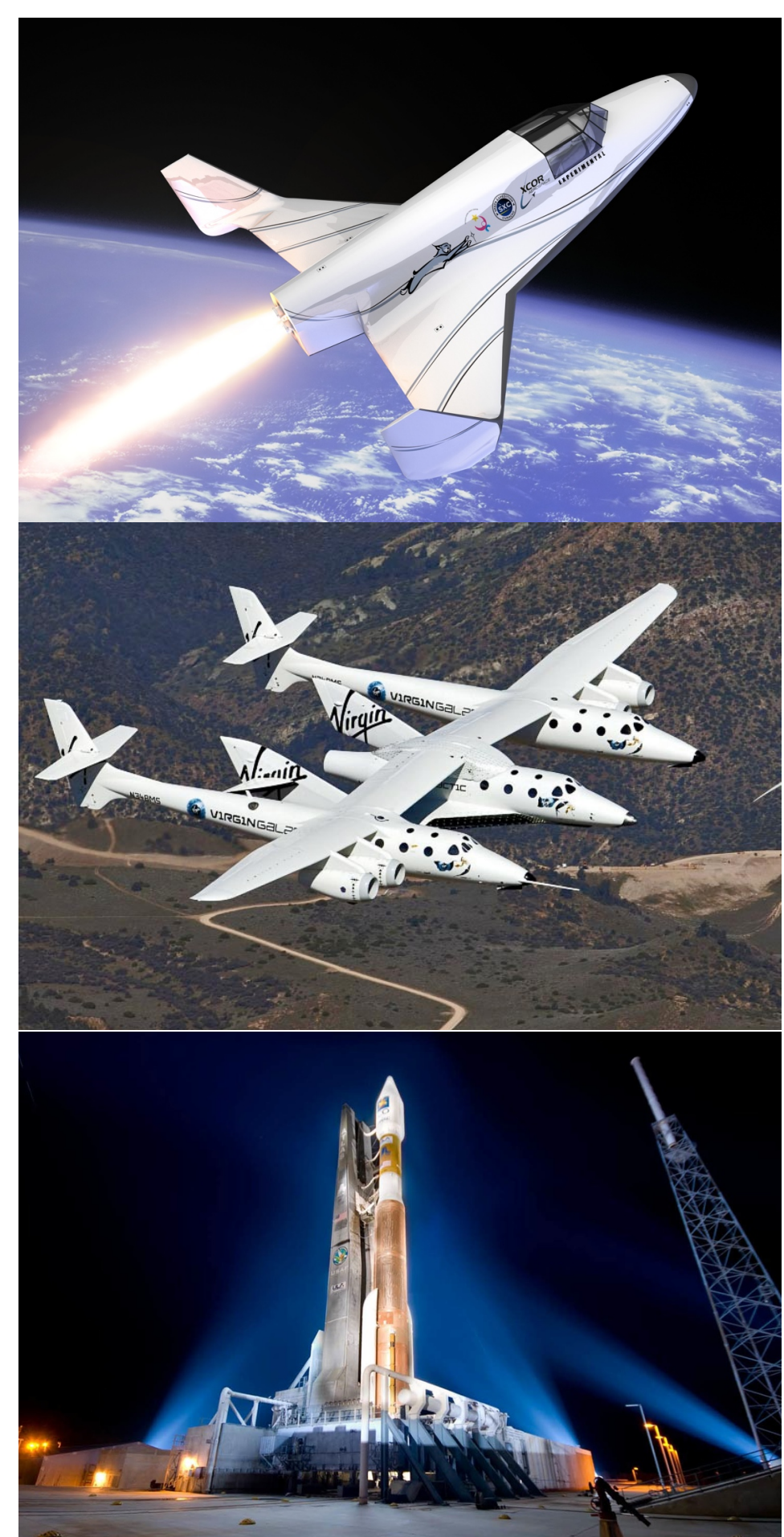
Stanford University Framework for Aircraft Risk Management (SU-FARM)





Current State Of Project

- **Create Compact Envelopes for arbitrary space vehicles flying from any spaceport.**
- **Simulate disruption in FACET.**
- **Have analyzed many vehicles from many spaceports.**
- **“Near-Elimination of Airspace Disruption from Commercial Space Traffic Using Compact Envelopes”**

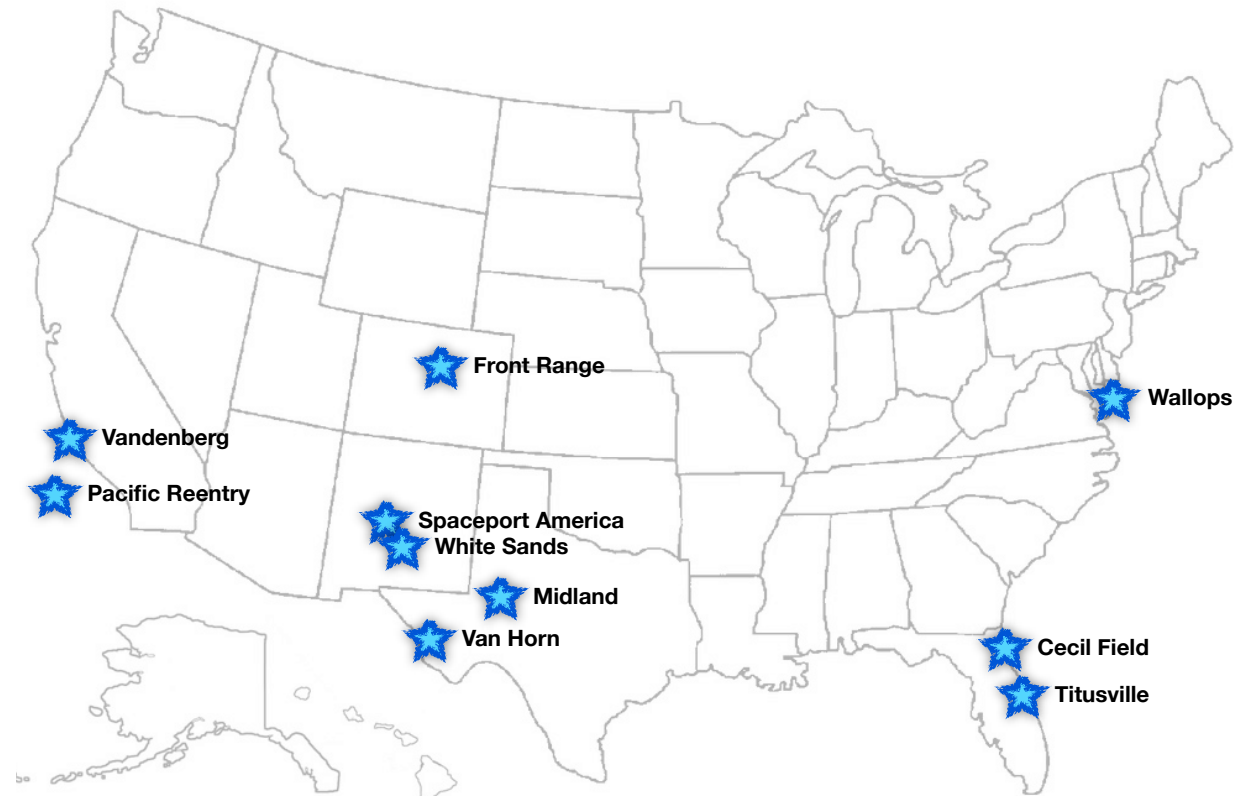


Near-Elimination of Airspace

Disruption...

Paper Simulated:

- **7 vehicles, 10 locations, 14 missions, 90 days**
- **Traditional Hazard Area vs Compact Envelopes**



Key Findings:

- **Dramatic reduction in impact near congested airspace.**
 - **Lynx at Front Range: Average aircraft affected reduced from 90 to 3.**
- **Completely eliminated disruption for some missions.**
 - **SpaceShipTwo at Spaceport America, AtlasV at VAFB, ...**

Concluding Thoughts

- **Surprised by the effectiveness of the Compact Envelope approach.**
- **FAA Human-In-The-Loop simulations**
 - **Scenarios based on compact envelope principles**
 - **Findings support our assumptions and vice-versa**
- **Compact Envelope ideas are being incorporated into future Space Vehicle Operations ConOps.**
- **Uploading to github**

Thank You

- **FAA Center of Excellence in Commercial Space Transportation**
- **Kevin Hatton, FAA Office of NextGen, Advanced Operational Concepts**
- **Paul Wilde and Dan Murray, FAA AST**
- **Francisco Capristán, Mykel Kochenderfer, Rachael Tompa**
- **FAA Tech Center**
- **FACET developers, NASA Ames**
- **MITRE**



