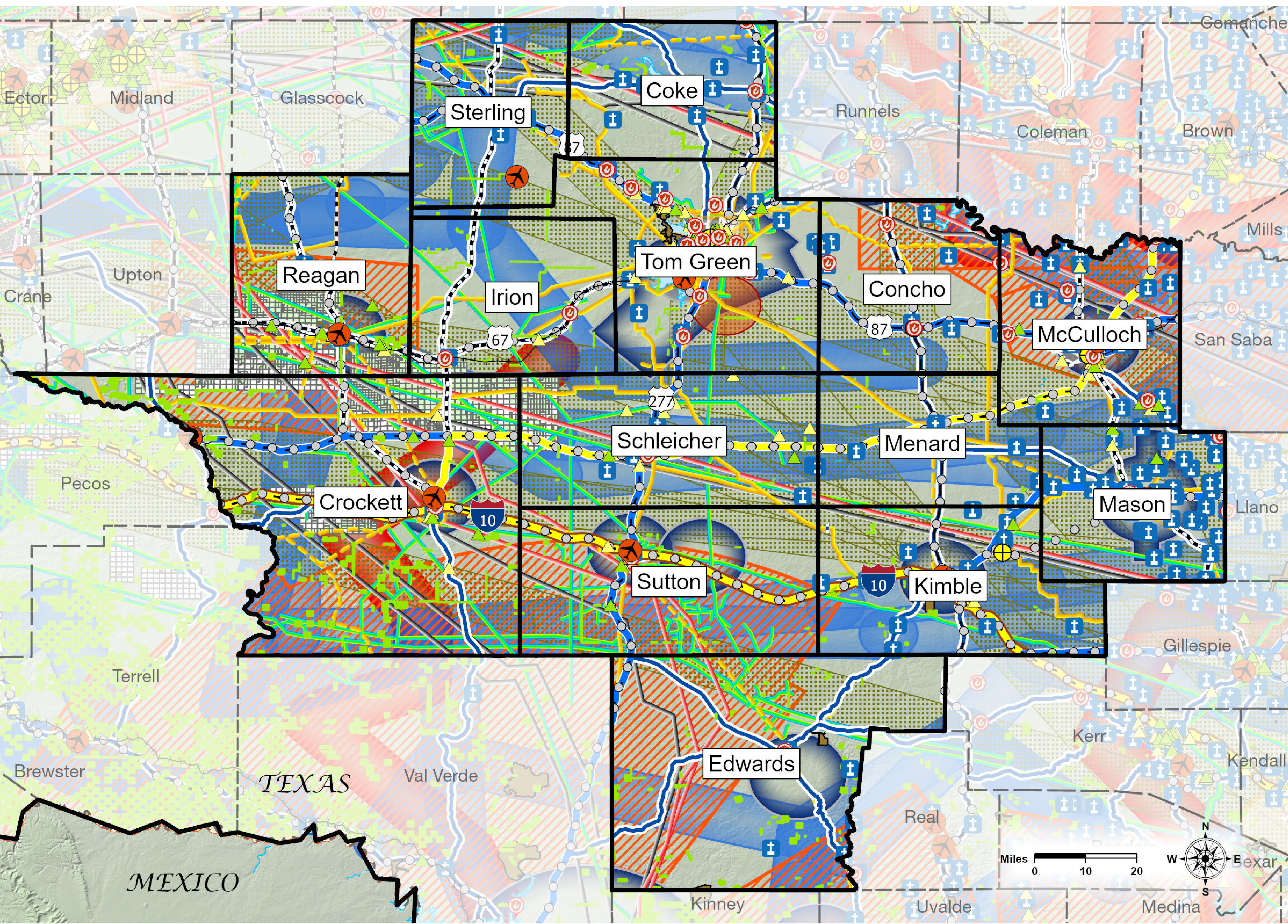
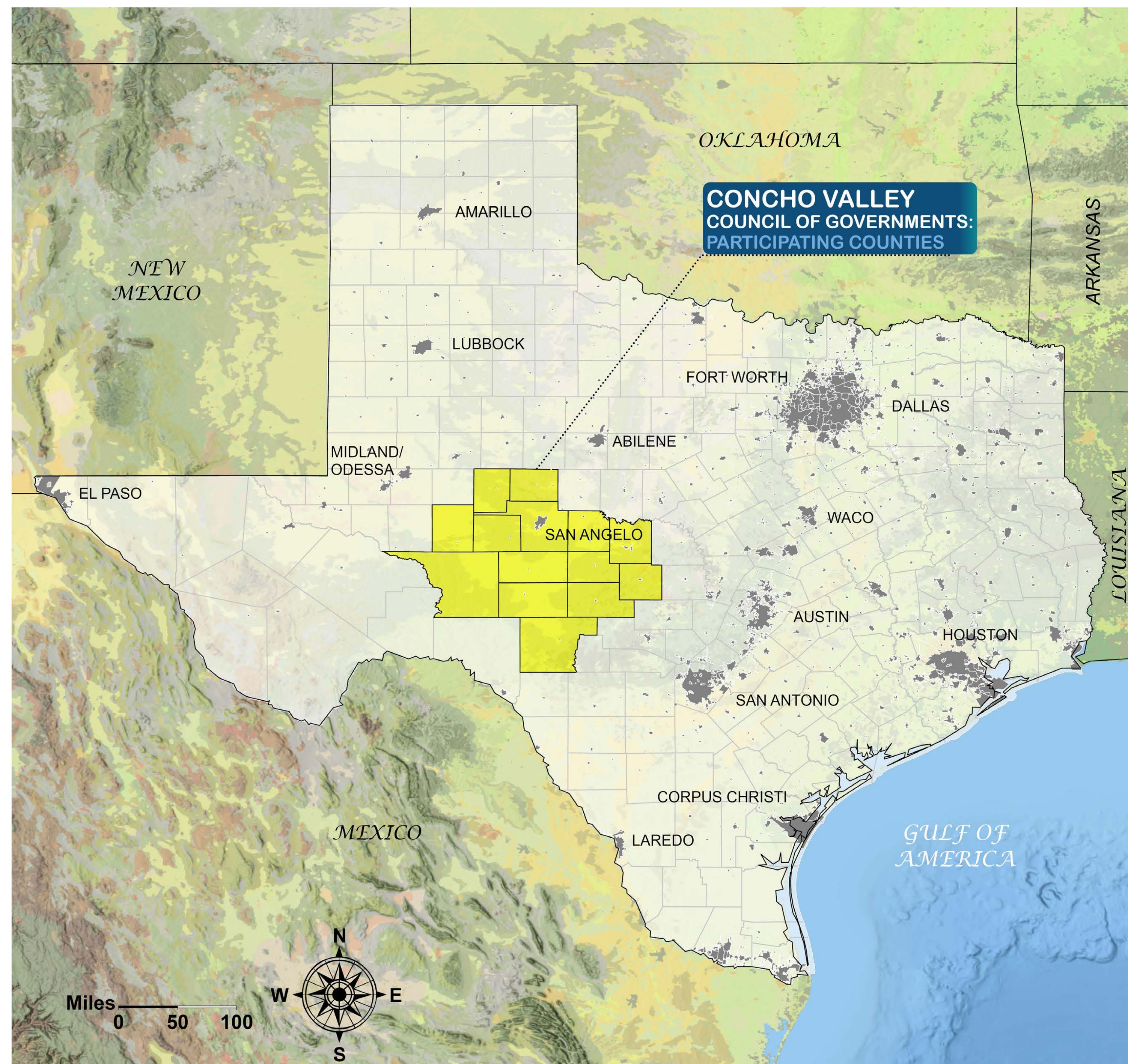


CVCOG Spaceport Feasibility Study



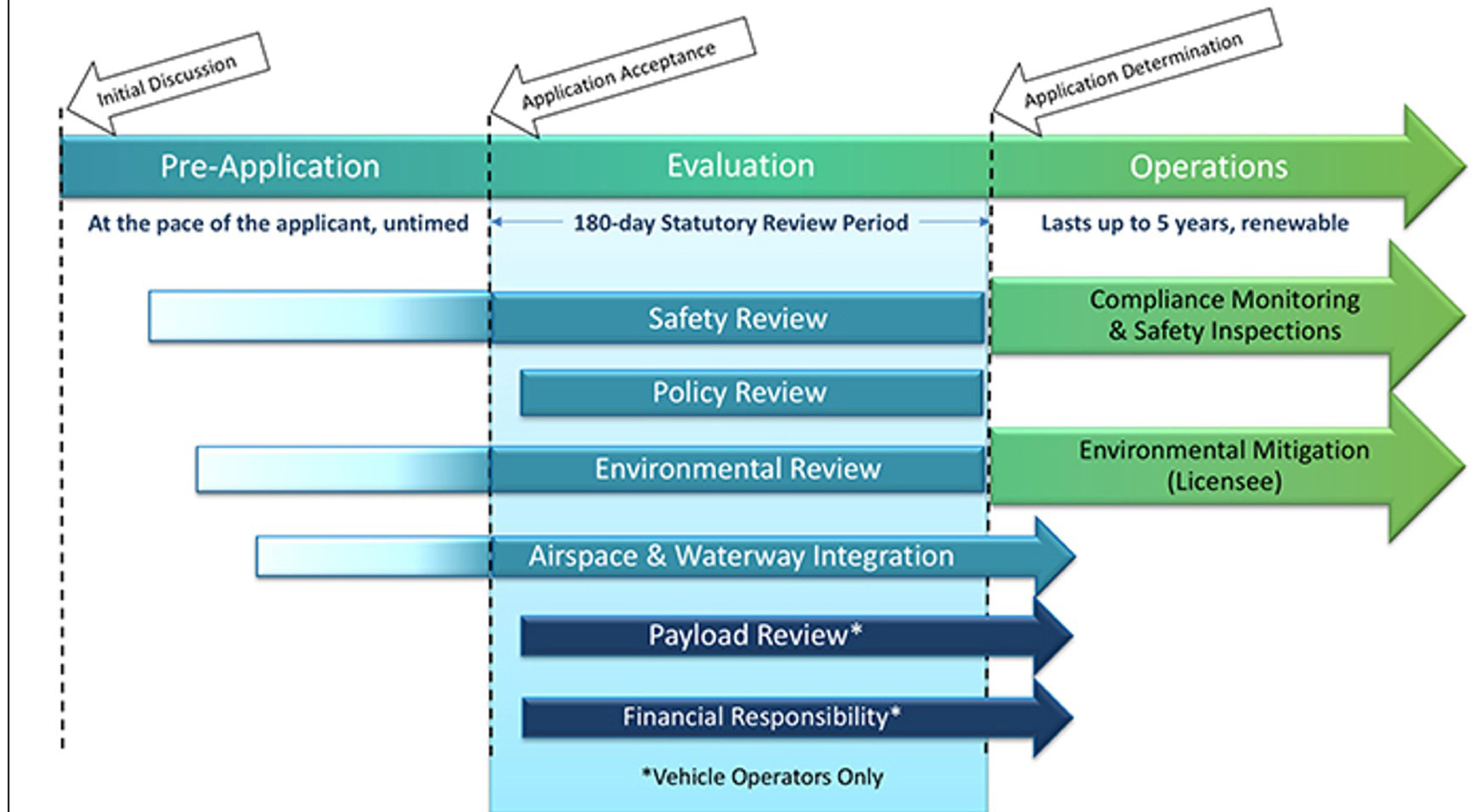
Legend

- | | |
|-------------------------------------|--|
| Texas State Boundary | Hard Minerals |
| CVCOG Counties | Highway Freight Network |
| County Boundary | TxDOT Connectivity Corridors |
| City Limit Boundary | Texas Space Industry Network - Primary |
| Military Boundary | Texas Space Industry Network - Secondary |
| Metropolitan Planning Organization | TxDOT Energy Sector Corridors |
| Texas State Parks Boundaries | Electrical Transmission - In Service |
| Permanent School Fund Lands | Electrical Transmission - Not Available |
| University Lands - Available Parcel | HGL Pipeline |
| University Lands - Oil/Gas Lease | Crude Oil Pipeline |
| Primary Roadway | Natural Gas Pipeline |
| Secondary Roadway | Petroleum Pipeline |
| Railroad | FAA Class E Airspace |
| Lake/Pond | FAA Class D Airspace |
| Airport | FAA Special Use Airspace - MOA |
| Fire/EMS Station | FAA Route Airspace |
| Cemetery | FAA National Defense Airspace |
| Superfund Site | FAA Military Training Route |
| Brownfields Site | FAA Low Altitude Training Route |
| RCRA - ACTIVE | |
| RCRA - INACTIVE | |



CVCOG Spaceport Feasibility Study

Licensing Process: Vehicle/Site



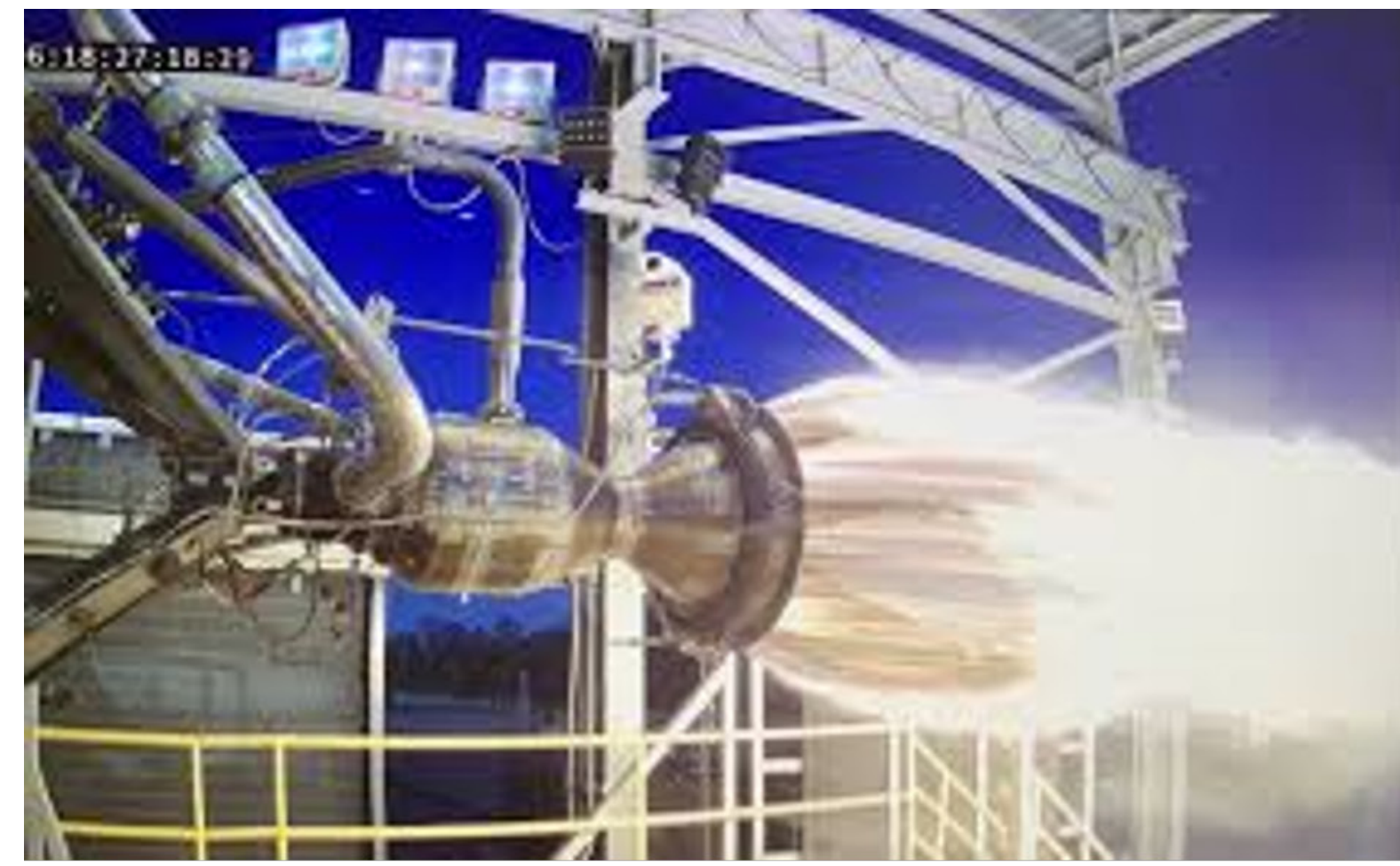
Institutional Challenges & Mitigations

Challenge	Mitigation
Environmental (NEPA/TEQA)	✓
CRAS	✓
Water Quality/Sources	✓
T&E Species	✓
Section 4(f) Lands	✓
Noise/Sonic Boom	✓
FAA Regulatory	
AST Licensing-Pre App Consult	✓
FSA / Explosive Siting	✓
AST Process	✓
FCC Licensing	
Add Frequency Allocation	✓
Airspace Scheduling & Coord	
Military	✓
Civil	✓
Overflight of Major Trans Hubs	
Railroads	✓
Interstates	✓

CVCOG Spaceport Feasibility Study

USE CASE 1 - ENGINE TEST / MULTI-MODAL PROVING GROUND

- ▣ Spaceport initially utilized for rocket propulsion development / test
- ▣ Multi-modal proving ground operations are envisioned
 - Provides diverse revenue streams for activities attracted by remote site characteristics (low population, secure, safe)
- ▣ Energy, Research, & Miscellaneous other activities possible such as
 - Data Centers
 - Satellite Uplink/Downlink/Tracking
 - Advanced Solar, Nuclear (Fission & Fusion)
 - Destructive Testing
 - STEM initiatives / Workforce Development



USE CASE 2 - AVIATION / AUTONOMOUS AERIAL OPERATIONS

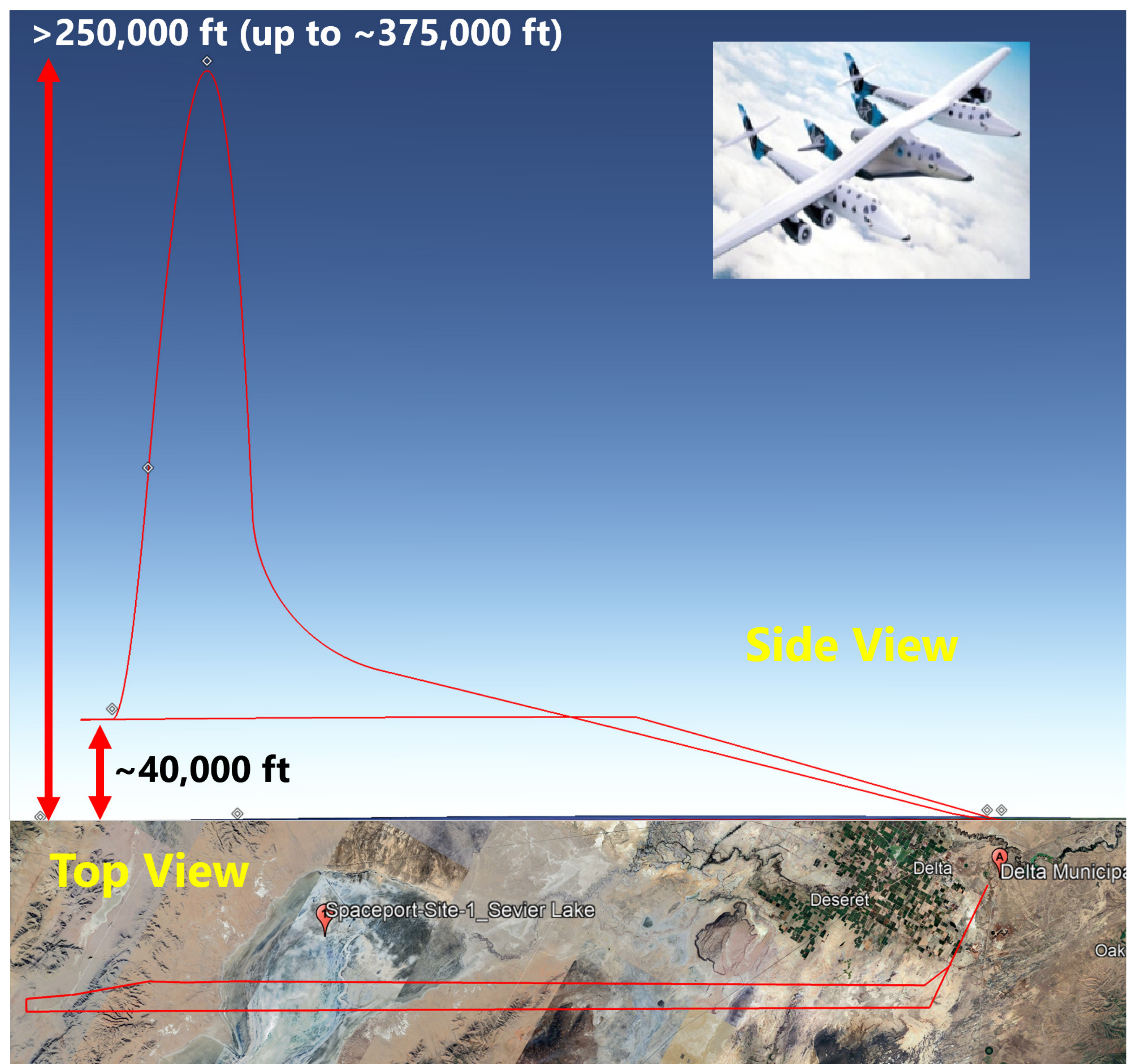
- ▣ Spaceport / Airport Dual-Use
 - Various aviation test applications
 - Supports STEM/Workforce Development
- ▣ Autonomous aerial operations
 - Some require proper runways
 - Others may use basic improved dirt strips
 - Low level and very high alt. ops possible
- ▣ Dual-use civil-military ops envisioned
 - Assumes an improved runway is available
 - Less than 5,000 feet runway may suffice for many UAS / UAM testing cases



CVCOG Spaceport Feasibility Study

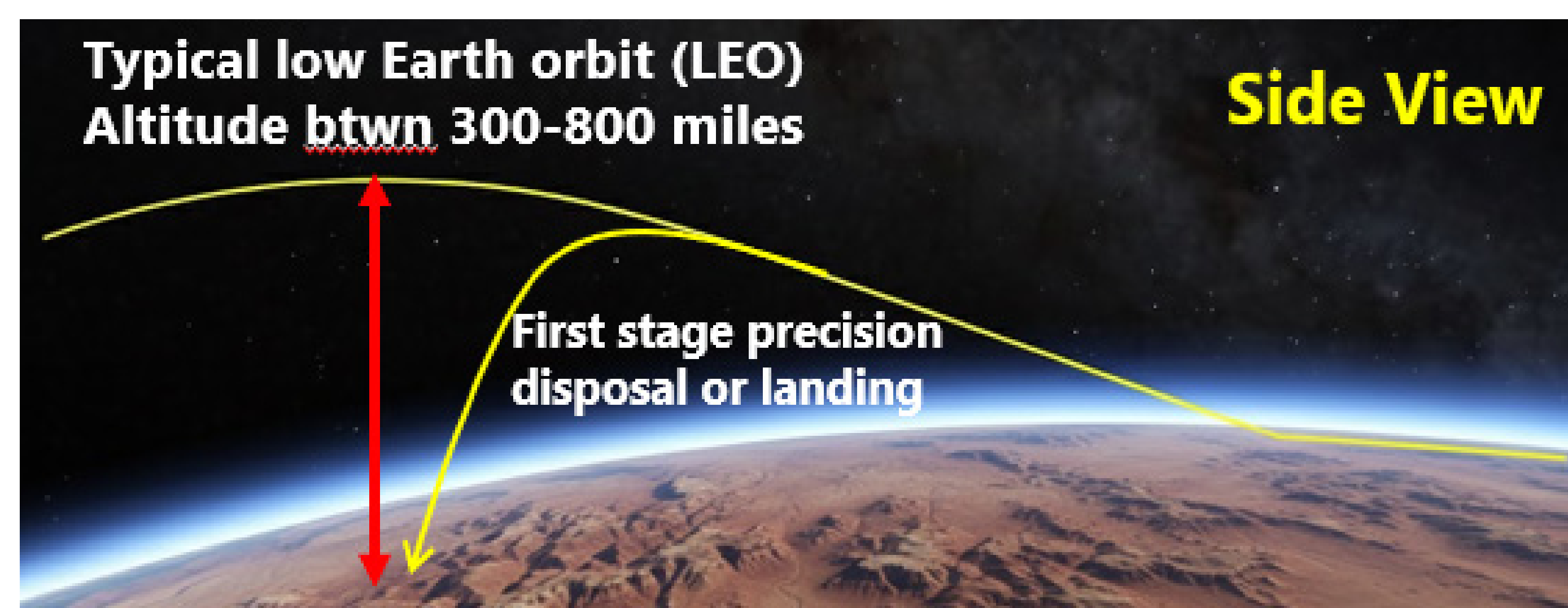
USE CASE 3 - HORIZONTAL LAUNCH & LANDING / SUBORBITAL

- ▣ Launch Vehicle (LV) Assumption:
 - Virgin Galactic operations with combo of White Knight 2/Spaceship 2 (WK2/SS2)
 - Other example: Dawn Aerospace *
- ▣ WK2 Releases ~40,000+ ft
- ▣ SS2 Apogee >250,000 ft
- ▣ Track length = ~80-90 miles
- ▣ Airspace closure space characteristics
 - ~100 x 30 miles box and ~2-4 hours
- ▣ Site needs (minimum):
 - Runway ~12,000 feet (concrete) + Apron
 - Hangar ~40,000 sqft
 - Comms/tracking/control/propellant/ARFF
 - Utilities + Roads



USE CASE 4 - HORIZONTAL LAUNCH & LANDING ORBITAL

- ▣ LV Assumptions
 - Virgin Orbit or Stratolaunch CONOPs
 - Takeoff w/rocket, fly to ~40-45K ft, drop multi-stage rocket w/payload, and launch to LEO or other needed orbit.
- ▣ Assumes use of extended local municipal runways (up to 12,000 feet).
- ▣ Trajectory shown is for polar launch (0-degree north).
- ▣ Assumes first stage disposals in remote area and/or landing with a precision parafoil recovery system.
- ▣ Airspace closures along first 100-120 miles of trajectory & ~20 miles wide.



CVCOG Spaceport Feasibility Study

USE CASE 5 - VERTICAL LAUNCH & LANDING / SUBORBITAL

LV Assumptions

- Traditional Sounding Rocket operations
- Could be Blue Origin New Glenn operations

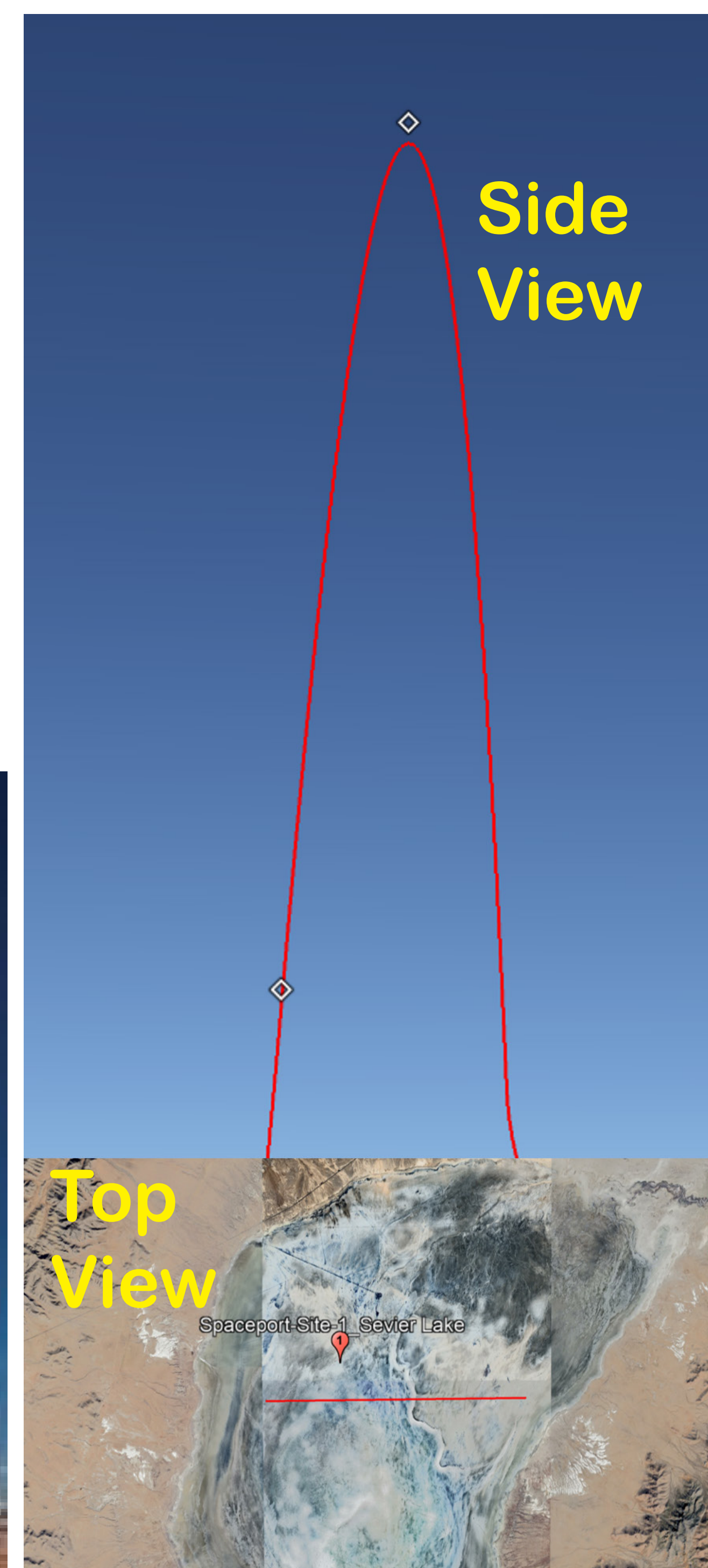
▣ Apogee = 2 (typical 50) < x < 400 miles

▣ Downrange drift up to 10+ miles

▣ Airspace closure space characteristics
~50 x 50 miles box and ~2 hours

▣ Site needs (minimum):

- Concrete pad(s) + propellant
- LV & payload prep facilities
- Comms/tracking/control/propellant/ARFF
- Utilities + Roads



USE CASE 6 - VERTICAL LAUNCH & LANDING SUBORBITAL P2P

LV Assumptions

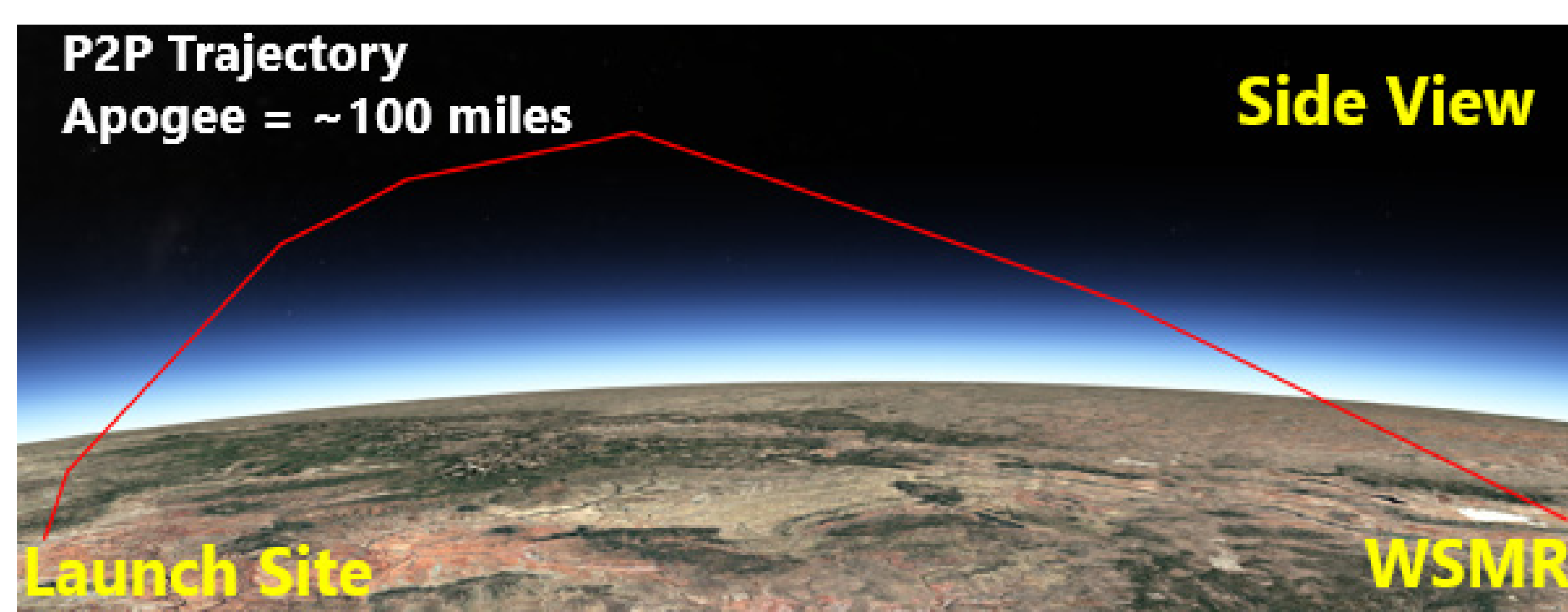
- Typical sounding rocket
- Hypersonic test vehicle (eg., HASTE*)

▣ CONOPs model from 1970s-1980s tests in Utah under the Athena and Pershing test/training programs

▣ Launch with landing downrange; today called point to point (P2P)

▣ Airspace closures along path approximately 20 miles wide (min)

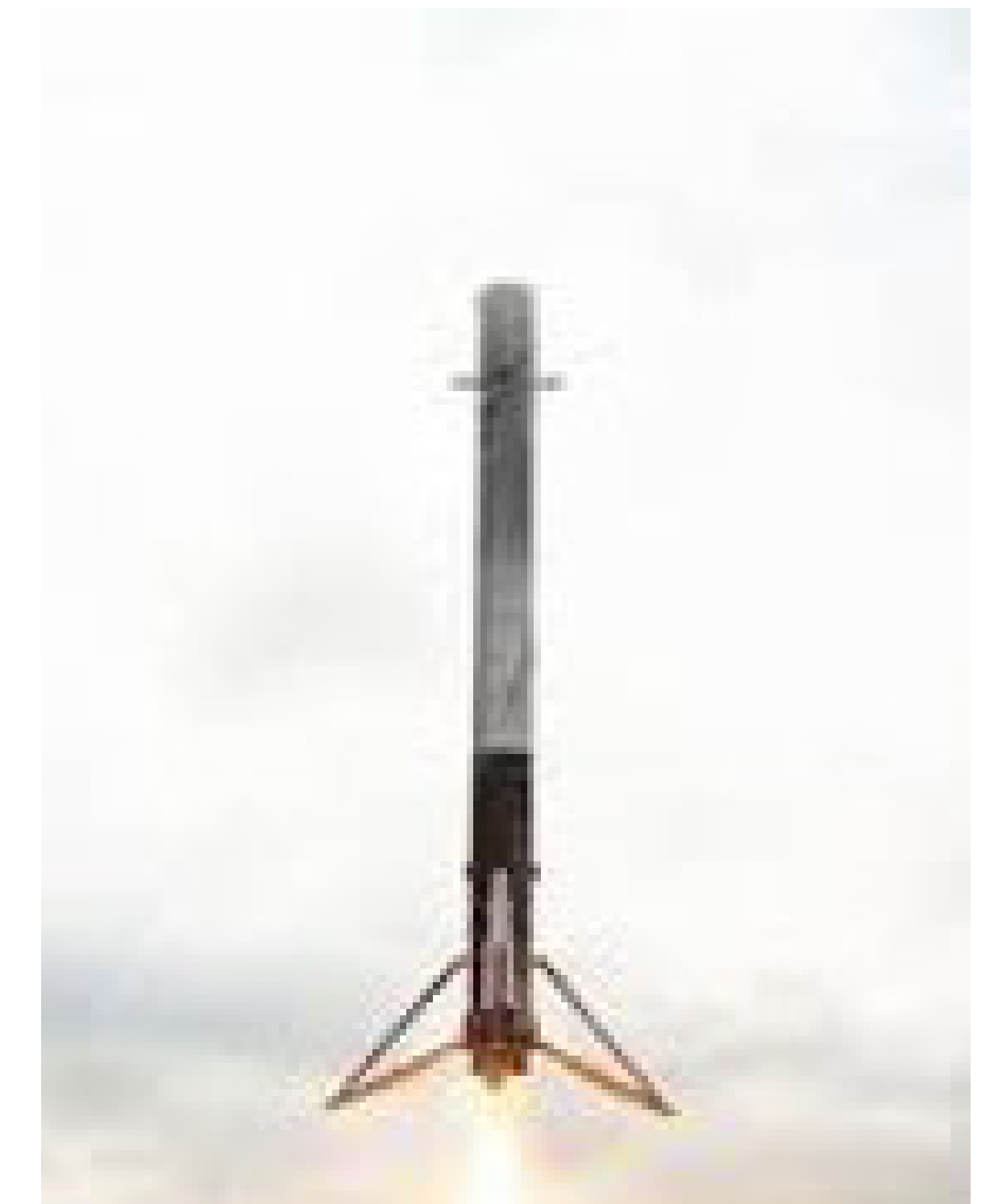
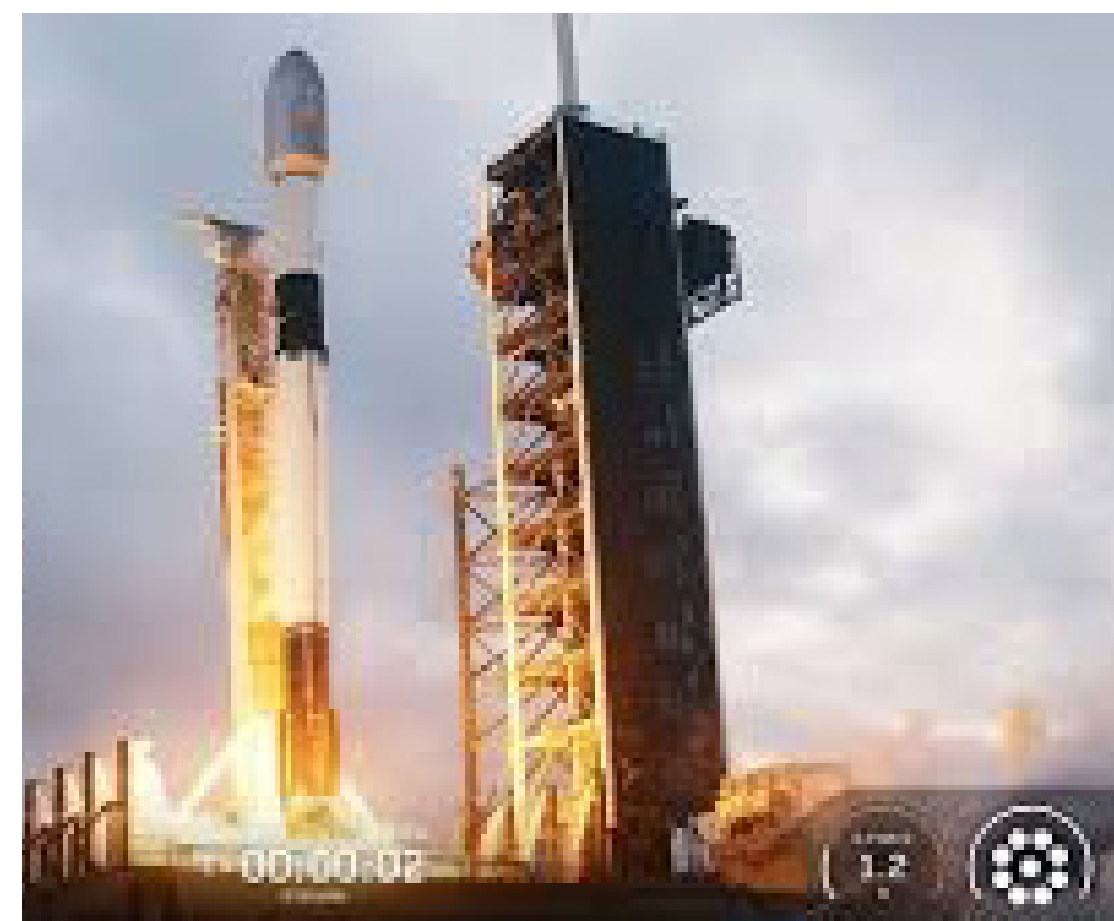
▣ Site needs like UC-5 plus downrange



CVCOG Spaceport Feasibility Study

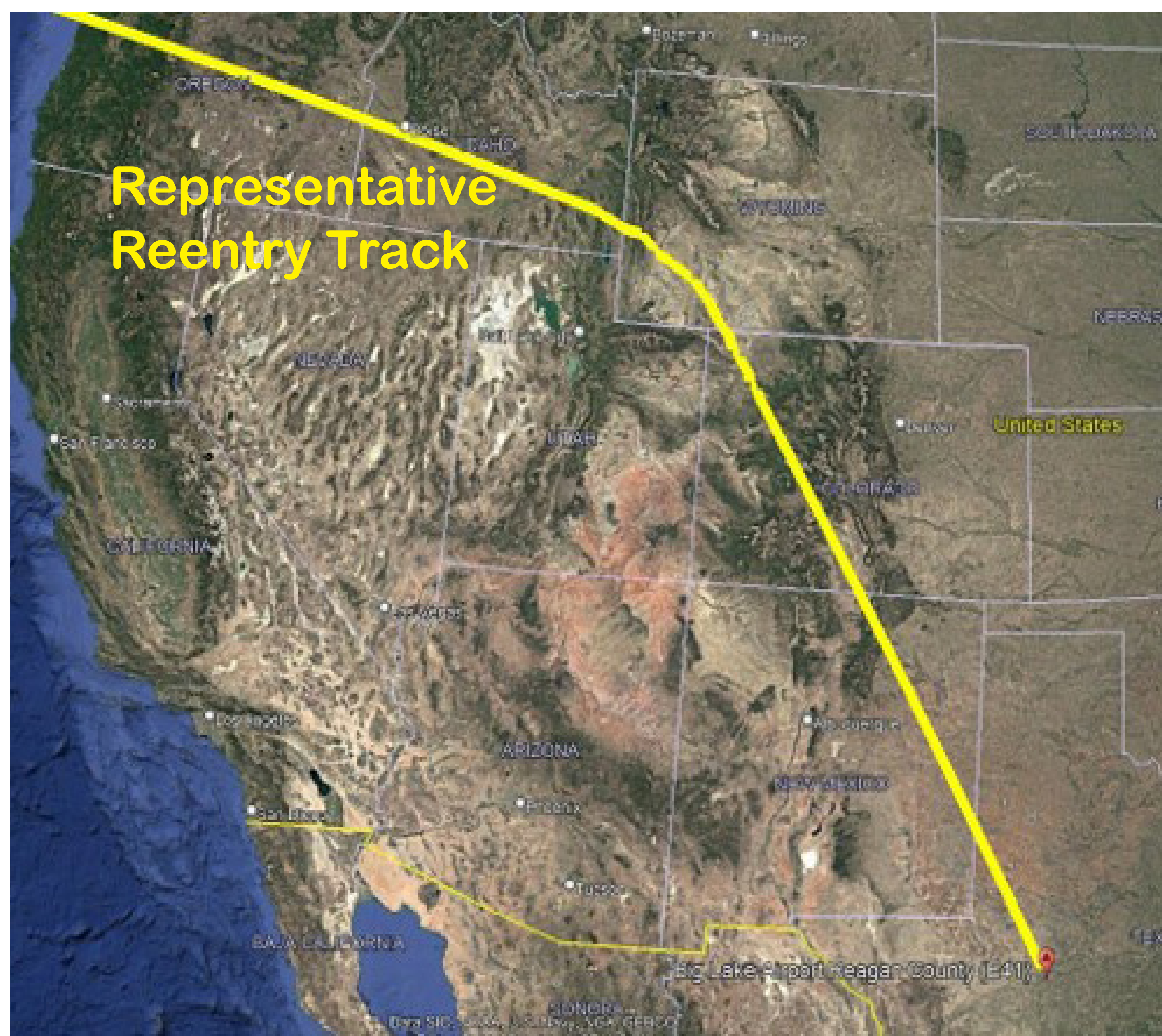
USE CASE 7 - VERTICAL LAUNCH & LANDING / ORBITAL

- ▣ LV Assumptions
 - Falcon 9 (F9) with RTLS or downrange landing of first stage booster
- ▣ Trajectory assumptions
 - Sun synchronous shown from Site 1
 - Either RTLS or downrange booster landing
 - Either site will generally work
- ▣ Airspace closures along first 100-120 miles of trajectory & ~20 miles wide (may be greater)
- ▣ Various trajectories are possible including northerly, southerly, and southeasterly



USE CASE 8 - ORBITAL REENTRY OPERATIONS

- ▣ LV Assumptions
 - Capsule or Winged "lifting body"
 - Precision landing capabilities
 - Horizontal glide to runway
 - Precision (parafoil) reentry (~50 yards CEP)
- ▣ Trajectory assumptions
 - West to east approach
 - Northern track with turn to south into Concho Valley
- ▣ Airspace closures along last 100-120 miles track & ~20 miles wide (may be greater)
- ▣ Various west-to-east reentry tracks are possible including from north or south



CVCOG Spaceport Feasibility Study

NOISE EVALUATION FOR CVCOG SPACEPORT FEASIBILITY STUDY

Rocket Operations

PROPOSED OPERATIONS
Launch and landing operations of Falcon 9 rocket from Concho Valley

PROPULSION NOISE ANALYSIS
Modeling for launch operations only (static fire and landing operations will be much less impactful)

SONIC BOOM ANALYSIS
Modeling for launch and landing operations


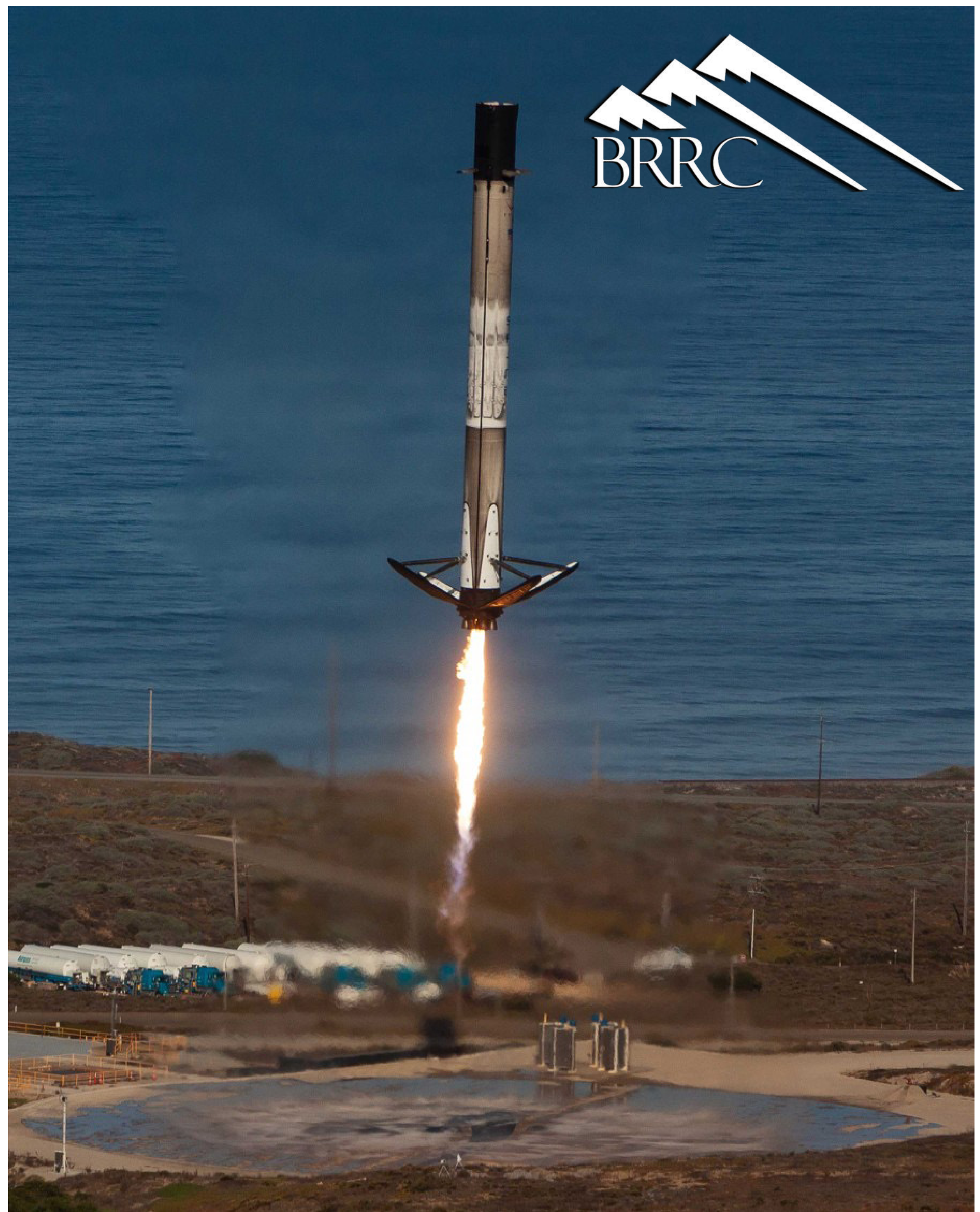
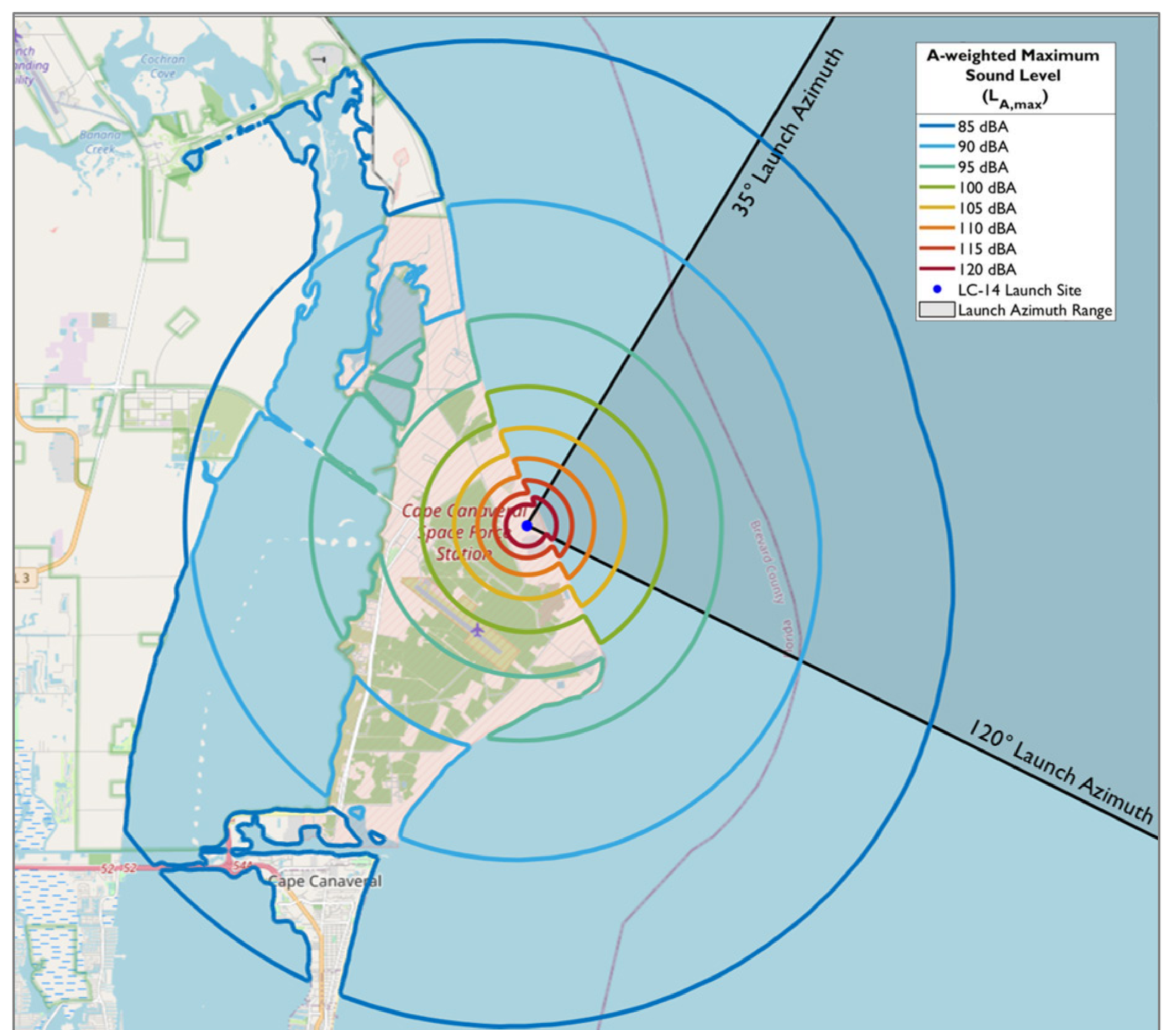
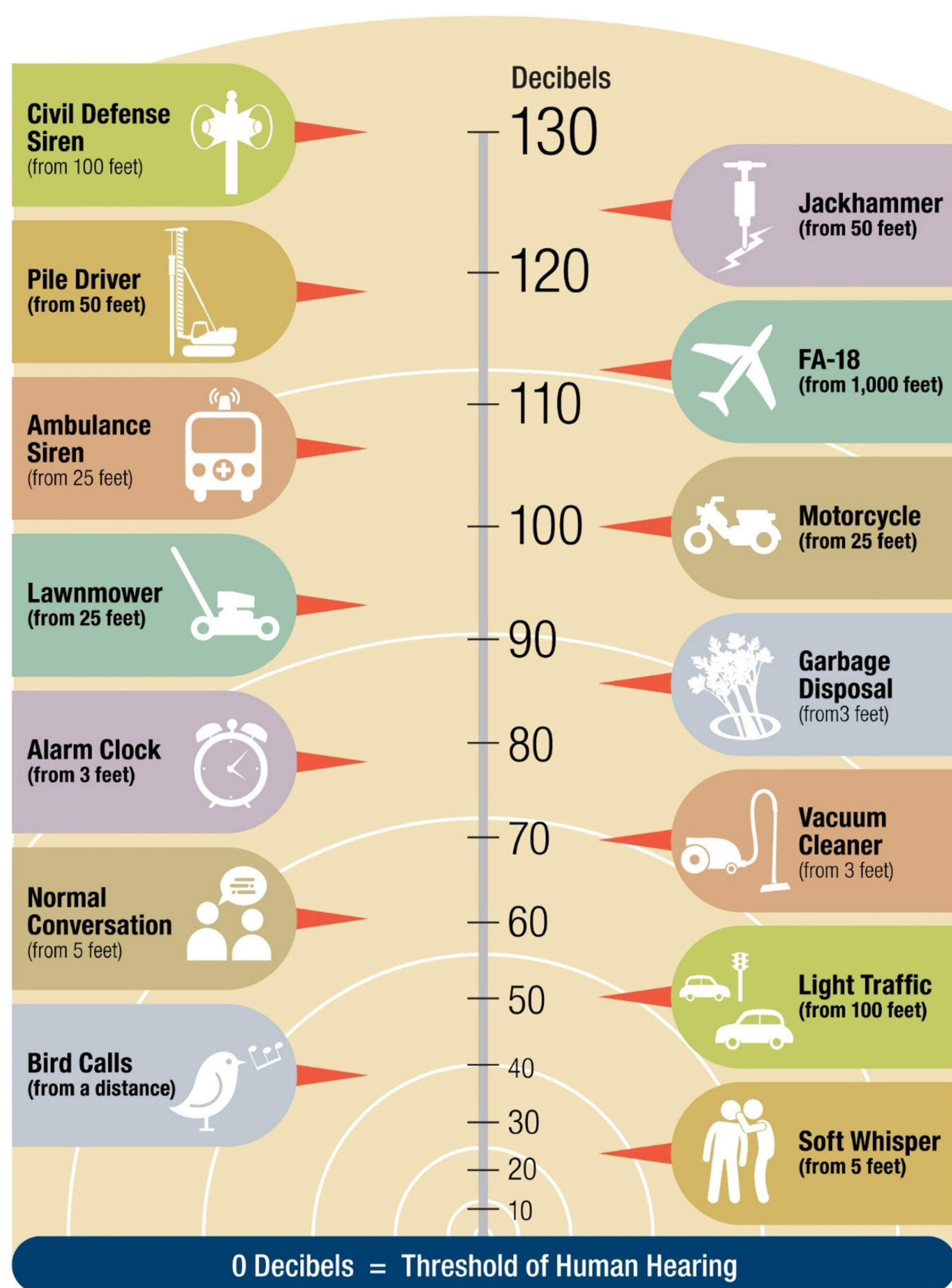


Image credit Pauline Acaline for Supercluster



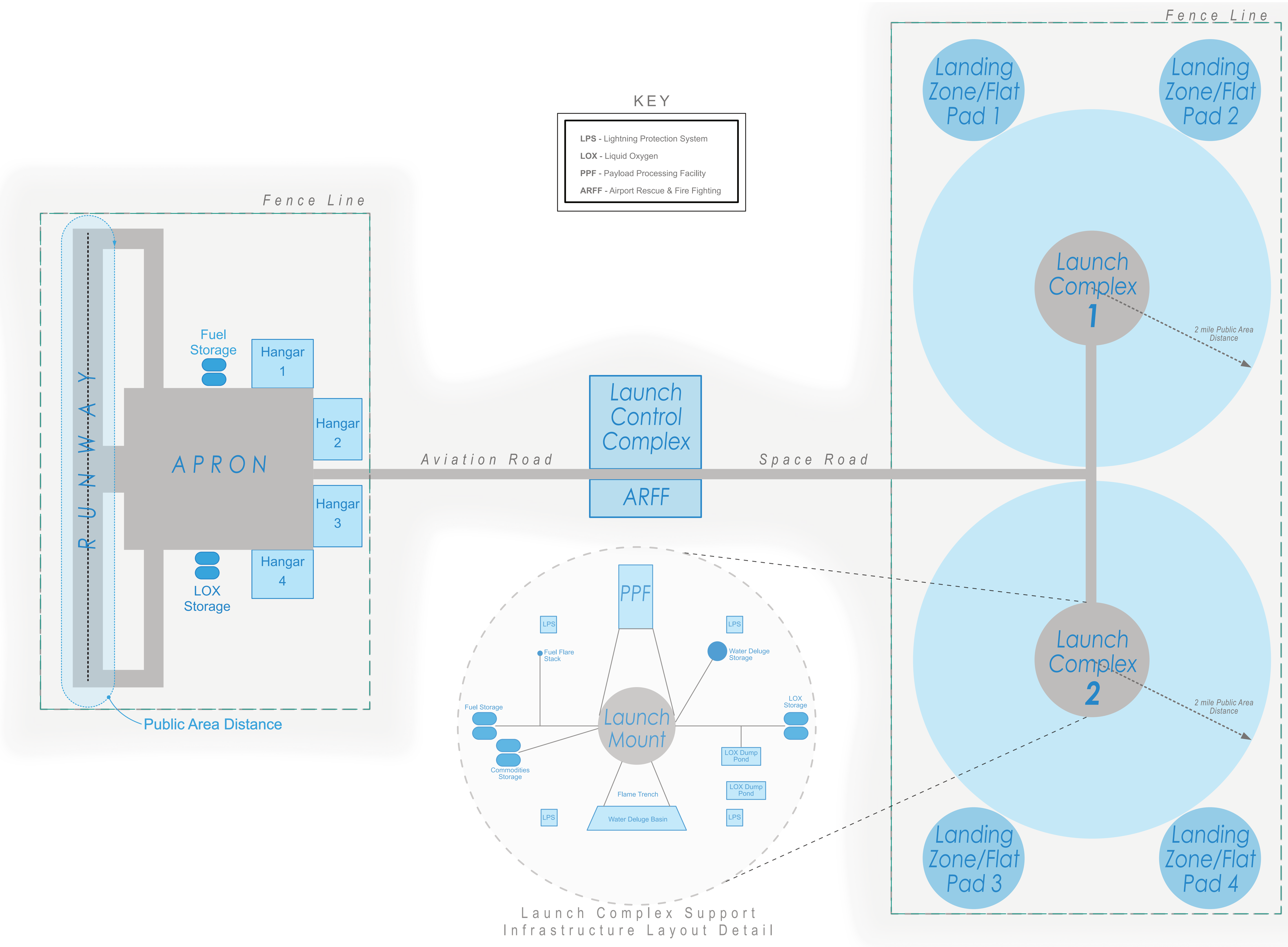
Propulsion Noise Analysis



CVCOG Spaceport Feasibility Study: Representative Spaceport Siting Criteria

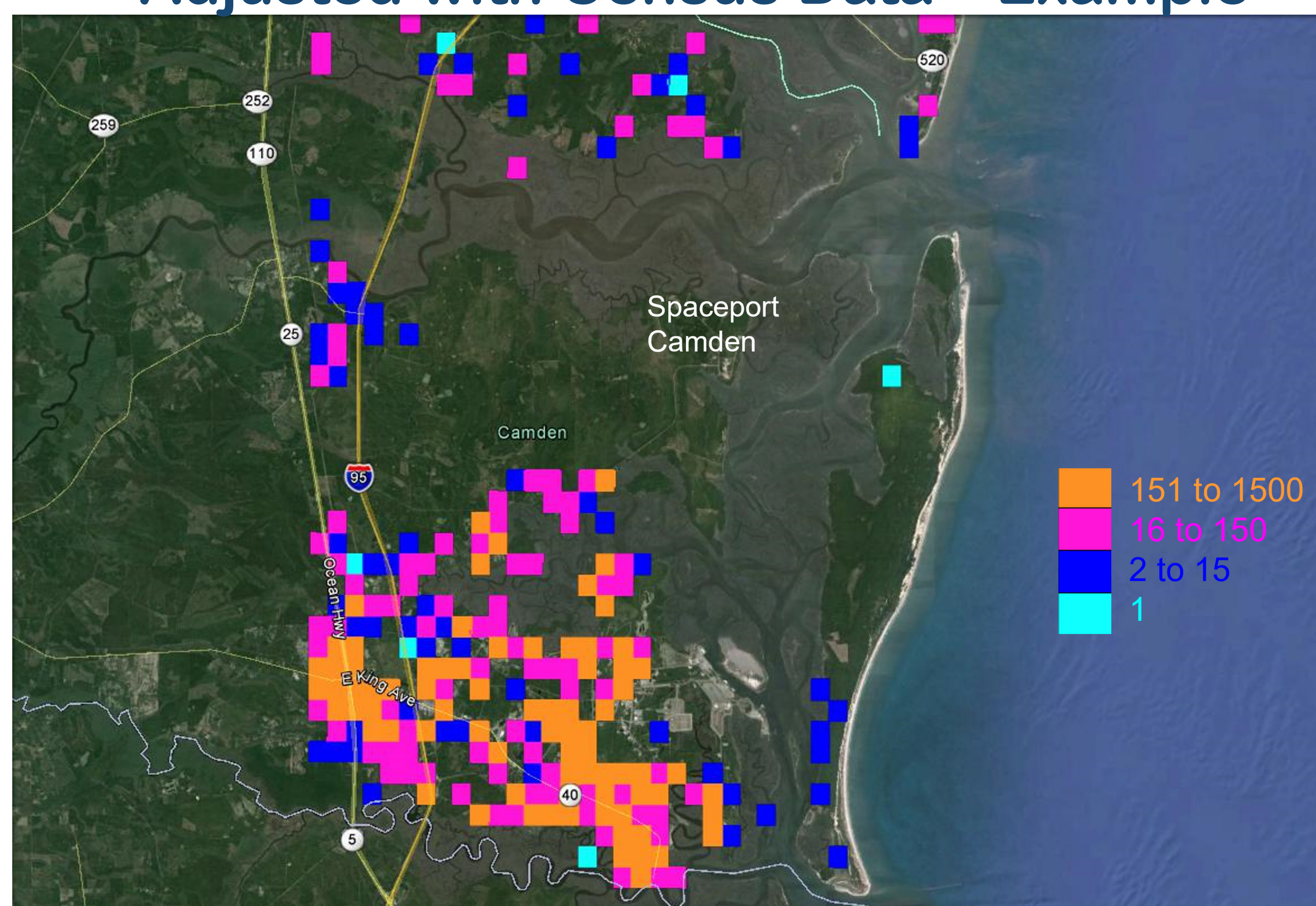
Category	Criteria & Requirements	Pass / Fail / Conditional	Rationale
<i>Airspace/Trajectory</i>	Supports at least one (more preferred) Northern, Southern, and/or Southeastern inland orbital trajectories. As a bonus, supports regional point-to-point flight and/or Southwestern orbital trajectories.		Site supports proposed trajectories, thereby addressing safety concerns with the uninvolved public.
<i>Broadband Connectivity</i>	Supports spaceport operational, security, and safety connectivity needs.		Support operational communication and coordination required for modern facilities
<i>County Location</i>	Candidate Spaceport site is within Sterling, Coke, Reagan, Irion, Tom Green, Concho, McCulloch, Crockett, Schleicher, Menard, Sutton, Kimble, Mason, and/or Edwards county.		Site within the Concho Valley Council of Governments (CVCOG) member counties.
<i>Emergency Services</i>	Fire/emergency services reasonably accessible.		Ensure emergency services are accessible and within range
<i>Environmental Constraints</i>	No obvious NEPA, Section 4(f), Section 106, or other fatal environmental flaws identified.		Avoid impacts to sensitive resources and/or wildlife.
<i>Infrastructure Conflicts</i>	Launch point does lie within 2 miles of a major thoroughfare (e.g., interstate, major state highway, rail line).		Reduce risk to the public and support trajectory.
<i>Land Area</i>	Minimum site size ~ 2,500 acres (~ 4 mi ²). More acreage is always preferred.		Support infrastructure and safety set-back needs of spaceport operations.
<i>Land Use Compatibility</i>	Surrounding land uses generally compatible (may be contractually or statutorily evacuated for launch operations, if needed).		Ensure surrounding use does not conflict with operational use. Also helpful for potential noise and expected casualty estimates.
<i>Military Operations Area (MOA)/Restricted Airspace</i>	Seek underutilized military-assigned airspace as appropriate, if aligned with other features / criteria addressed in this table.		Reduce commercial and military air traffic conflicts.
<i>Population Overflight</i>	Avoid overflight of any population within 2 miles of the launch site. Ensure region 2-10 miles from the site may be evacuated if required. Avoid overflight of towns with population of 10,000+ within 20 miles, and towns of 40,000+ within 100 miles of launch site.		Reduce risk to the public and support compliance with safety requirements.
<i>Railroad Proximity</i>	Avoid sites with active rail lines within 2 miles of the launch point. However, seek sites that are between 2-10 miles from a rail line to promote enhanced access and development.		Reduce risk to railroad operations, but also utilize rail capabilities for the benefit of the spaceport.
<i>Regulatory Environment</i>	Must appear to be able to meet all federal, state, and local regulatory and compliance requirements.		Conform to federal, state, and local regulatory requirements, laws, and zoning restrictions.
<i>Relatively Clear Weather</i>	Favorable weather patterns, lack of rain / cloud cover, lower humidity and generally stable atmospheric conditions.		Minimize operational disruptions and safety risks associated with frequent adverse weather conditions.
<i>Runways ≥ 8,000 ft</i>	In relative proximity to an airport with at least an 8,000 ft runway, 12,000 ft preferred.		Support travel and delivery nearby to the spaceport.
<i>Site Configuration</i>	Contiguous site capable of accommodating safety buffers.		Ensure adequate continuous land area to accommodate safety buffers and separation from surrounding uses.
<i>Topography</i>	Predominantly flat terrain; no major hilly areas.		Support spaceport operational needs and efficient construction.
<i>Transportation access</i>	Reasonable access to regional road networks.		Provide efficient access for employees, emergency services, and construction.
<i>Water Availability</i>	Aquifer or reliable water source available.		Sufficient supply for operations and fire protection.

CVCOG Spaceport Feasibility Study: Representative Spaceport Layout

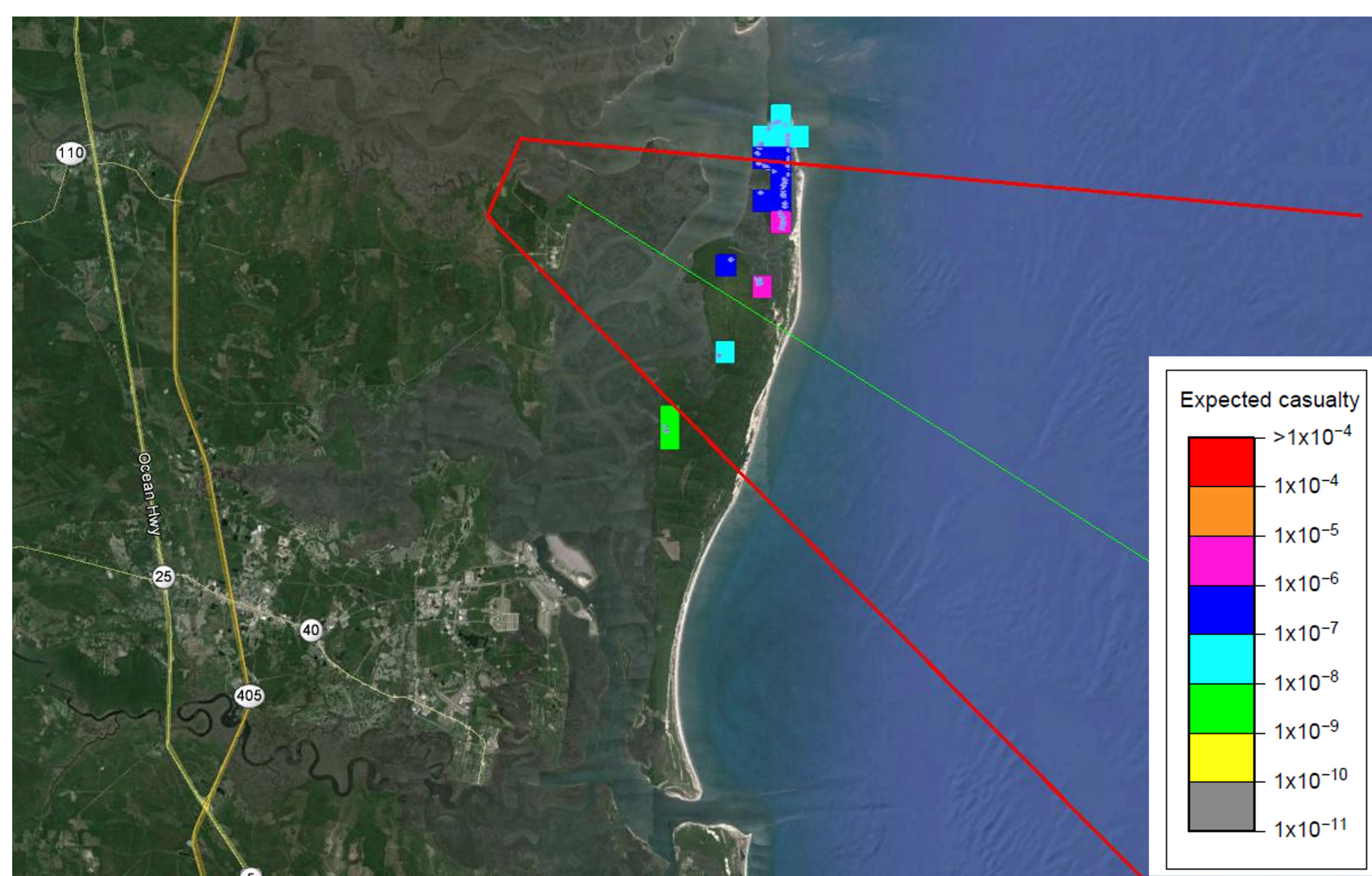


CVCOG Spaceport Feasibility Study

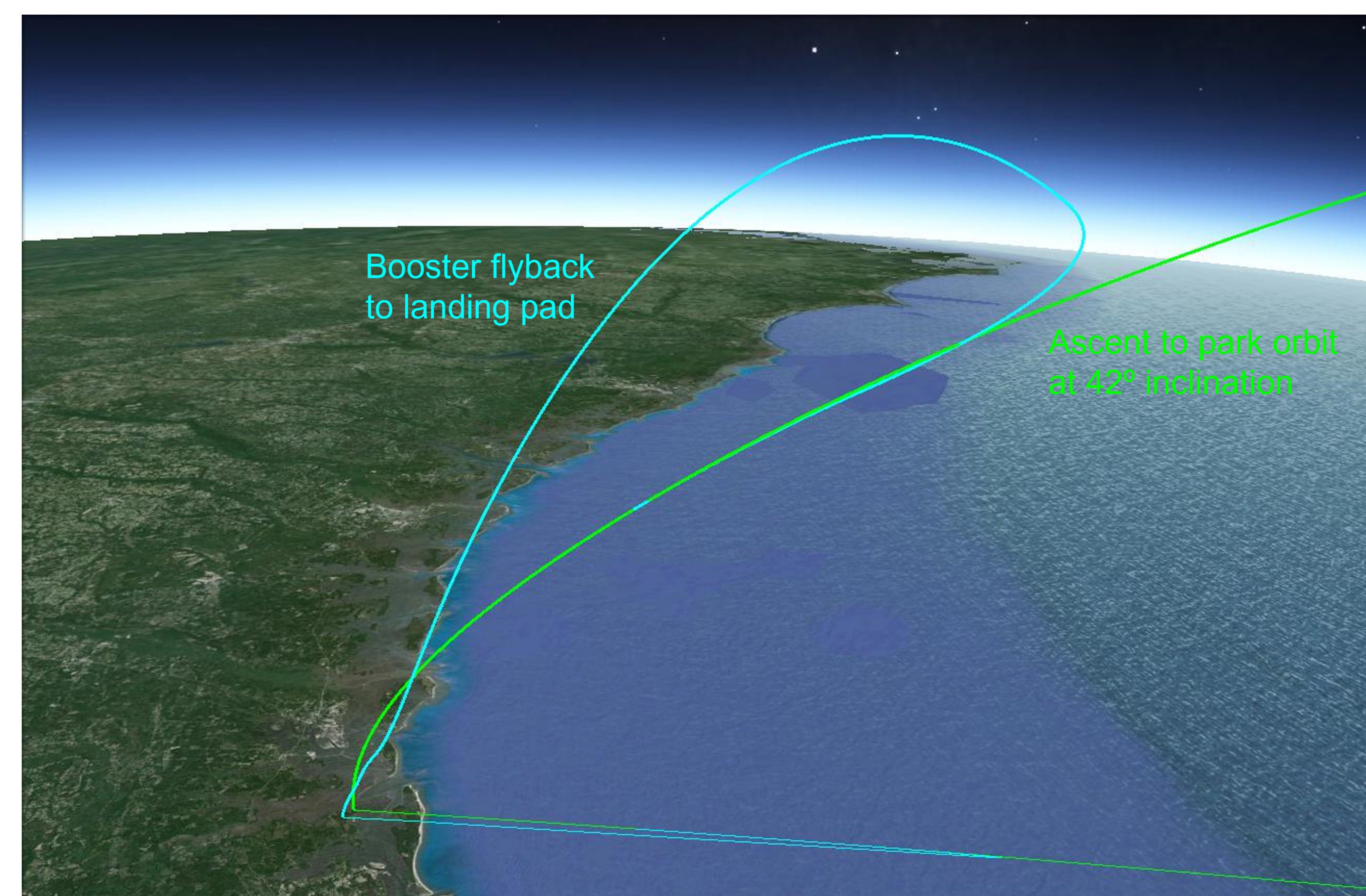
Gridded Population Database, Adjusted with Census Data – Example



Ec Grid, On Track Failure – Example



Ascent Trajectory – Example



Ec Grid, On Track Failure – Example

- Modeled both on track (OT) failures and malfunction turn (MFT) failures
- Probability of failure (flyout) = 0.02: 90% OT, 10% MFT
- Probability of failure (flyback) = 0.02: 90% OT, 10% MFT
- LandScan population grid adjusted to match Census data with the number of persons added in each of the 55 CI/LCI houses accordingly (0, 1, or 2 persons per house)

Expected Casualty (per million)

Population Data	Fly Out			Fly Back		
	OT	MFT	total FO	OT	MFT	total FB
Census with CI/LCI 2 per house	5.02	0.54	5.56	6.01	2.51	8.52
Census with CI/LCI 1 per house	2.51	0.27	2.78	3.01	1.26	4.26
Census with CI/LCI 0 per house	0.00	0.00	0.00	0.00	0.00	0.00

- FAA requirements (CFR / Part 450.101 Safety criteria):
Collective risk EC < 100 / million or 1.E-4