Space Vehicle Operations

REDAC Deep Dive

March 10, 2015

Kevin Hatton
SVO Program Manager, ANG-C42

President's Space Policy


NATIONAL SPACE POLICY
of the
UNITED STATES *of* AMERICA

JUNE 28, 2010

"Enhance Capabilities for Assured Access To Space:

Enhance operational efficiency, increase capacity, and reduce launch costs by investing in the modernization of space launch infrastructure."

FAA Administrator's Priority Initiatives

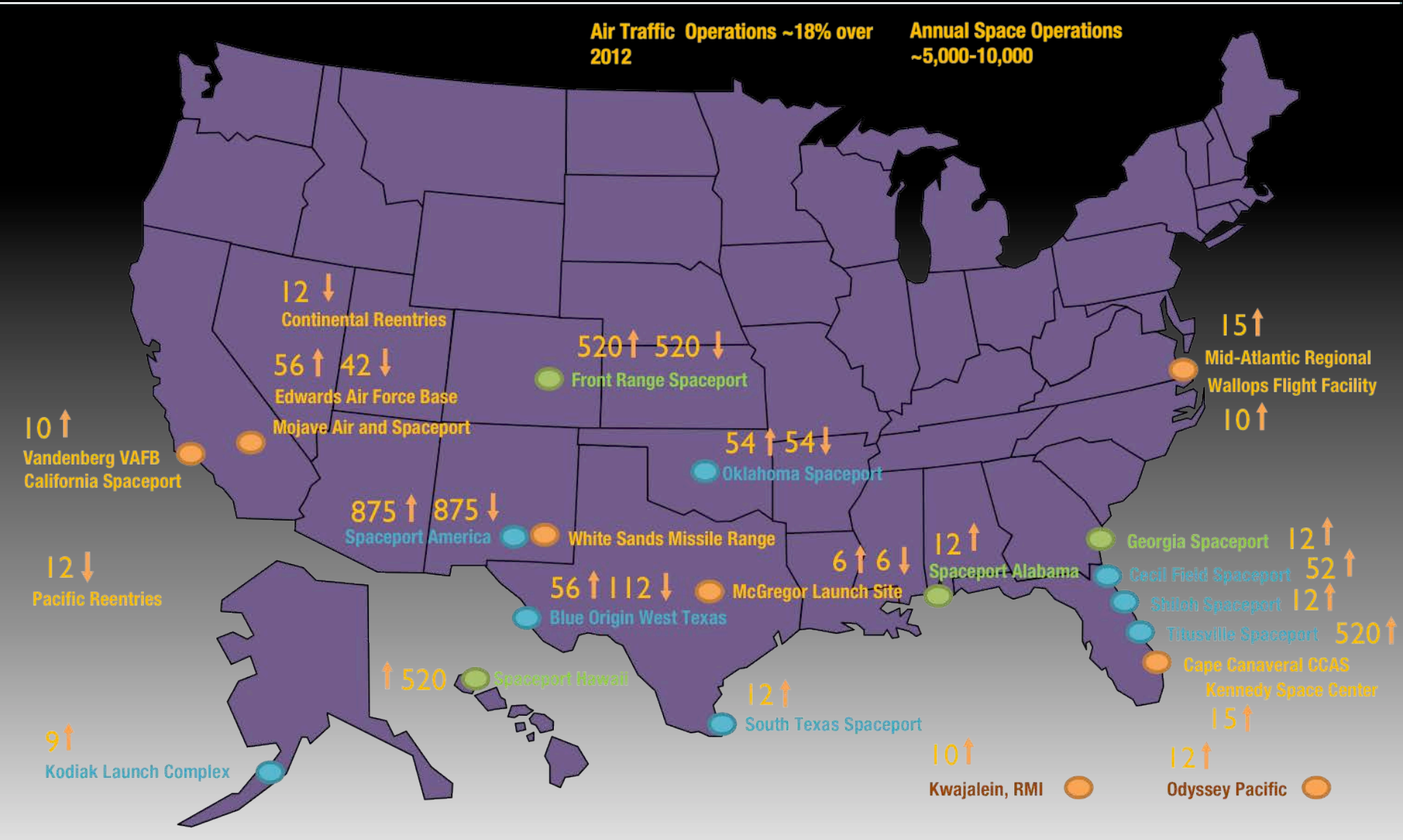
National Airspace System (NAS):

Lay the foundation for the NAS of the future by achieving prioritized NextGen benefits, integrating new user entrants, and delivering more efficient, streamlined services

Related Sub-Initiative:

Integrate new user entrants (unmanned aircraft and commercial space)

2025 Space Activity Projections



= Launch (over 1,800)

= Landing/Recovery (over 1,600)

Current Shortfalls

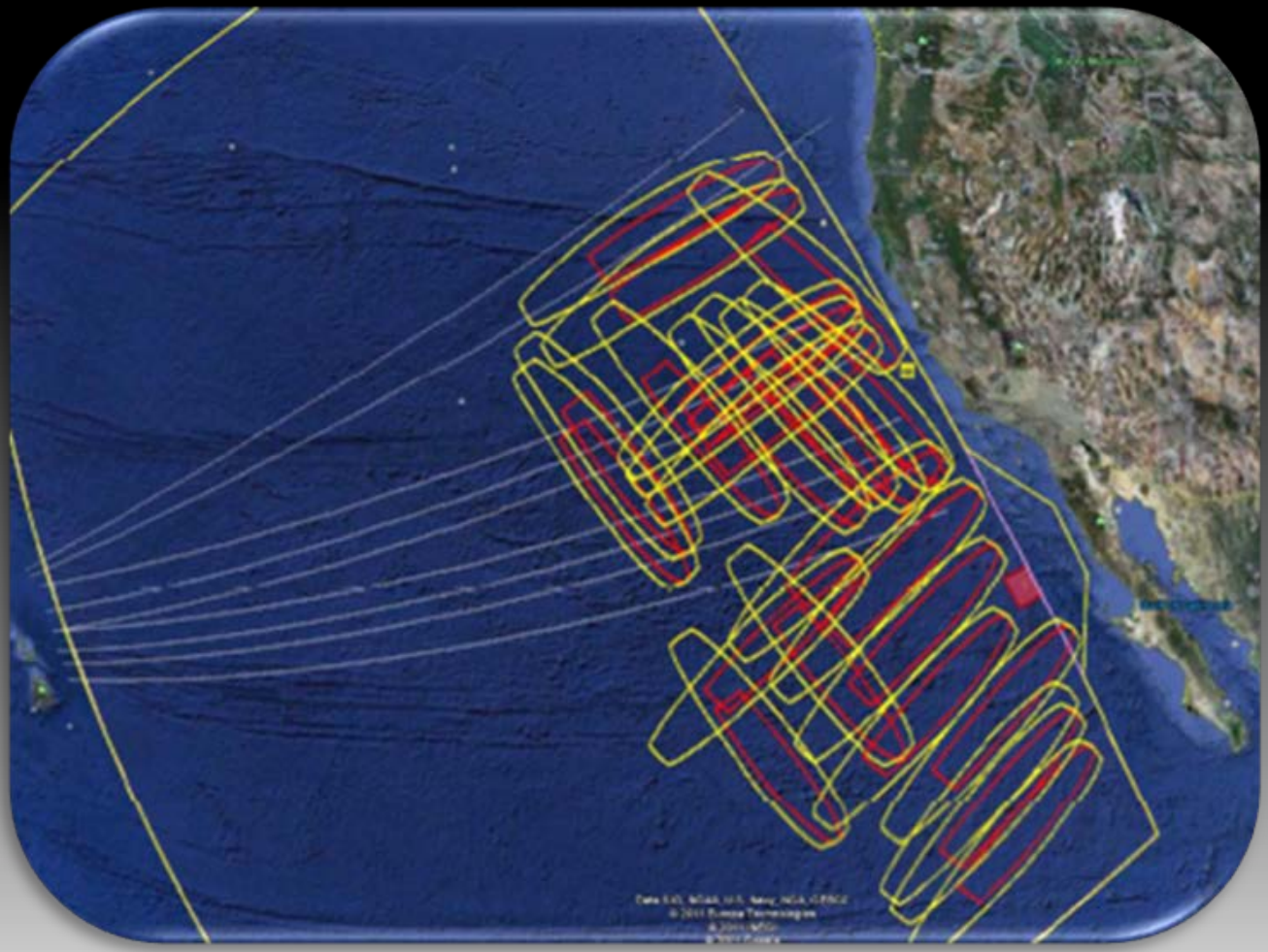
FAA currently lacks sufficient capabilities to accurately model NAS impact of space vehicle operations during the planning phase.

Lack of real-time space vehicle tracking capabilities in FAA systems results in decreased efficiency and missed opportunities for improved safety methods.

FAA currently employs airspace management approaches that include closing relatively large volumes of airspace for significant lengths of time during launch and re-entry operations.

FAA currently lacks a real-time debris threat response capability.

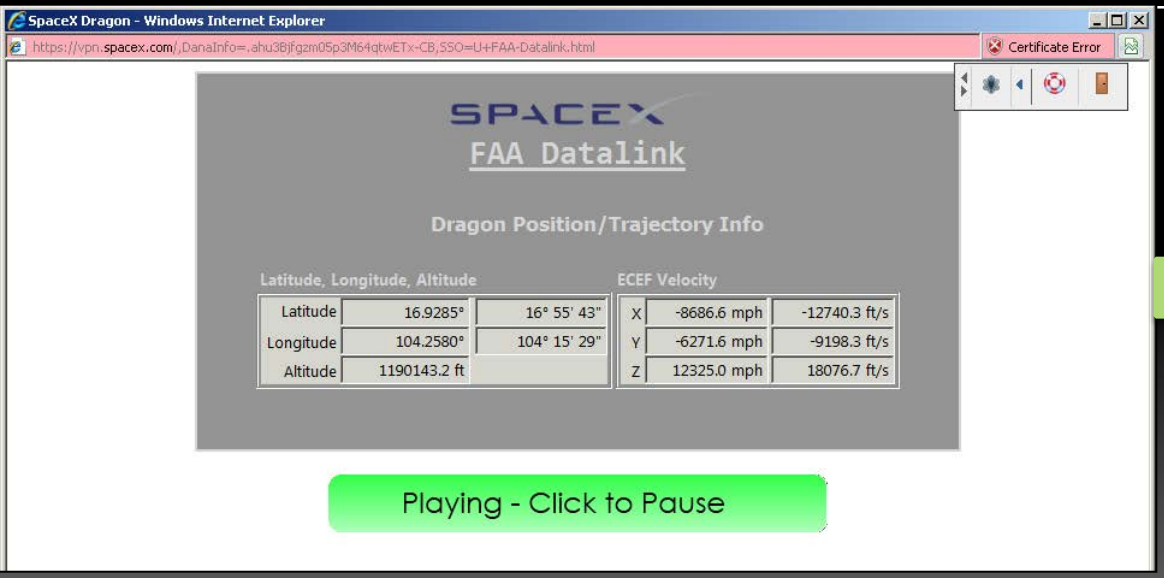
Pre-Mission Planning

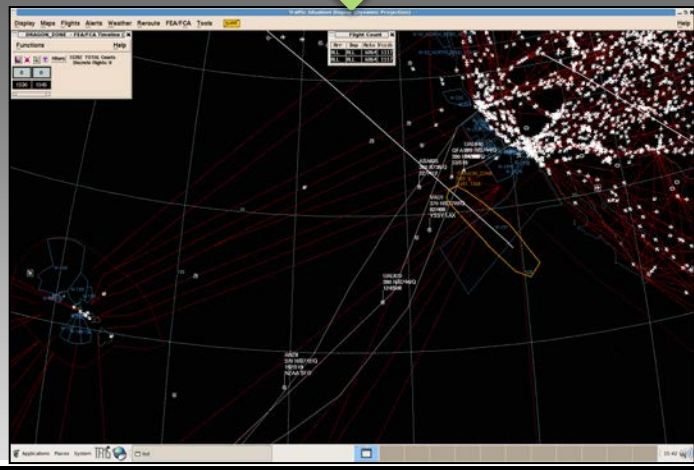


Pre-mission planning includes assessment of NAS impact for multiple mission scenarios.

Currently, there are NO automation tools for conducting this assessment.

“Real-Time” Position Information





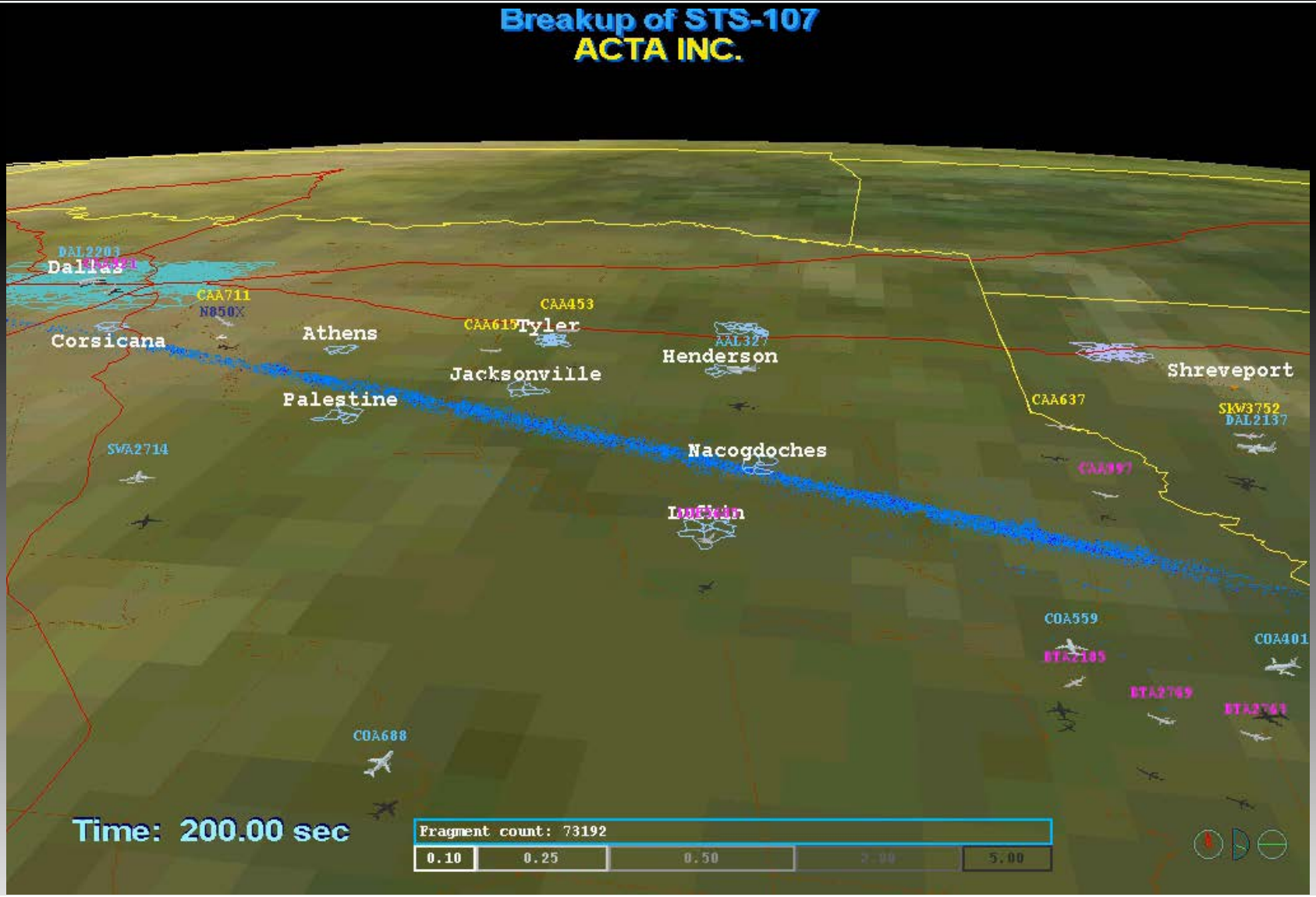
Web Portal to SpaceX

Telemetry must be manually “paused”, copied on paper or read aloud, and typed into the Traffic Situation Display (TSD) at the FAA Command Center.

Other Operators

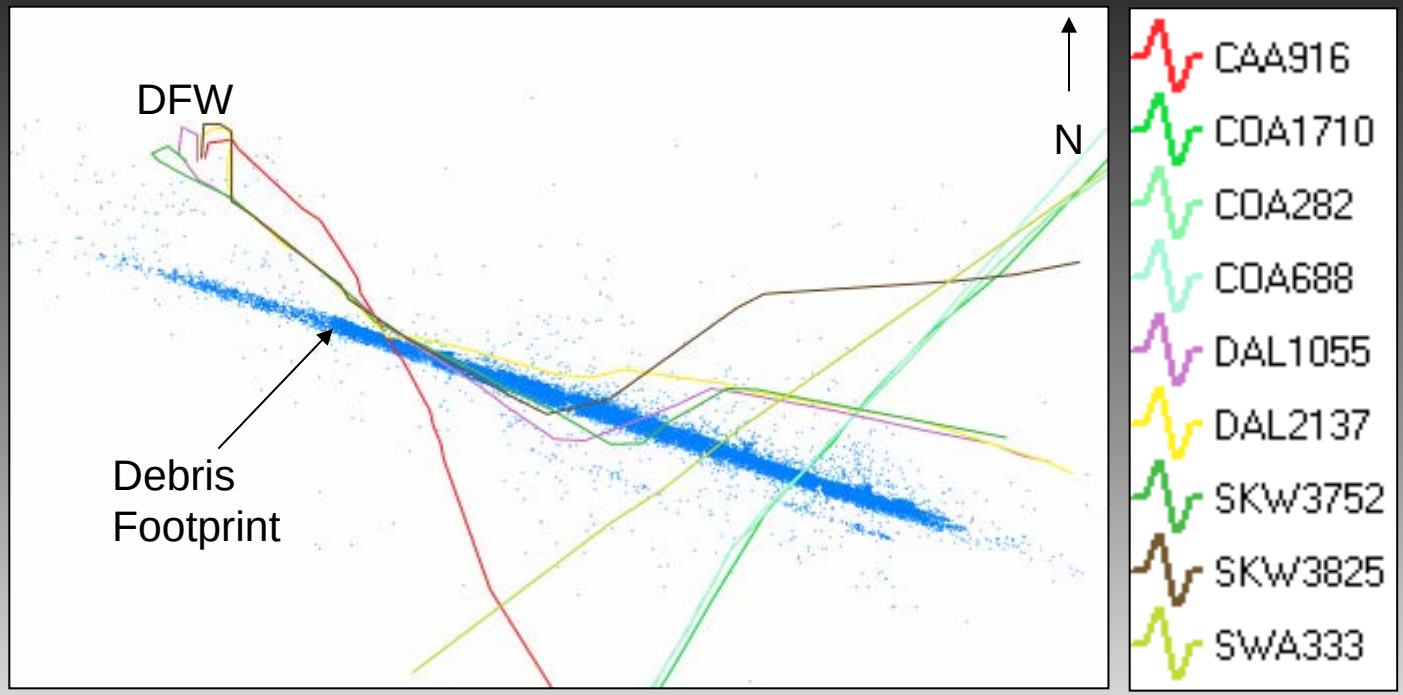
For operators that do not provide data via the web, this process is conducted over the telephone with the space vehicle operator.

Shuttle Columbia Debris Dispersion



Debris Hazard to Aircraft

- The 2003 *Columbia* accident illustrated a need to better manage the risk to aircraft flying near the potential debris hazard associated with space vehicle operations
- FAA ATO procedures existed for Shuttle landings prior to *Columbia*, but they did not address the hazards to aircraft of falling debris

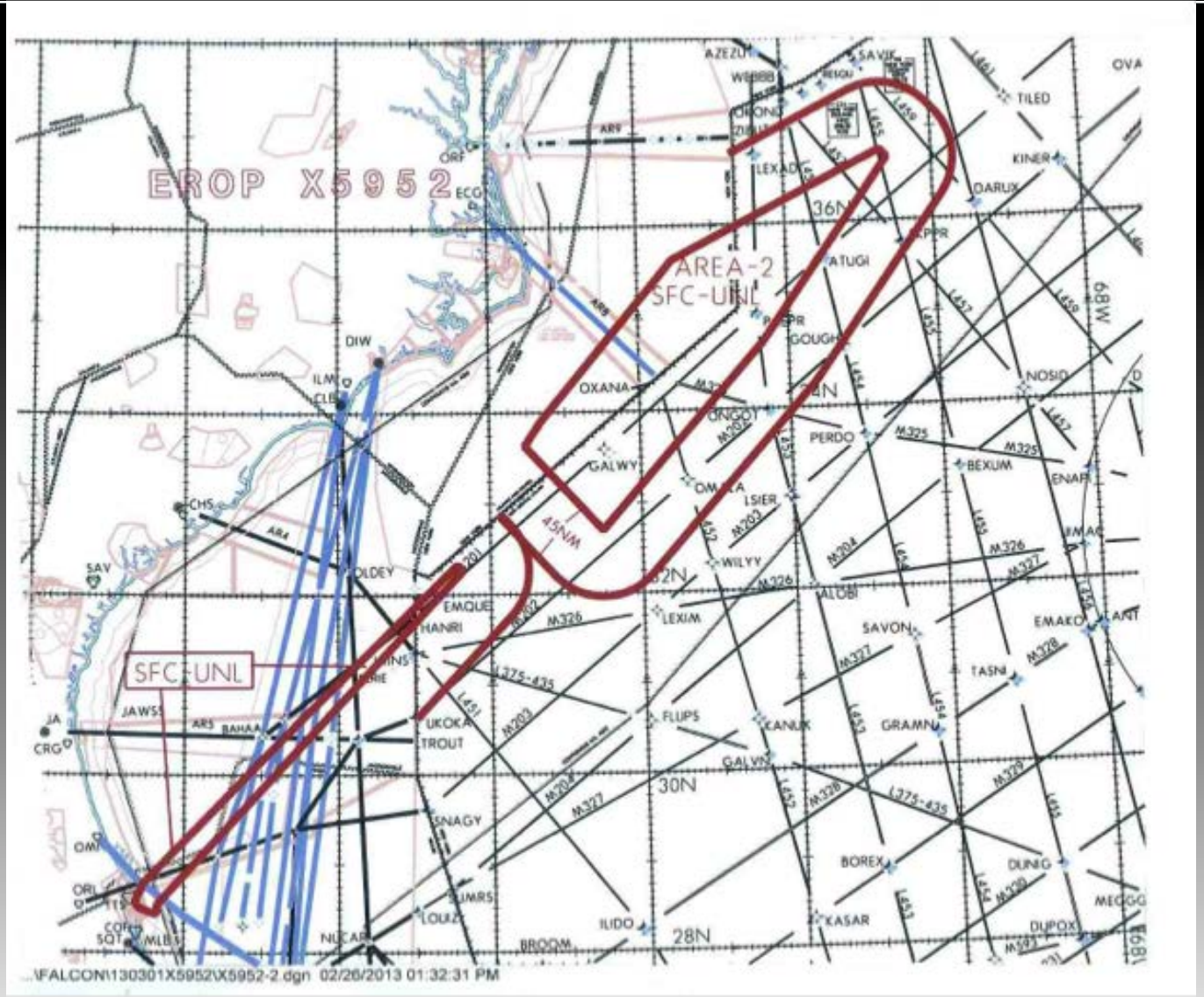


Recent Failures

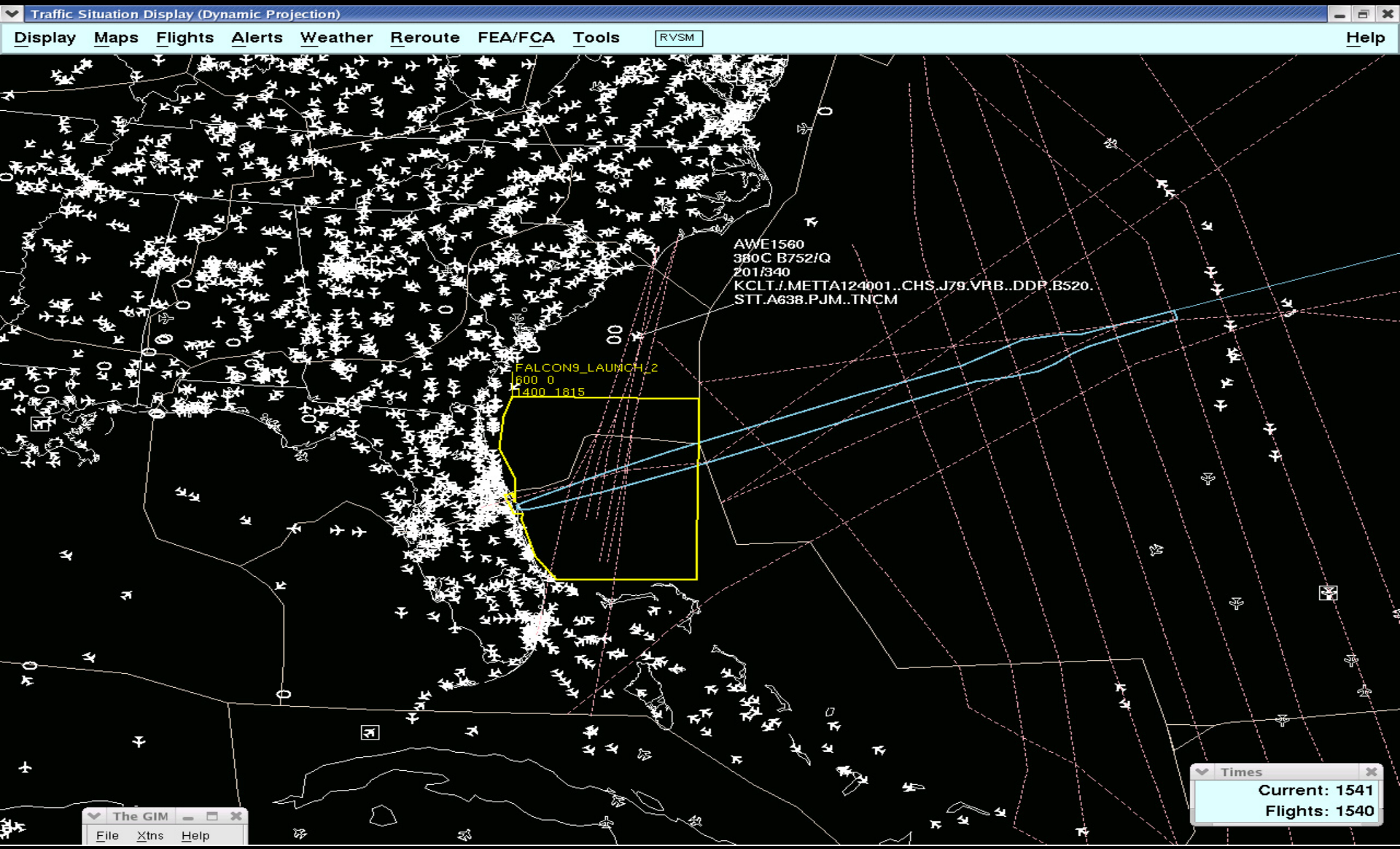
Antares
October 28, 2014

SpaceShipTwo
October 31, 2014

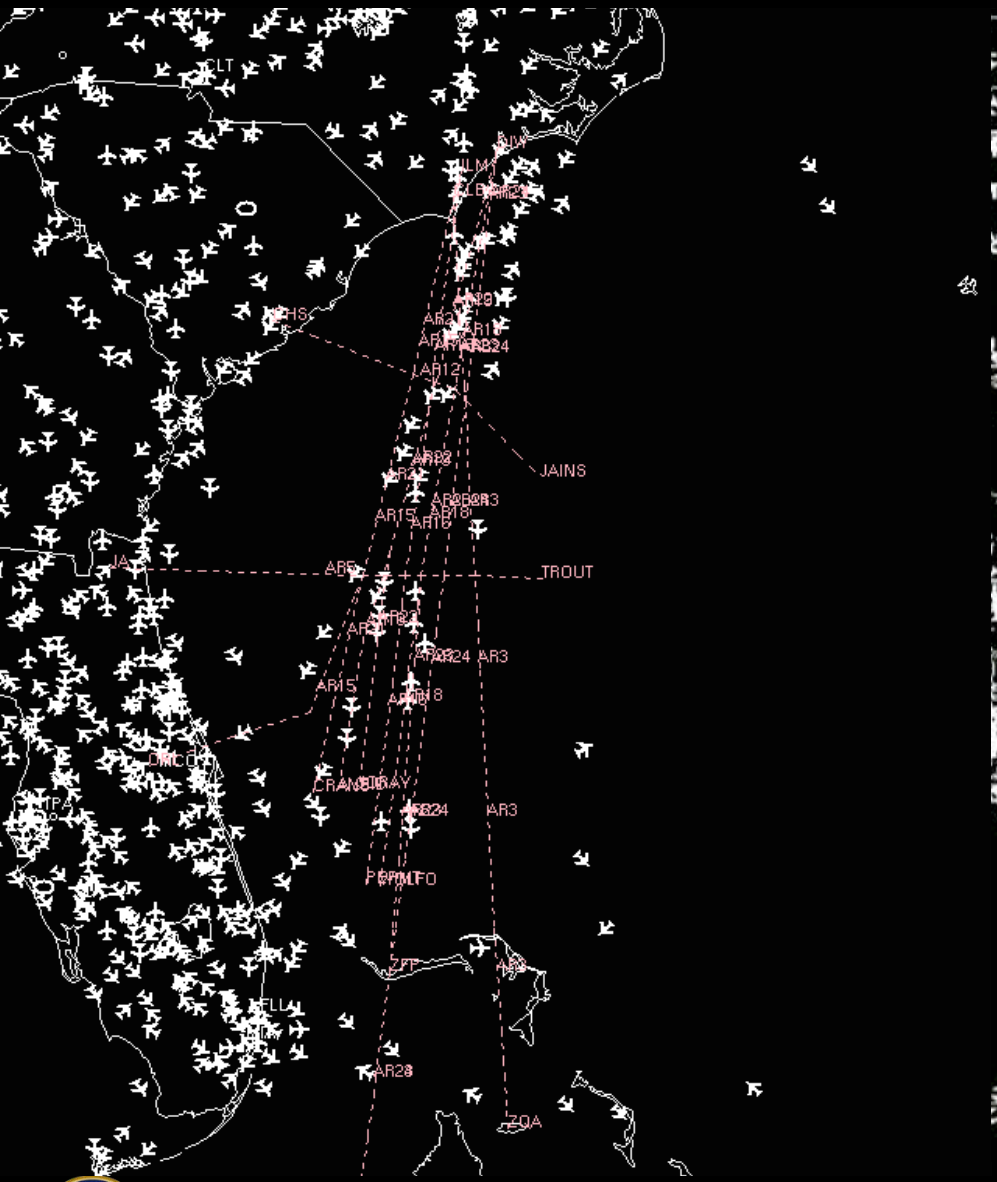
Launch Hazard Areas

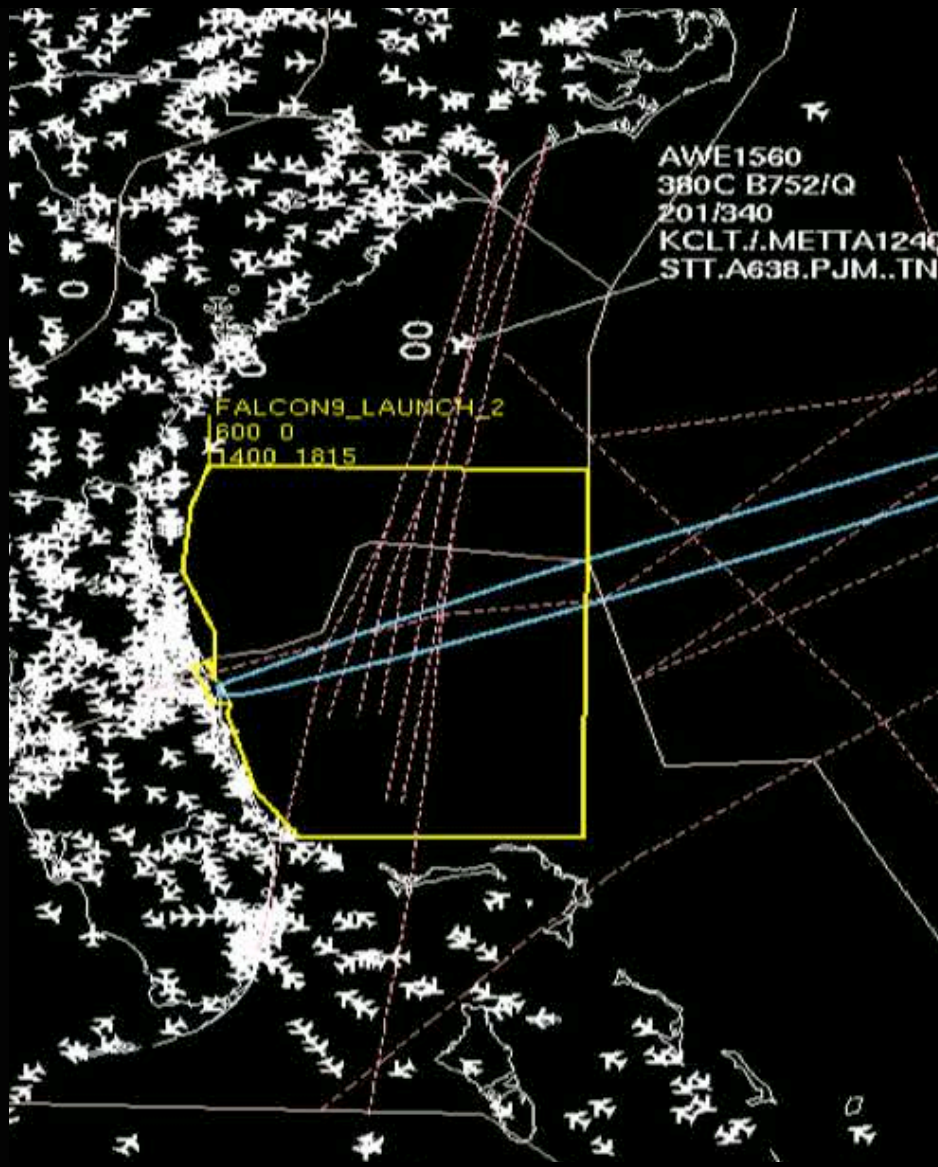


NAS Impact - Launch



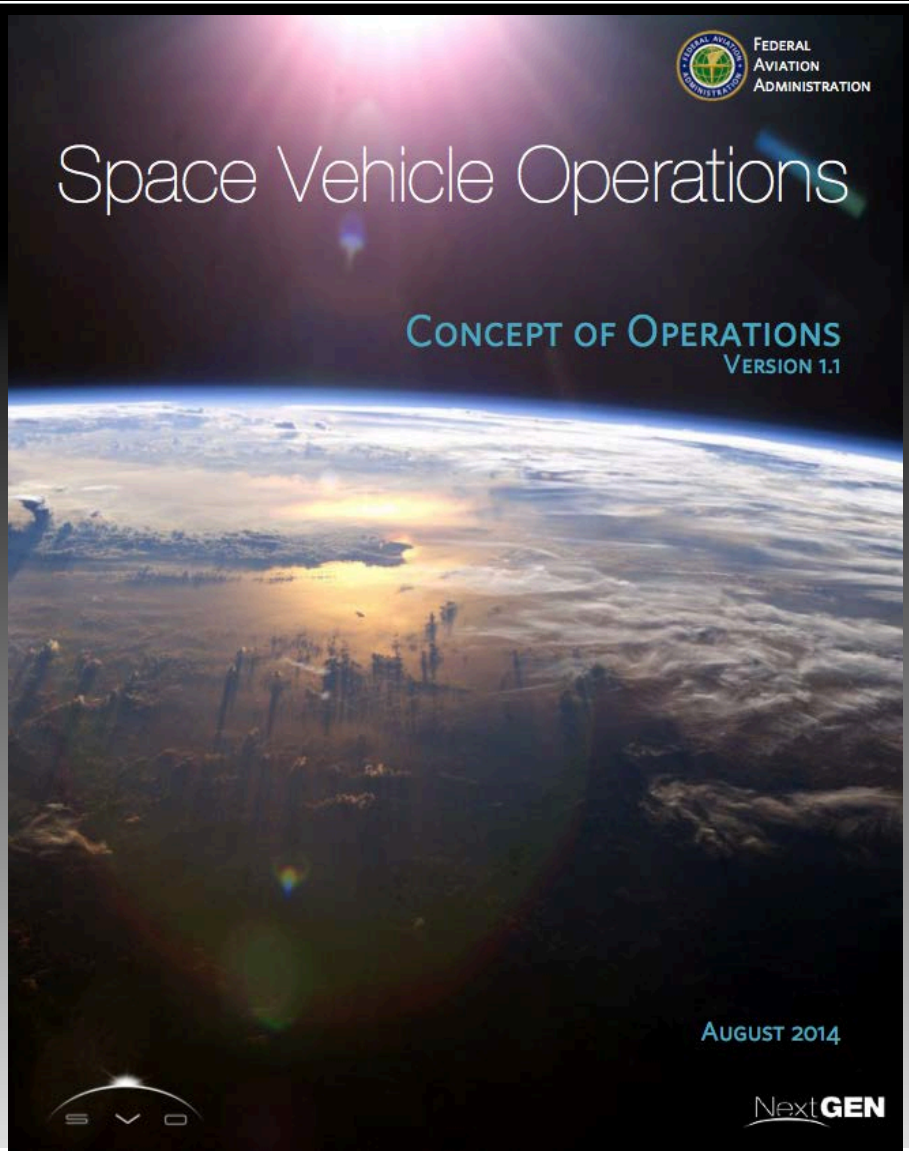
NAS Impact - Launch





SVO Concept of Operations

The NextGen Space Vehicle Operations Concept of Operations identifies new procedures and capabilities that are envisioned to improve the management of space launch and recovery missions in the NAS.



Desired Improvements

Planning

- Automation for evaluating NAS performance effects of SV operation
- Integrated NAS planning for SV and aircraft
- Streamlined and standardized planning process
- Hazard analysis methodologies that decrease volume of protected airspace

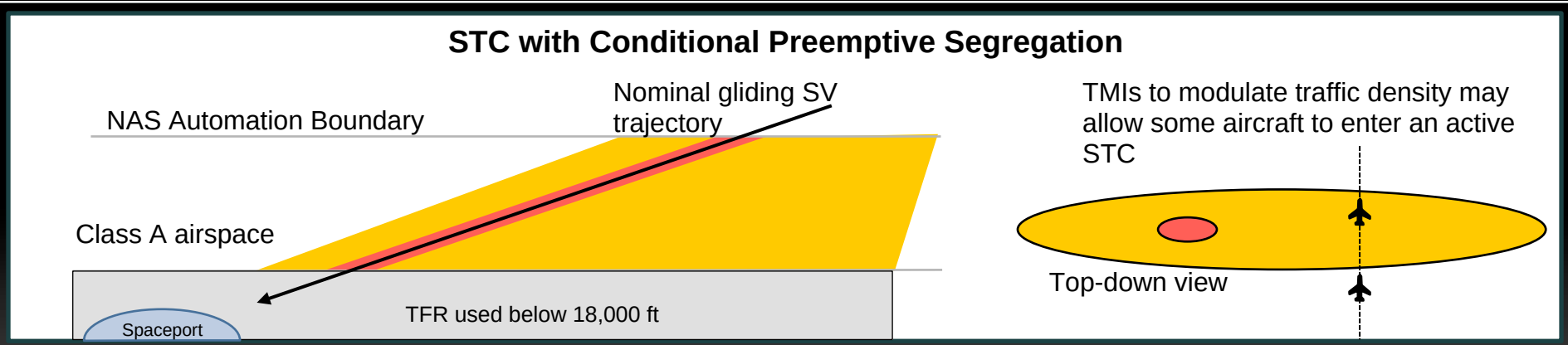
Real Time

- Integrate SV operational data into ERAM/TFM automation
- Space Transition Corridors and 4D trajectory deconfliction
- Reactive separation from off-nominal debris hazards
- Continuous SV surveillance and health monitoring

Post-Ops

- Standardized means for collecting and analyzing NAS performance data
- Evaluate impact on all NAS users
- Establish “best practices” to improve future operations

Space Transition Corridor



STC is derived from:

- SV trajectory analysis – determines the volume(s) of airspace necessary to contain the SV trajectory and its normal variations
- SV hazard analysis – determines the volume of airspace necessary to ensure the protection of other NAS users from SV off-nominal hazards

- STC may utilize Conditional Preemptive Segregation
  - Requires aircraft to operate on predefined routes through potential debris or other off-nominal hazard volumes and TMIs modulate the traffic to tightly control the number of aircraft based on maintaining acceptable levels of risk

STC Just-in-Time Activation

Pre-Activation Phase

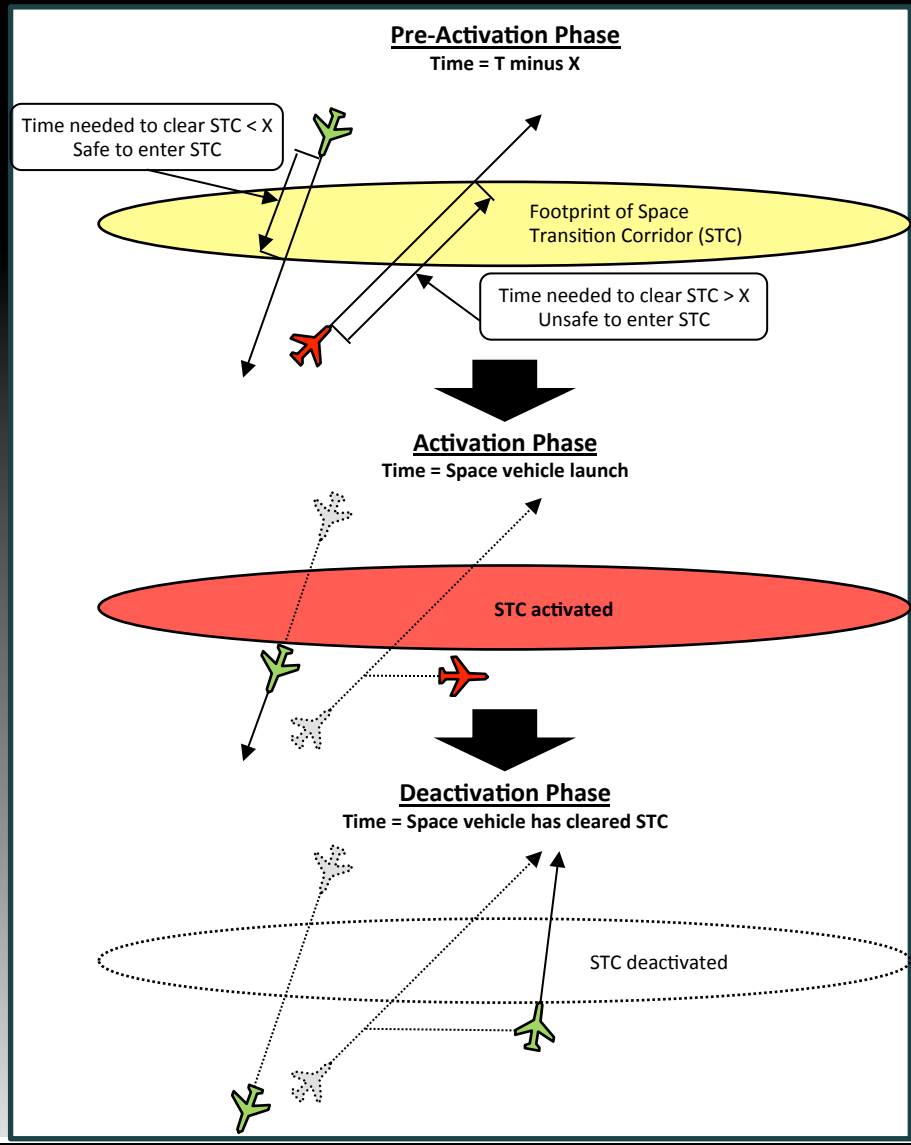
- Begins when high certainty launch or reentry time is received from the operator
- Aircraft operating in the STC are allowed to exit on their planned route
- No additional aircraft are allowed to enter STC

Activation Phase

- Short duration
- No air traffic operations allowed

Deactivation Phase

- Occurs when SV clears STC and no immediate hazard exists



Mid- and Far-Term SVO Concept

Mid-term View

Focus
Protecting from Debris

Airspace management methods include a safety buffer to protect against off-nominal events

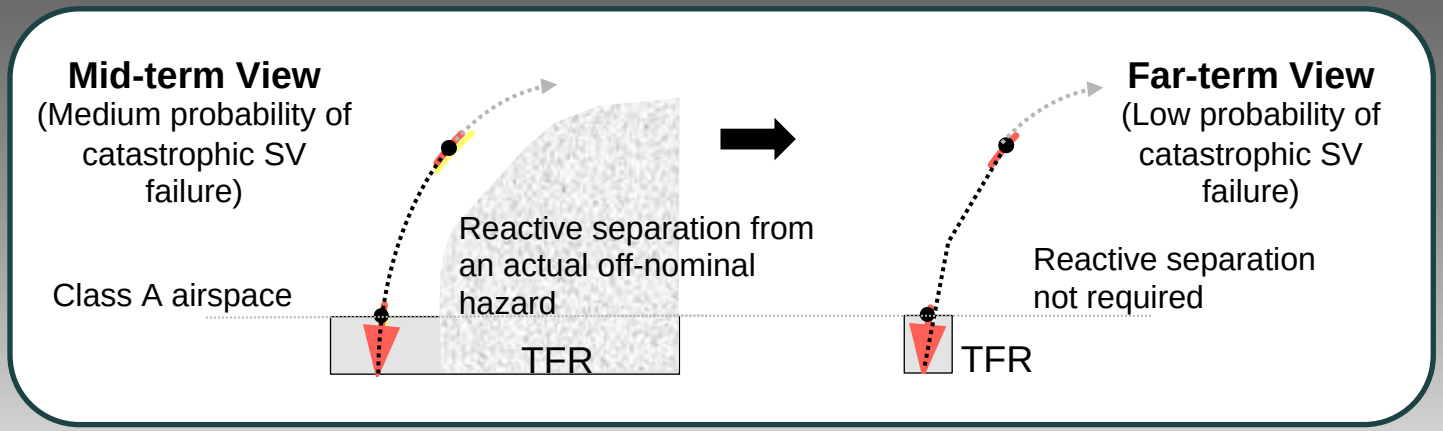
SV Integration Path

- SV operations are frequent, predictable, and repeatable
- The potential for catastrophic failure is low and comparable to aviation
- ATC system is highly dynamic and responsive

Far-term View

Focus
Protecting from Collision

Collision-based 4DT Deconfliction is dominant airspace management method (may include wake vortex separation if applicable)



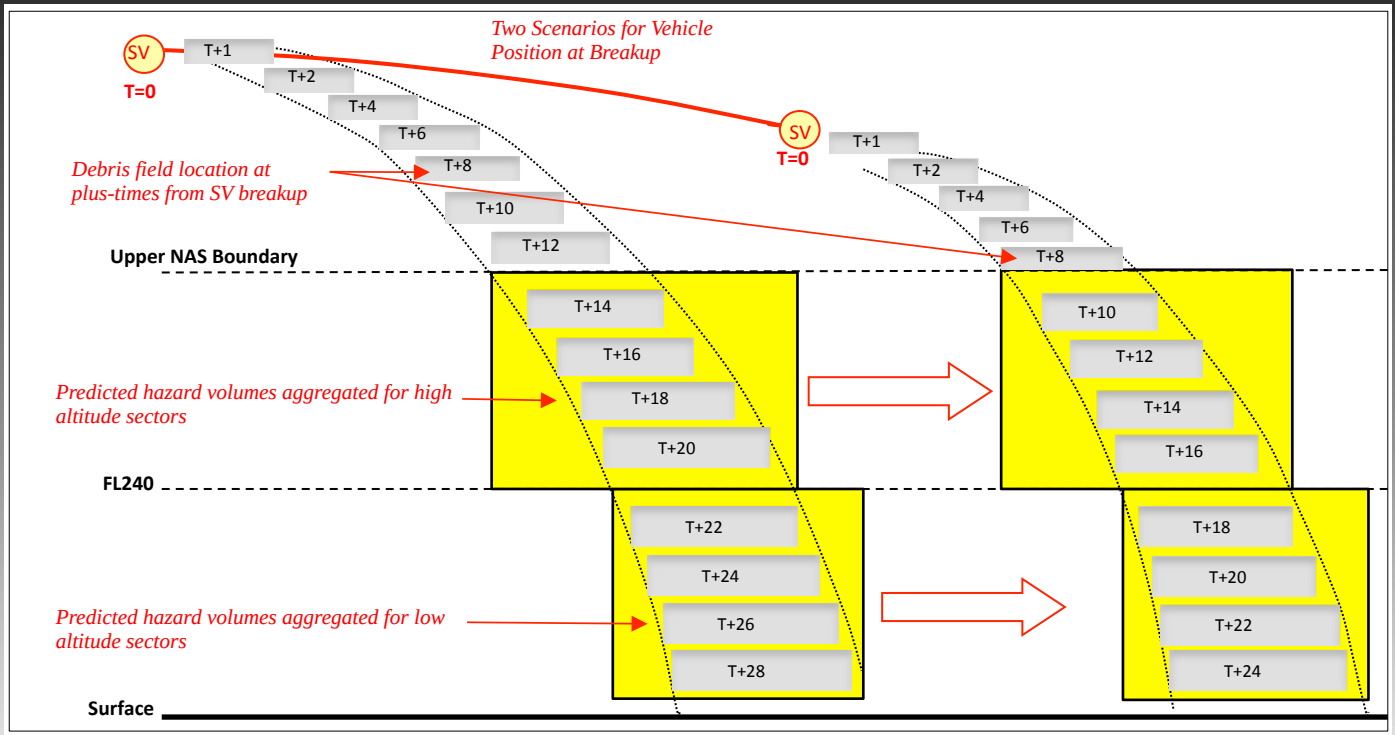
Reactive Separation

- Reactive separation from a hazard begins when ANSP receives indication of off-nominal event (e.g., breakup)
  - Data from surveillance, onboard sensors, or other communication from SV mission control system
  - SV equipped with Smart Fragment Technology:
    - Fragments broadcast their positions so the hazard volume can be more accurately predicted

Reactive Separation

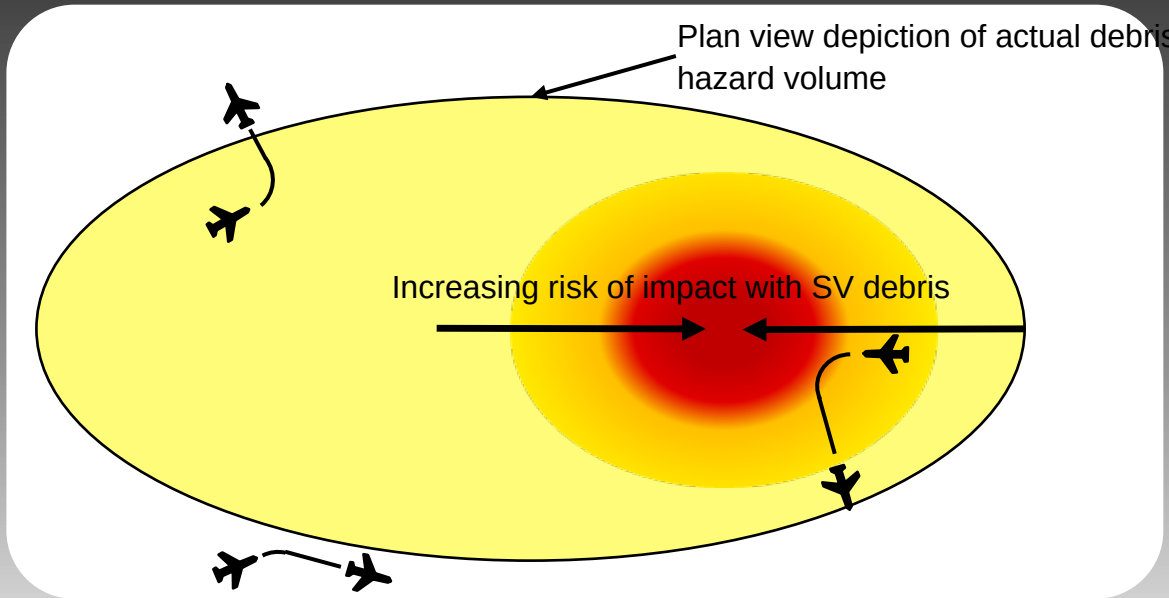
If an off-nominal event occurs, ANSP automation provides the following:

- Calculation and display of hazard volumes
- Trajectory solutions that prevent flights outside the hazard volume from entering it
- Ranked trajectory solutions for clearing affected NAS traffic from the hazard volumes



Reactive Separation

- Levels of risk are identified and support developing ranked trajectory solutions
- Also available to pilots of aircraft with access to SWIM for situational awareness
  - ATC is responsible for coordinating hazard avoidance maneuvers



Expected Benefits

- Additional NAS airspace management options provide flexibility to ANSP and operators.
- Improved NAS efficiency (fewer delays, reduced fuel burn and emissions) due to:
  - Off-nominal hazard analysis methodologies that decrease the size of the hazard volume and/or enable traffic to enter potential hazard volumes when modulated by TMIs.
  - Duration of airspace closures for SV operations is reduced.
  - Ability to reactively separate other NAS users from an off-nominal hazard allows aircraft to utilize more airspace below SV operations.
- Planning process is more efficient for ANSP, SV operators, and NAS users.
- Shared situational awareness among actors in the SV operations planning process leads to improved mission and flight planning.

SVO Human-in-the-Loop Experiment

October 21-30, 2014

FAA Technical Center
Atlantic City, NJ

SVO HITL At-a-Glance

DATES

October 21-30, 2014

PARTICIPANTS

8 En Route Air Traffic Controllers
2 En Route Traffic Management Coordinators
2 Command Center Specialists
2 Traffic Management Officers

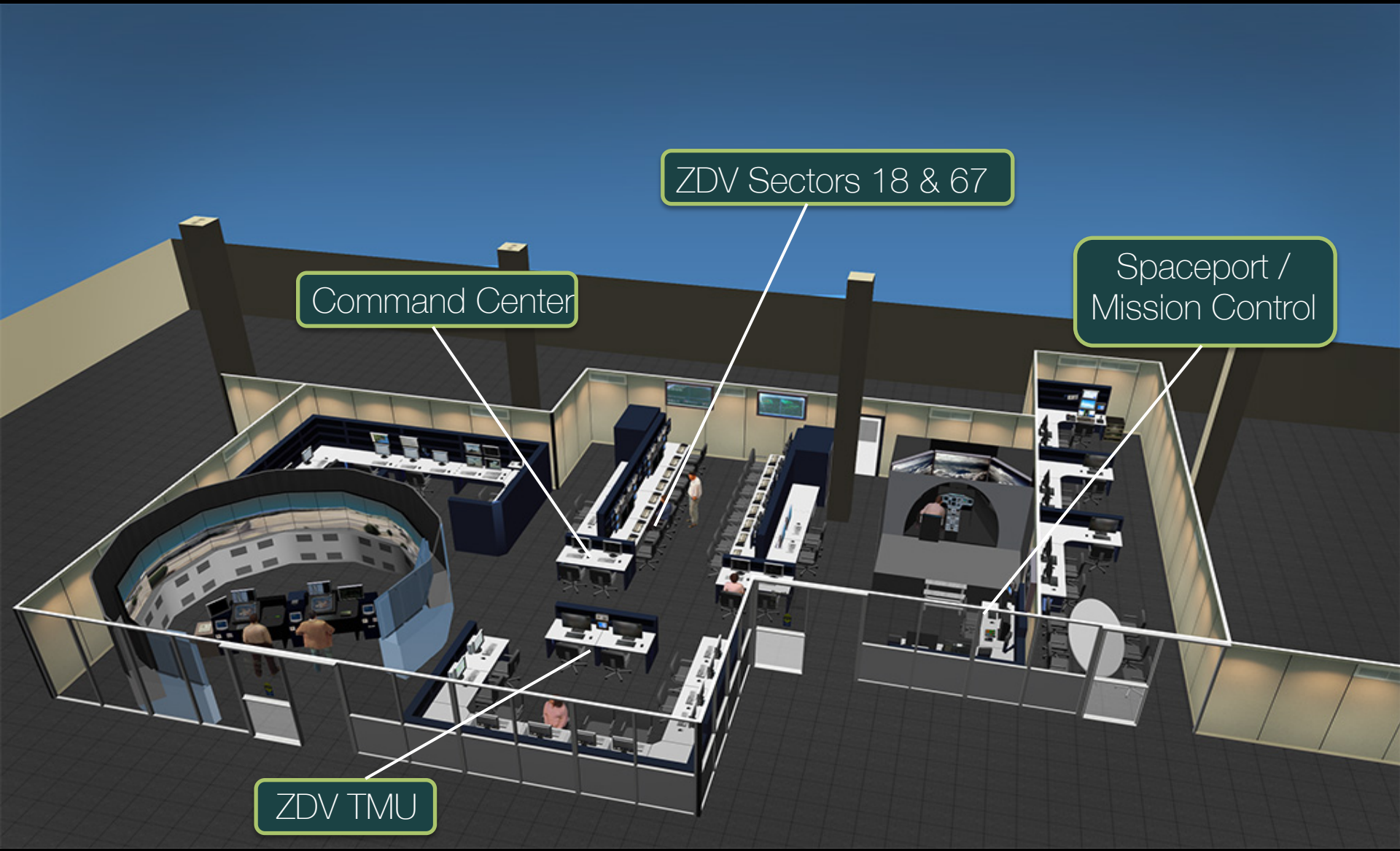
FIELD FACILITIES REPRESENTED

Albuquerque ARTCC
Los Angeles ARTCC
Boston ARTCC
Chicago ARTCC
Miami ARTCC
Seattle ARTCC
Indianapolis ARTCC
Atlanta ARTCC
Minneapolis ARTCC
Denver ARTCC

EXPERIMENTAL CONDITIONS

20 50-minute scenarios
50% Data-Comm equipage
Integrated ERAM / TFMS
Over 3,000 flights per scenario

Human-in-the-Loop Environment



ERAM and TSD Capabilities

① Real-time tracking of space vehicle with 1 second refresh rate (spacecraft only)

② Space Transition Corridor (STC) and status displayed :

a) Pre-Notification Phase

b) Pre-Activation Phase

c) Active Phase

ERAM

③ Space vehicle target same as aircraft target

④ Automated identification and assessment of affected aircraft

⑤ Space vehicle and data block freeze on ERAM upon vehicle failure

⑥ Debris Hazard Volumes displayed on ERAM

TSD

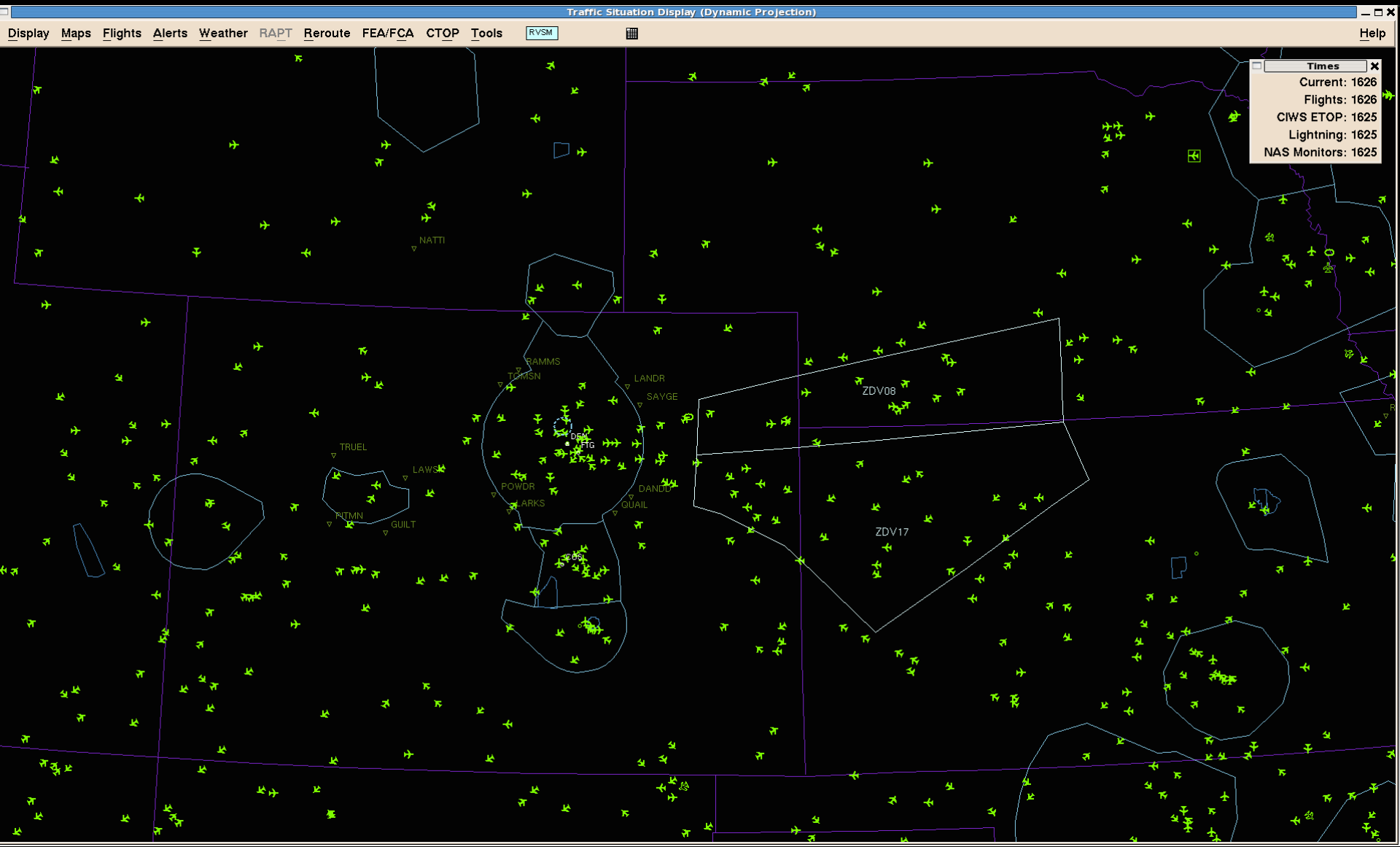
③ New space vehicle icon

④ Examine flights impacted by STC (as with FEA/FCA)

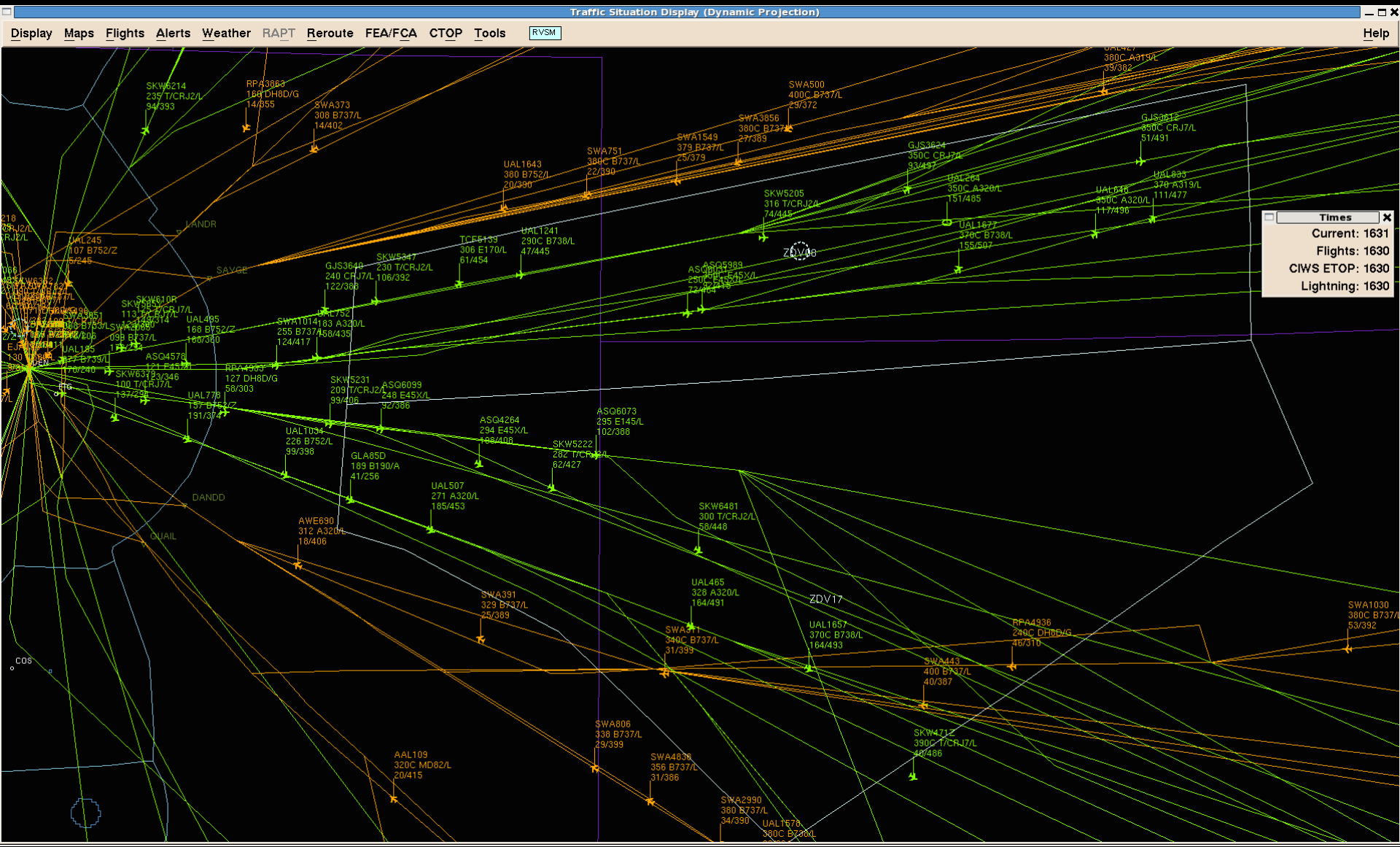
⑤ Space vehicle icon freezes and a dashed red circle appears around the icon on TSD upon vehicle failure

⑥ Multiple Debris Hazard Volumes (stratified and time-constrained) displayed on ERAM

ZDV Sectors 18 & 67 (Ultra High FL360+)



Denver Arrival & Departure Flows



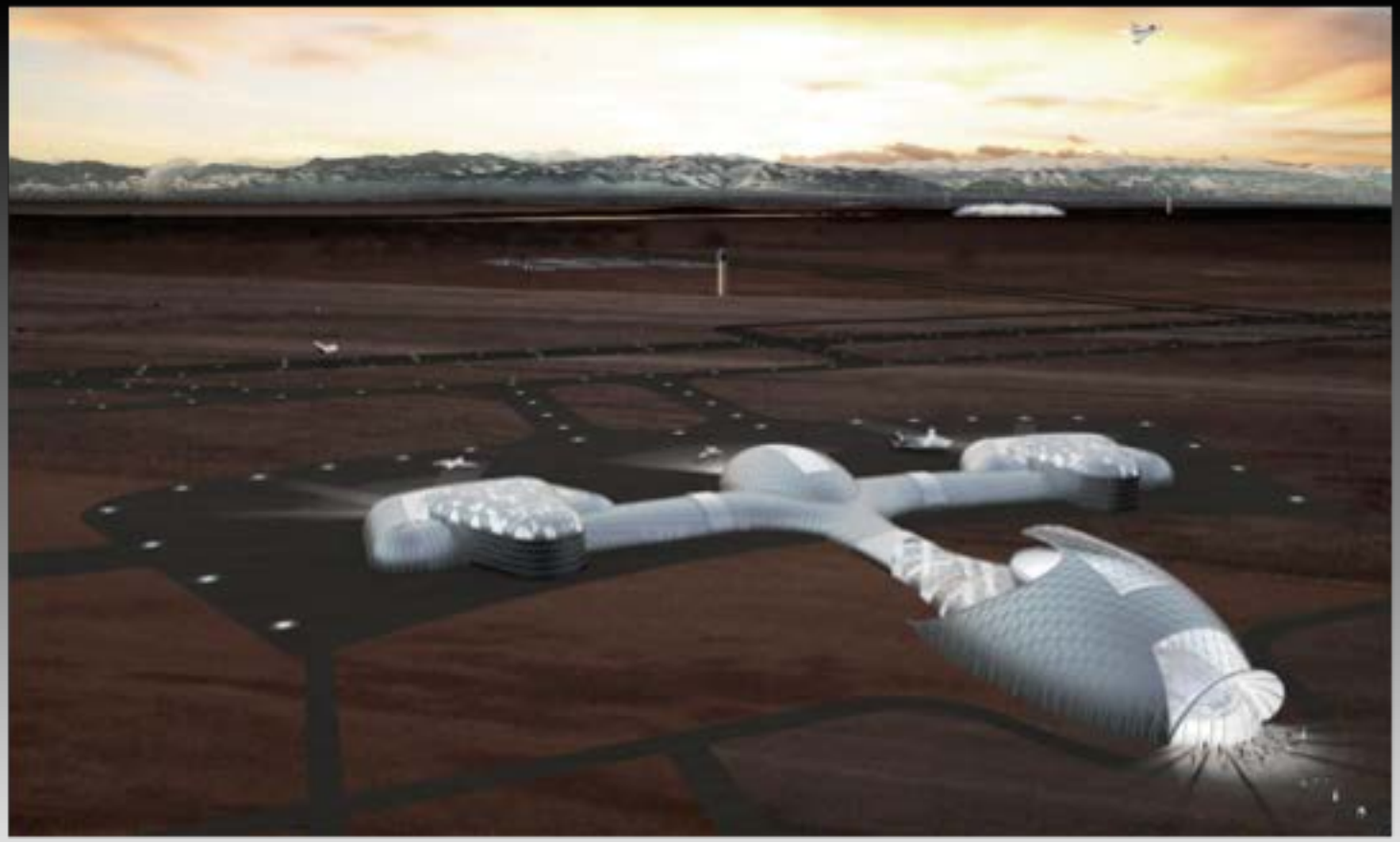
FEDERAL AVIATION ADMINISTRATION

NextGEN

Lynx Suborbital Vehicle

Denver International Spaceport (KDIS)

"Denver Spaceport", used in the HITL, is a fictional spaceport located southeast of Denver International Airport



Dragon Capsule Version 2

SPACEX

DRAGON

NextGEN

SVO Human-in-the-Loop

ZDV Sector 18

D R

ZDV Sector 67

R D

Two adjacent sectors including one radar controller and data controller each

TMC

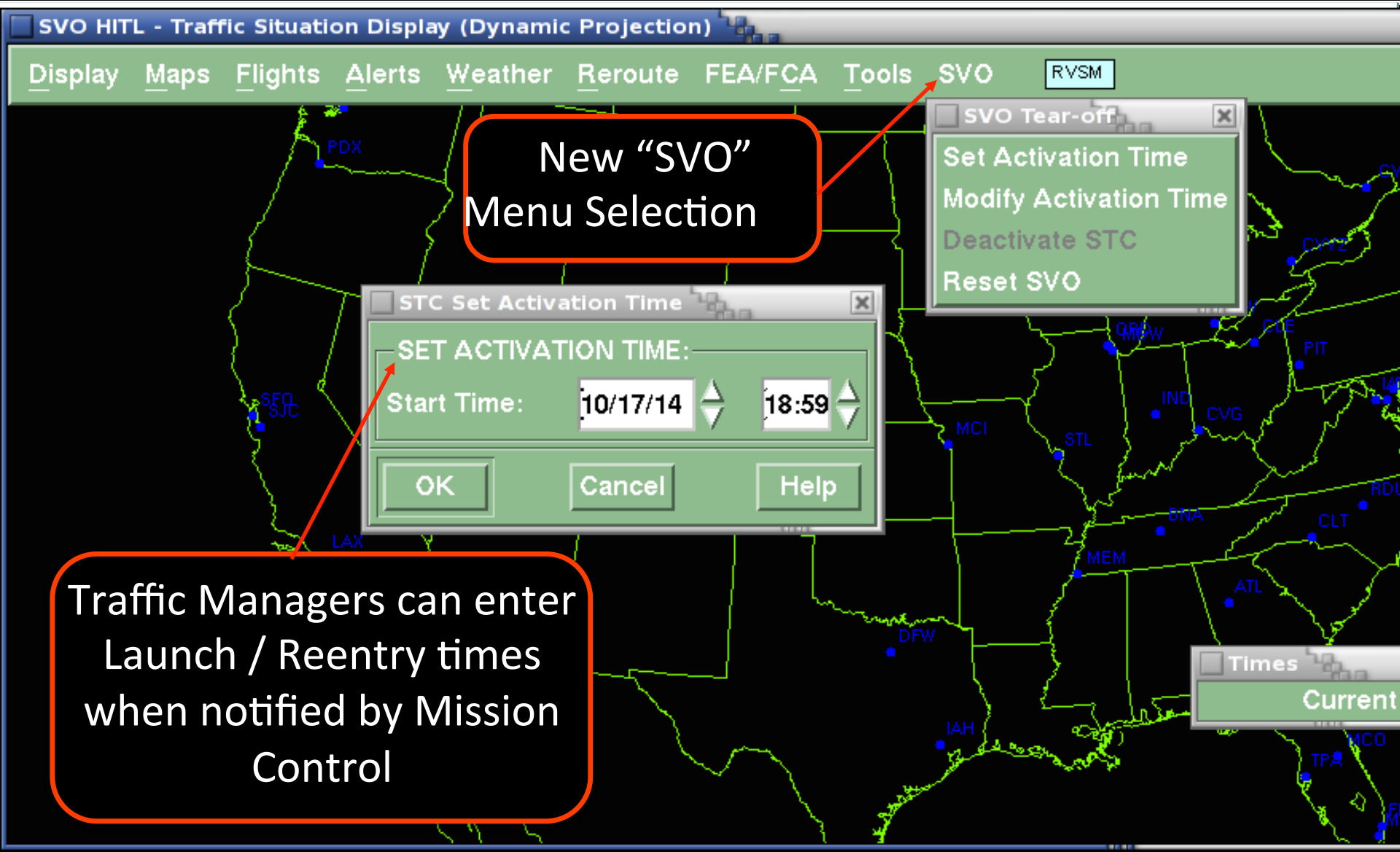
One Traffic Management Coordinator

Command Center

Space Vehicle Mission Control

SVO Human-in-the-Loop

SVO Human-in-the-Loop

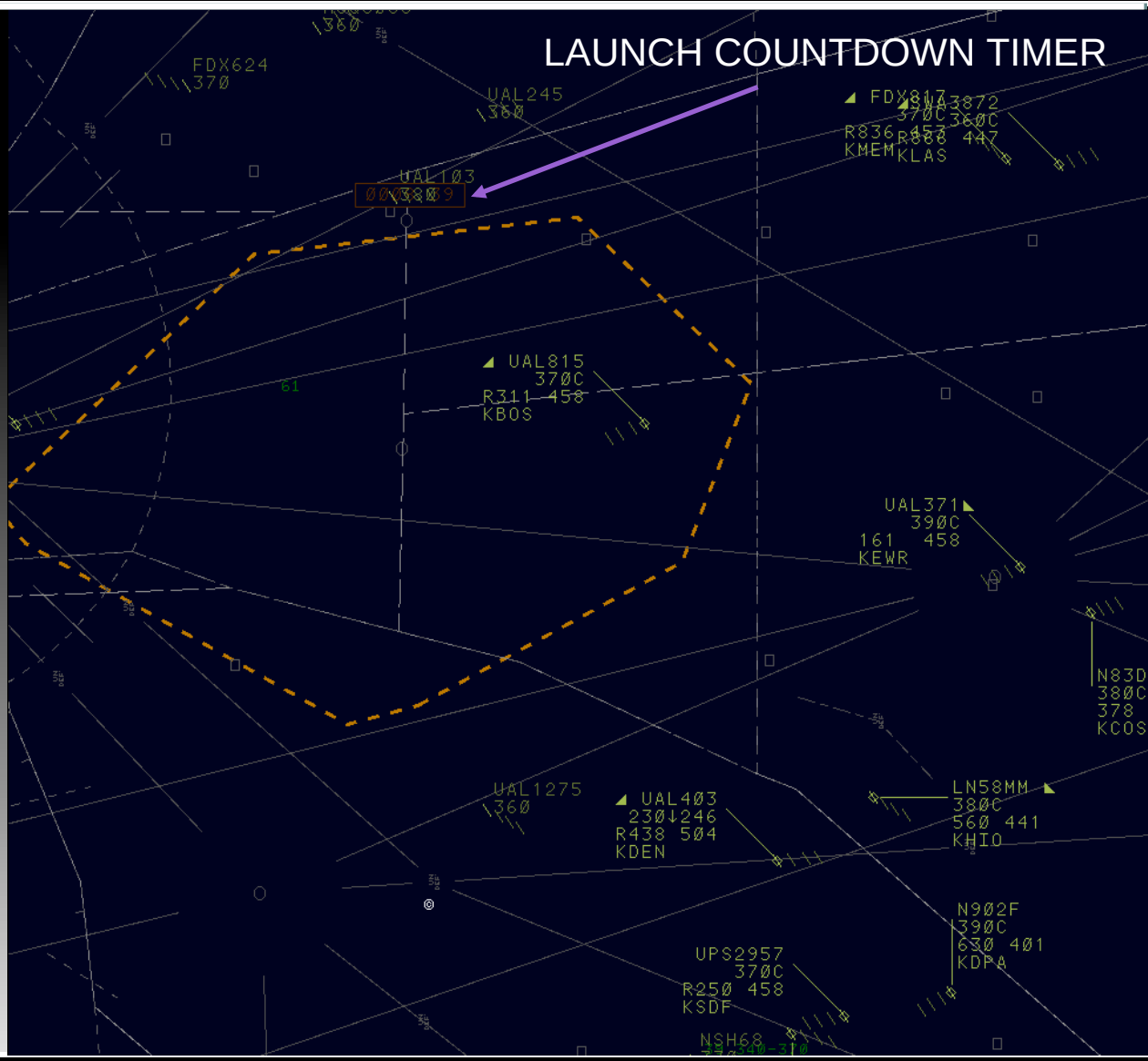


NextGEN

SVO Human-in-the-Loop

PRE-ACTIVATION STC

- High Certainty Launch Time has been received 10 minutes prior to launch
- Dashed orange boundary
- Only aircraft that can exit before the launch/recovery are in the STC

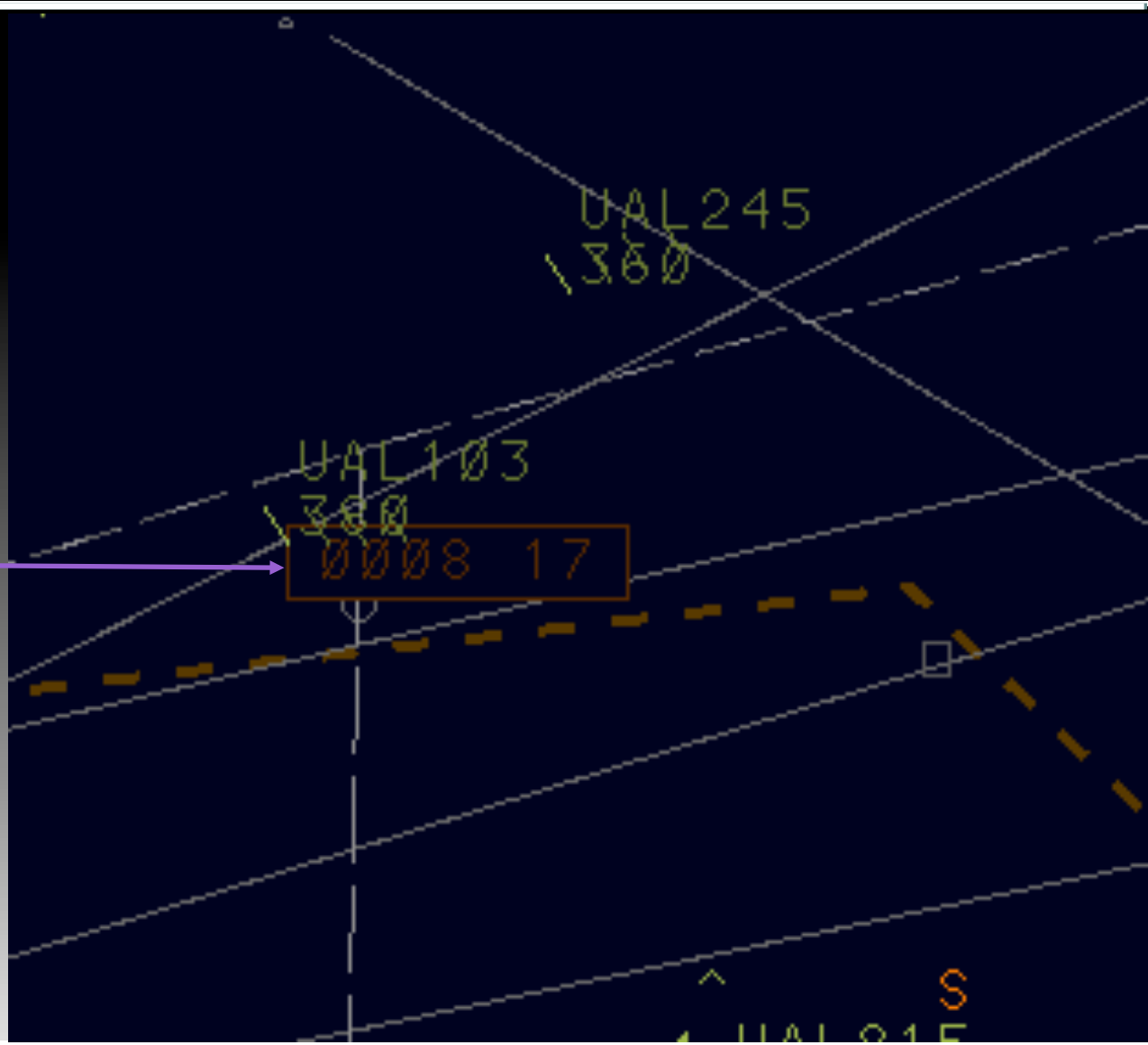


NextGEN

SVO Human-in-the-Loop

COUNTDOWN TIMER

- Time remaining until launch/ recovery in red
- Starts at T minus 10:00 minutes
- STC is “HOT” when countdown reaches 00:00



NextGEN

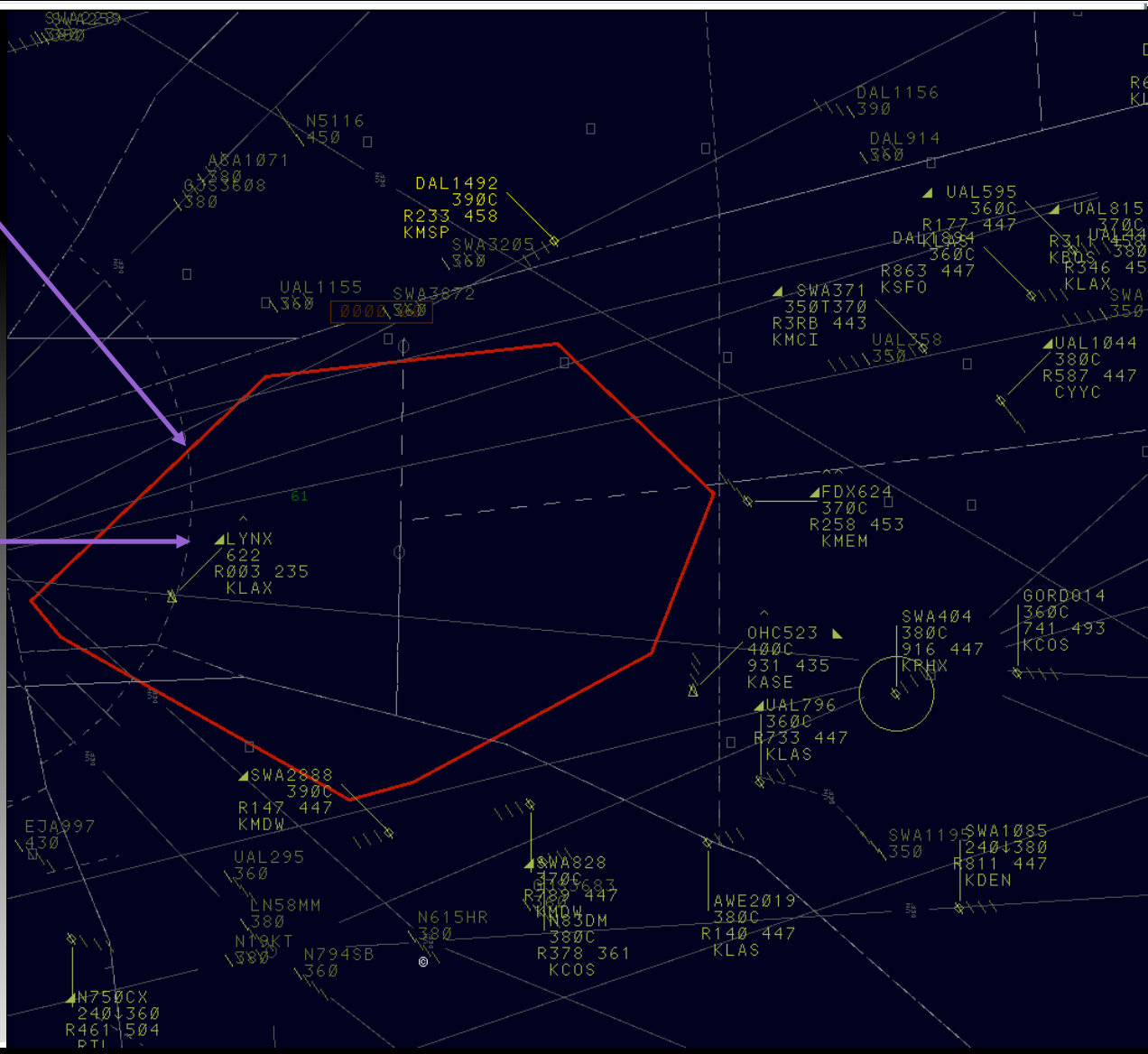
SVO Human-in-the-Loop

ACTIVE STC

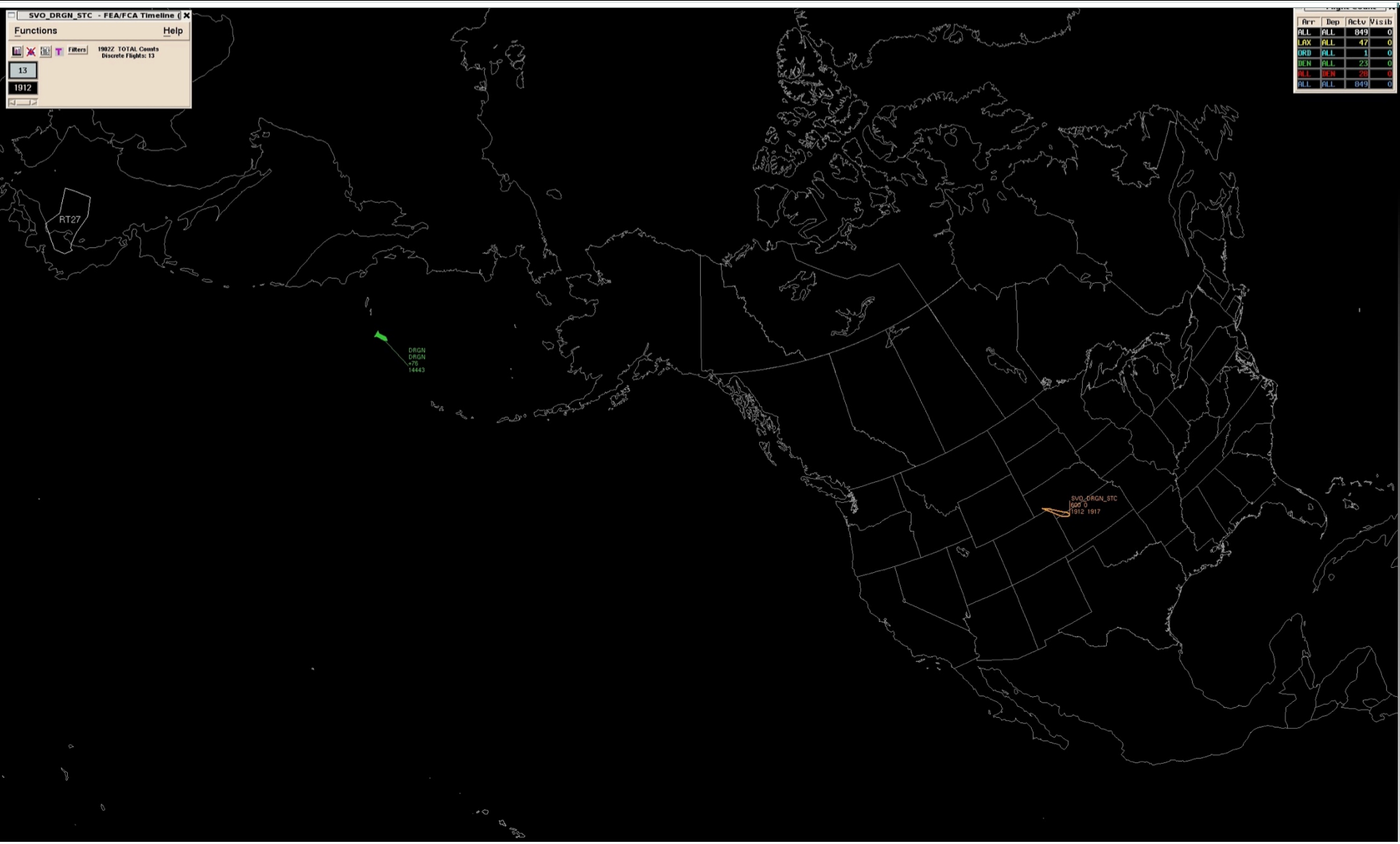
- Solid red boundary
- NO Aircraft in STC

SPACE VEHICLE

- Full data block
- 1-second update



SVO Human-in-the-Loop



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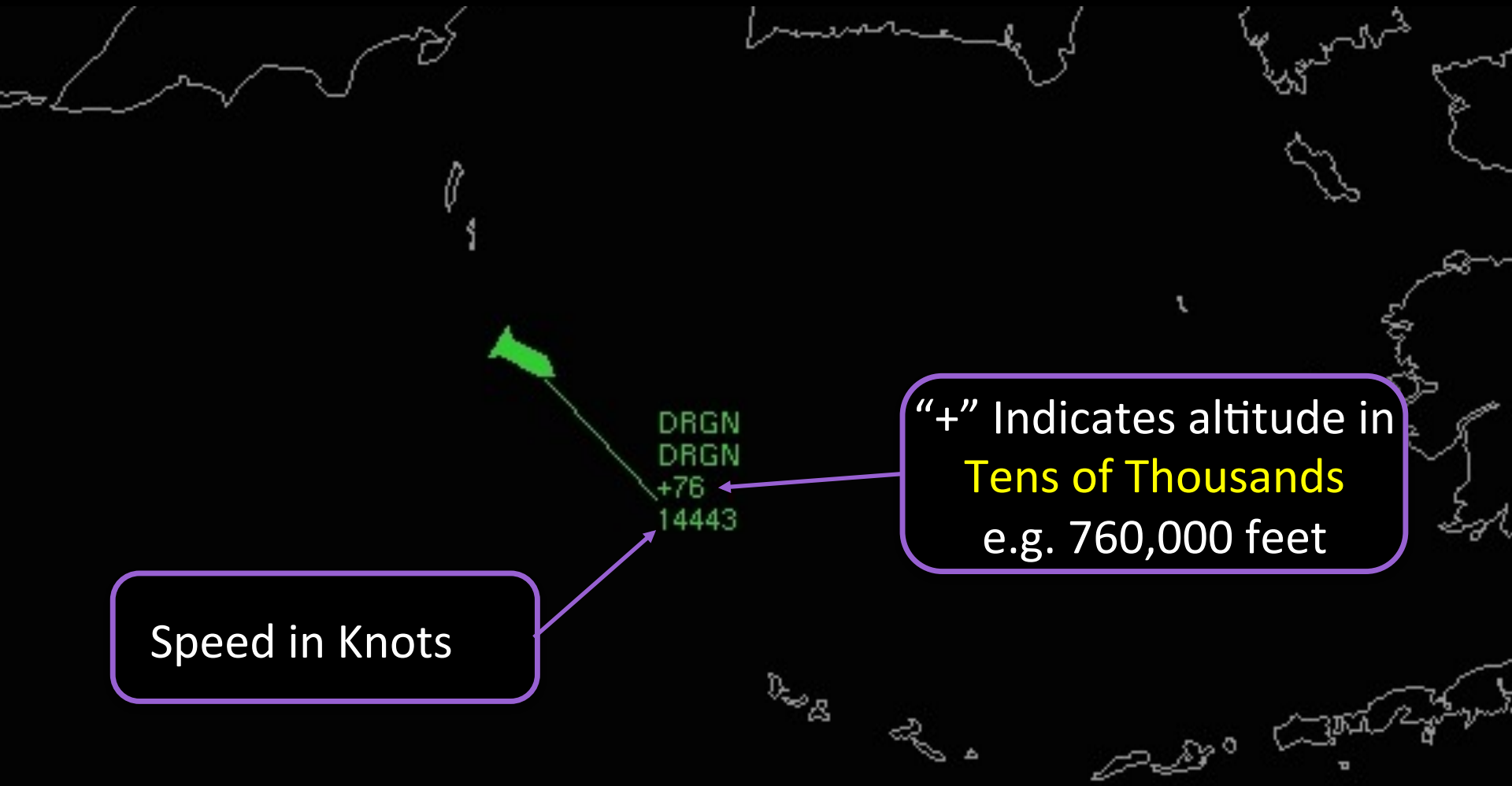
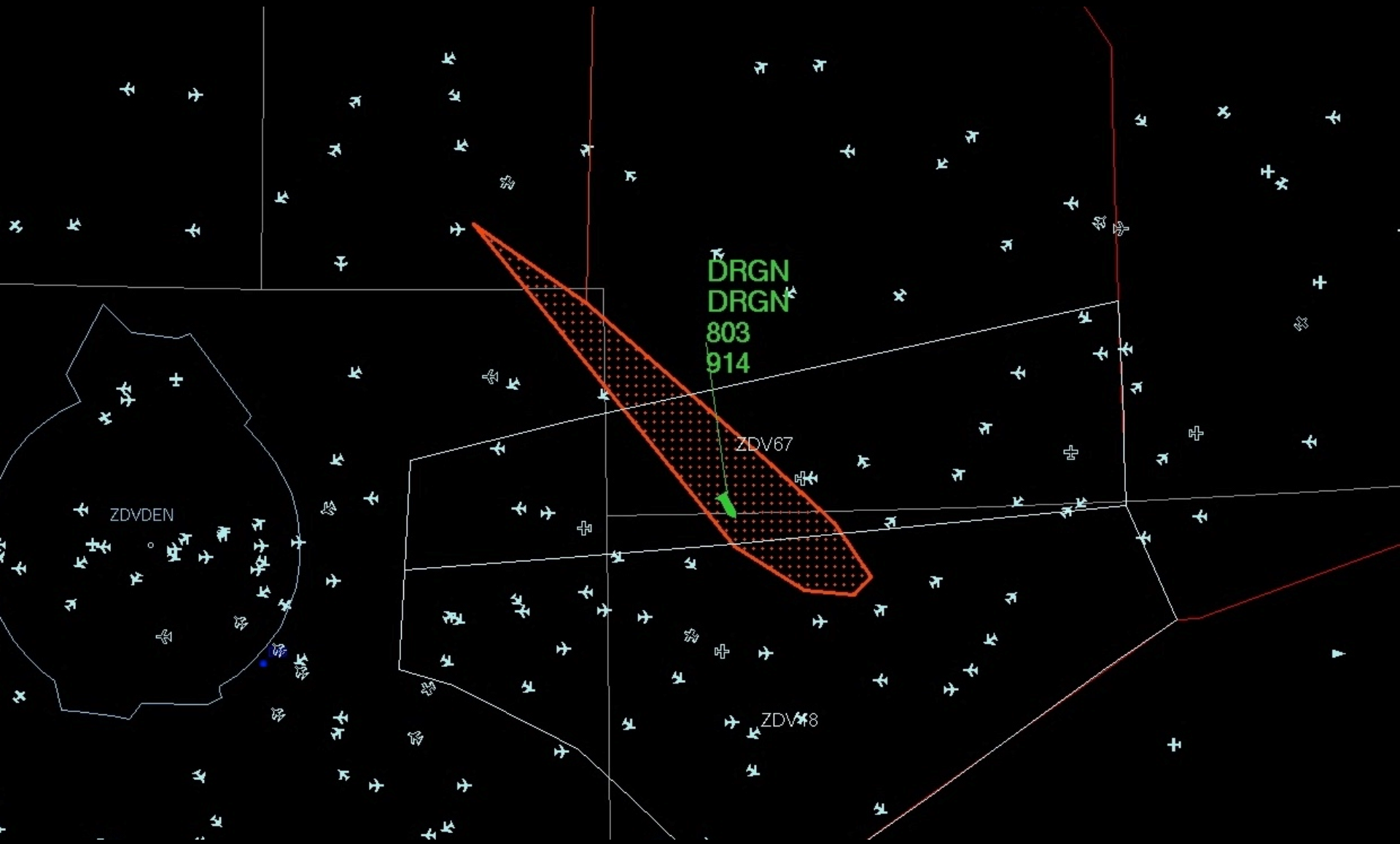
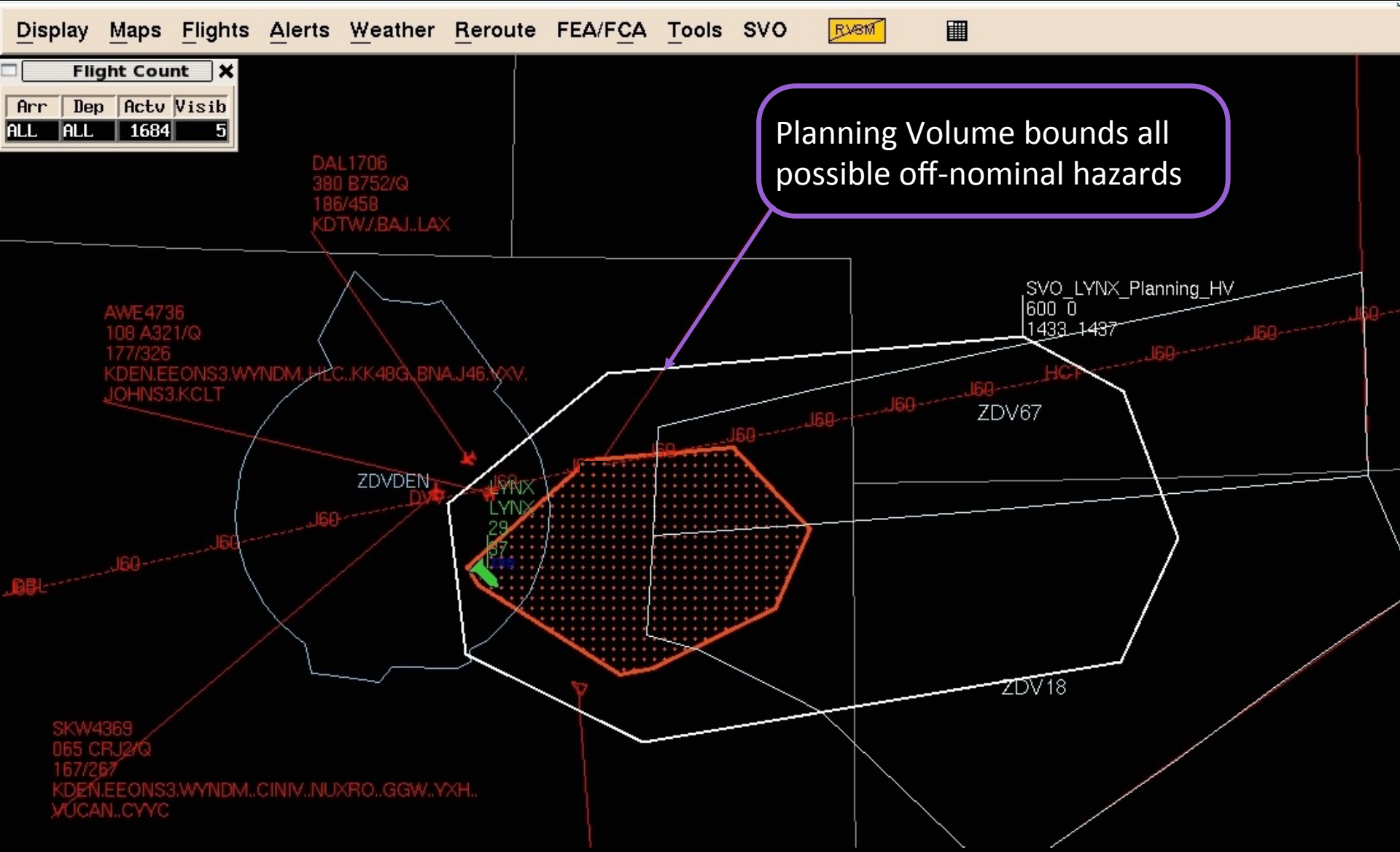


SVO Human-in-the-Loop

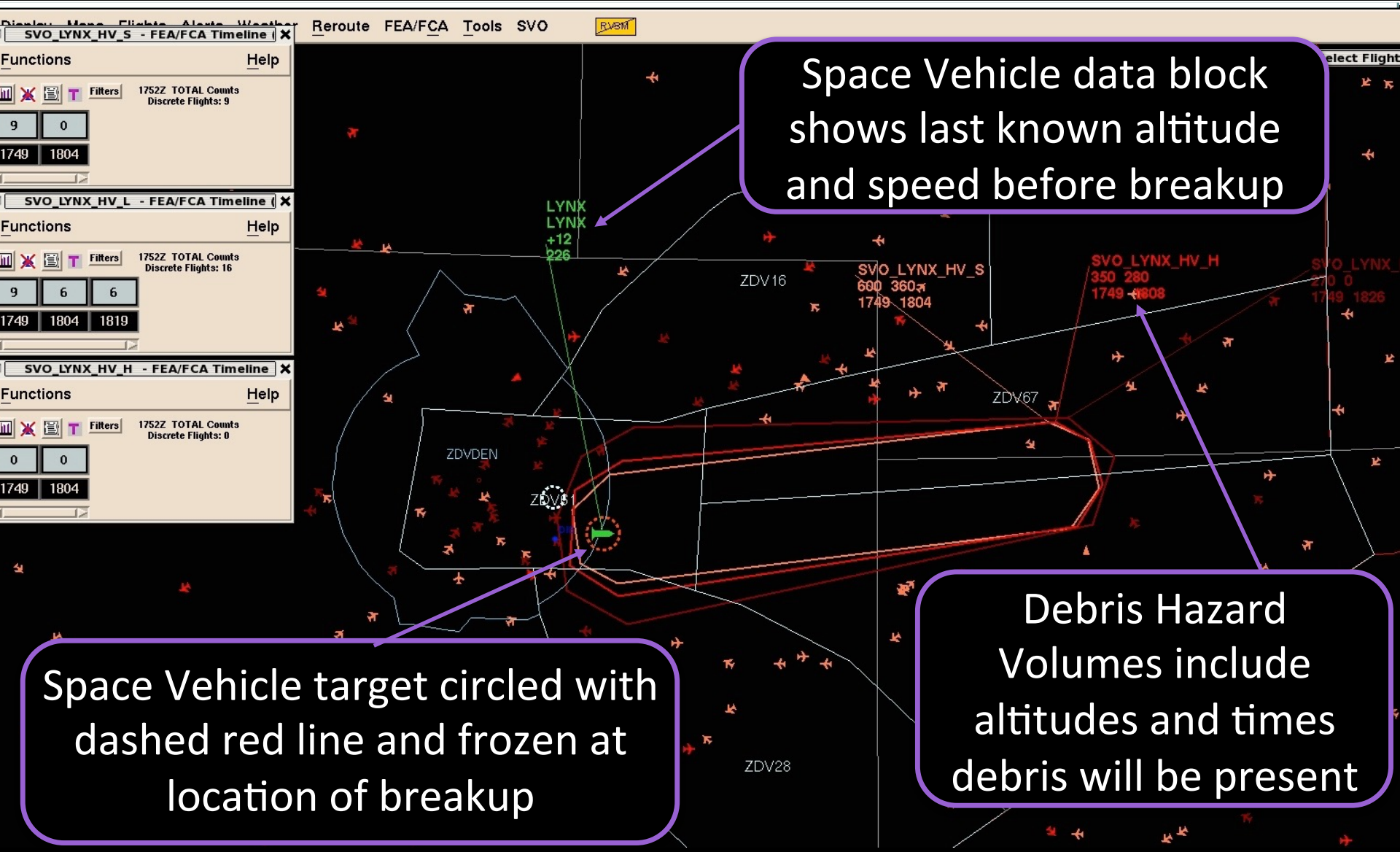


SVO Human-in-the-Loop



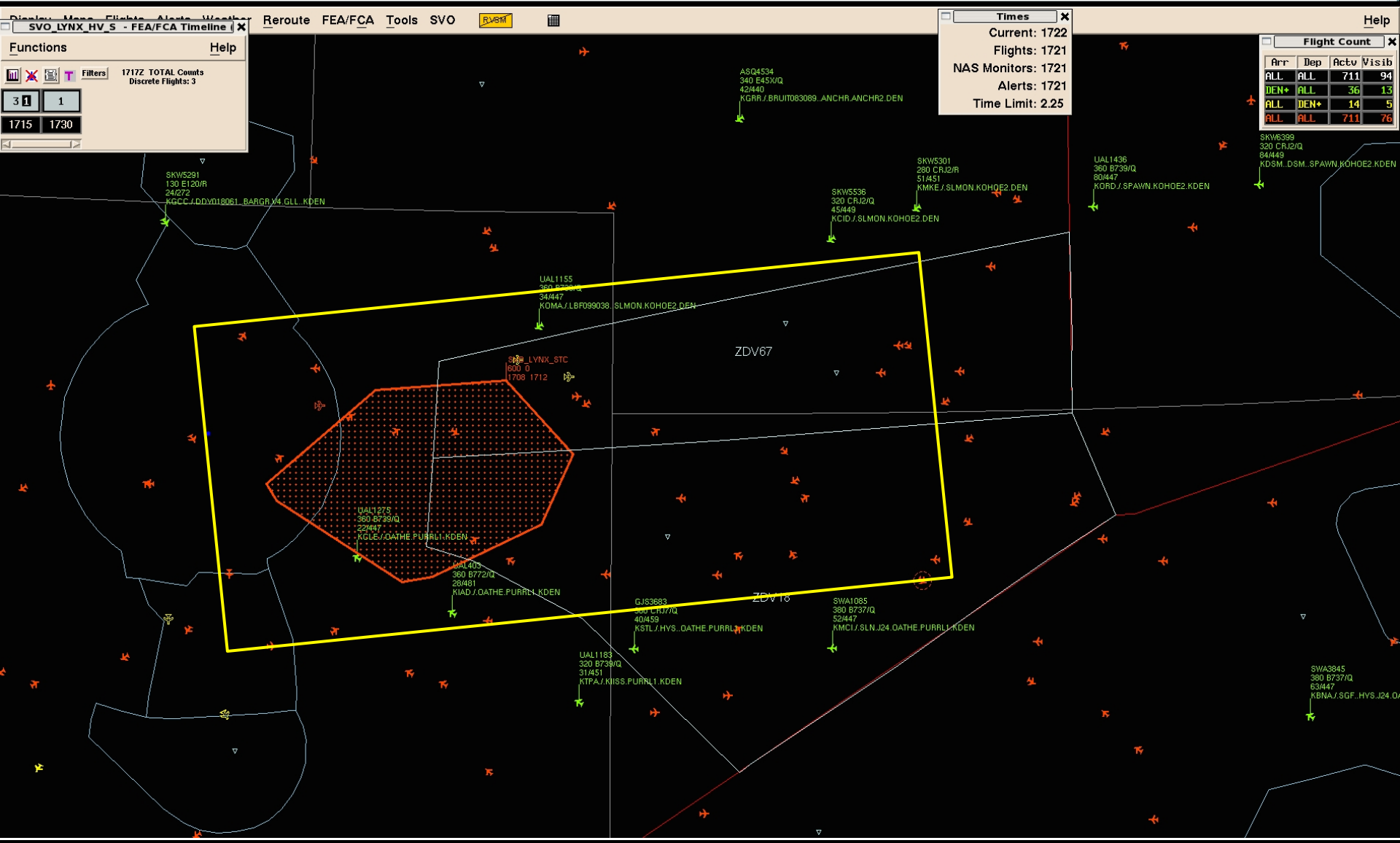
NextGEN

SVO Human-in-the-Loop



NextGEN

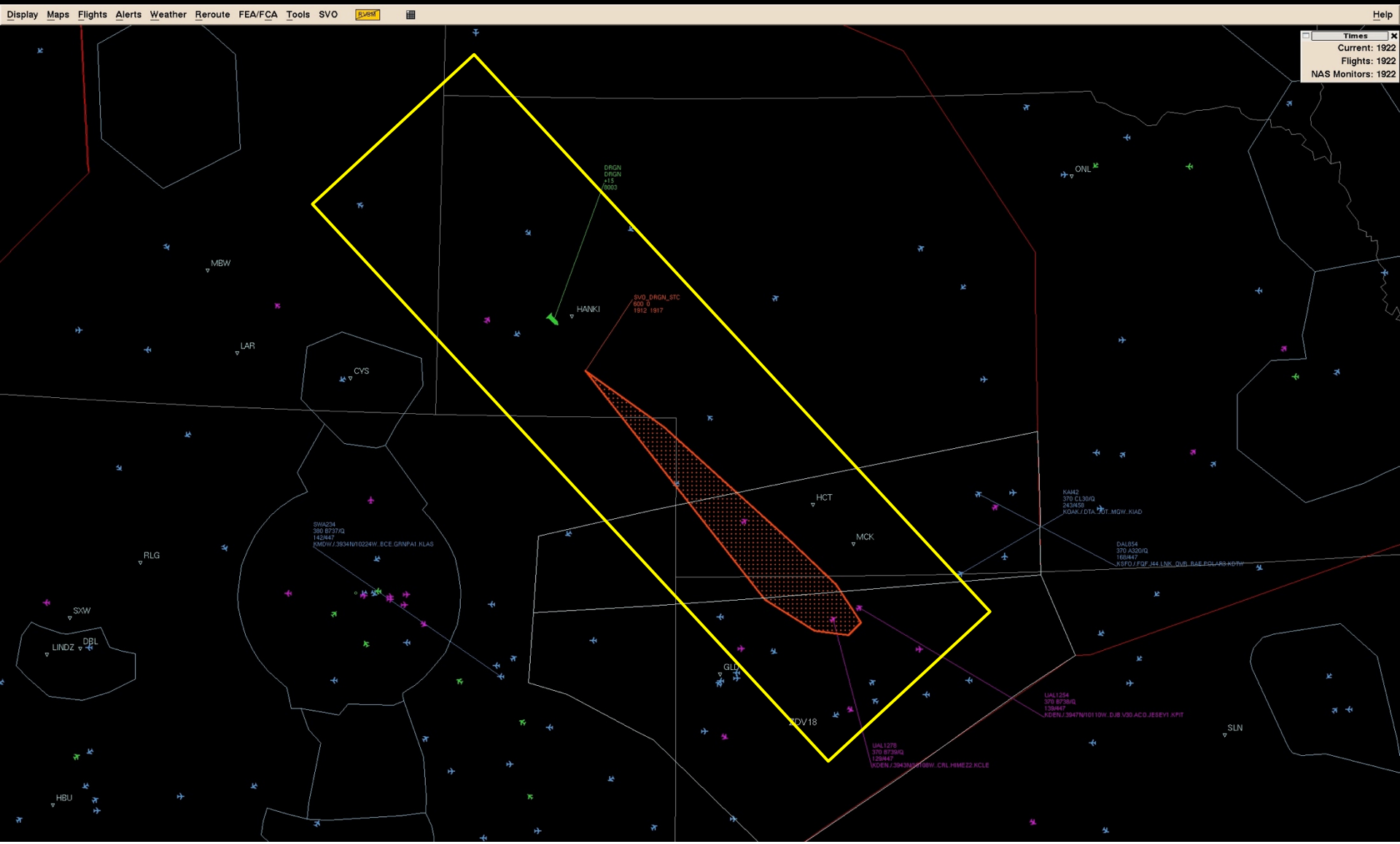
SVO vs. Legacy Hazard Areas



FEDERAL AVIATION ADMINISTRATION

NextGEN

SVO vs. Legacy Hazard Areas



FY11-12 Funding

Research:	Funding:	Vendor:
FY11 - SVO Shortfall Analysis	$ 300K	EIS/Crown
FY12 - 4D Protected Volumes	130K	Stanford
FY12 - SVO Concept of Operations	425K	Boeing/Mosaic
FY12 - SVO Debris Threat Mitigation	800K	ACTA
Total FY11 – FY12:	$ 1.655M	

Activities/Deliverables:

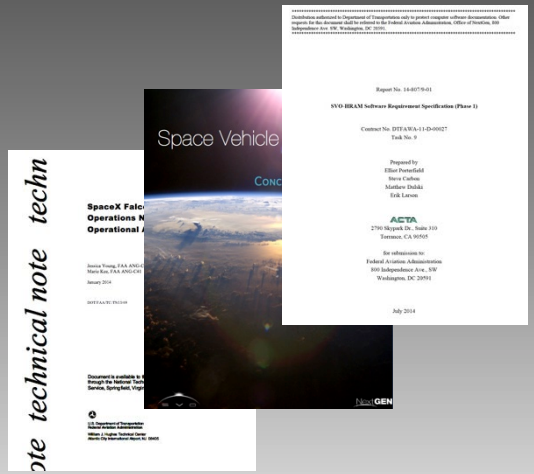
- SVO Focus Group #1 (December 2012)
- SVO Shortfall Analysis Report (April 2013)
- SVO Focus Group #2 (September 2013)

FY13 Funding

Research:	Funding:	Vendor:
FY13 – SVO Debris Threat Mitigation	$ 200K	ACTA
FY13 – NAS Impact & 4D Volumes	140K	Stanford
FY13 – Debris Mitigation HITL	500K	NIEC/Volpe
Total FY13 PLA:	$ 840K	

Activities/Deliverables:

SVO Impact Analysis Report	January 2014
SVO Cognitive Walkthrough	January 2014
SVO Concept of Operations	August 2014
SVO Hazard Risk Assessment Prototype	July 2015



FY14 Funding

Research:	Funding:	Vendor:
FY14 – SVO Data Exchange Requirements	$ 300K	MITRE
FY14 – SVO AIXM/FIXM Development	400K	Volpe/Mosaic
FY14 – SVO Concept Engineering Support	100K	ACTA
Total FY14 PLA:	$ 800K	

Activities/Deliverables:

SVO FIXM Final Operational Input	April 2016
SVO Data Exchange Requirements Report	June 2016
SVO TFMS Requirements Report	July 2016

Future SVO Funding

Planned Research:	Funding (est):	Vendor:
SVO 4D Trajectory Concept Development	$ 100K	Stanford
SVO Mini-Global II Demonstration Scenario (2016)	200K	Volpe/Mosaic
Super 60 (requirements for operations above FL600)	550K	TBD
SVO HITL #2: Low Altitude Debris Mitigation	1500K	TBD
SVO ConOps v2.0 Update	425K	TBD
SVO HITL #3: Oceanic Operations	1350K	TBD


Spaceport America

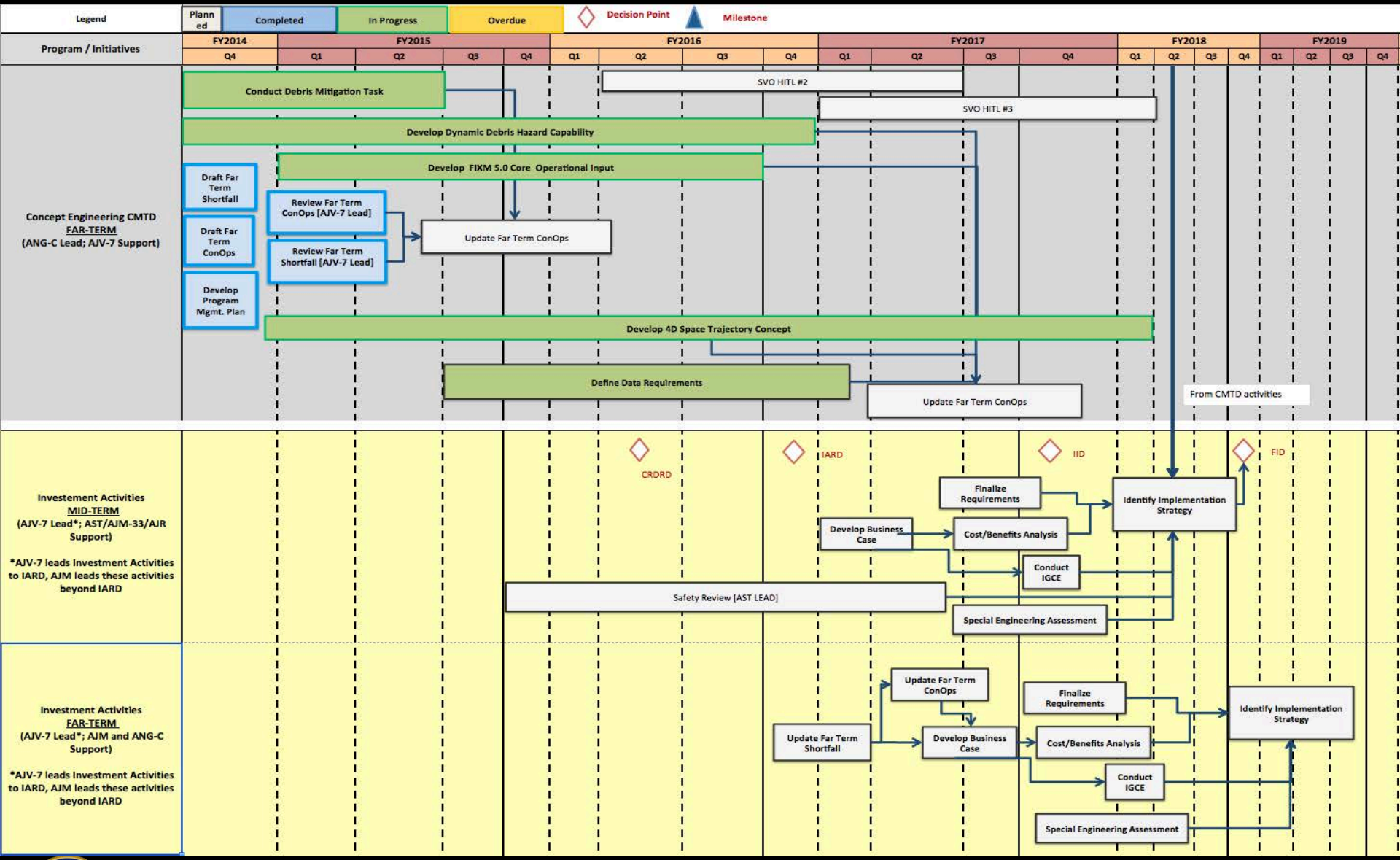

U.K. Spaceport


Spaceport Sweden


Caribbean Spaceport

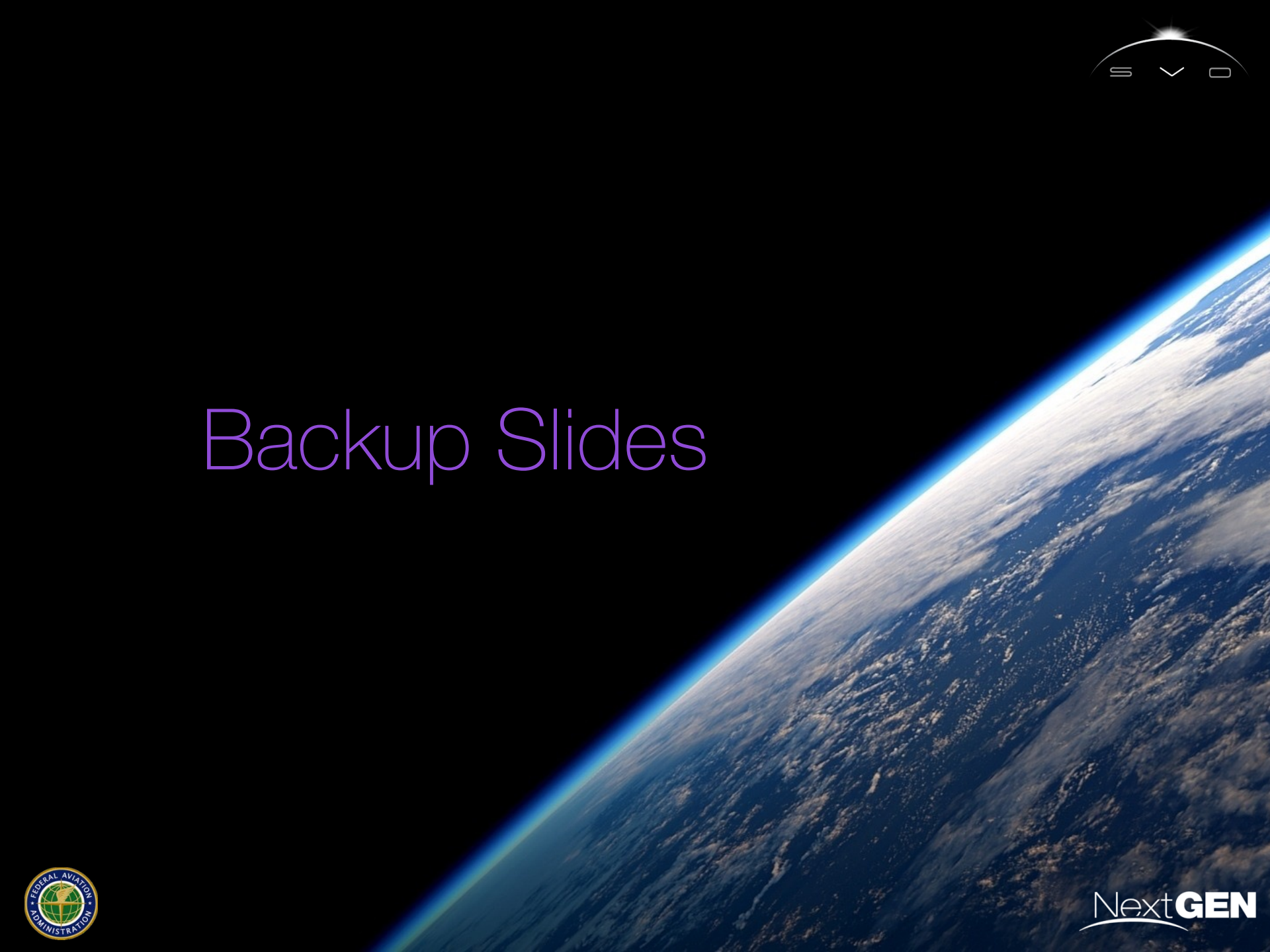

Spaceport Malaysia

Draft Roadmap ANG,AJV,AST,AJM



Questions / Discussion

Backup Slides



Develop 4D Compact Envelopes

Objective:

Through the COE CST, continue development of the 4D Compact Envelope concept in an operational context, including Air Traffic Management procedures

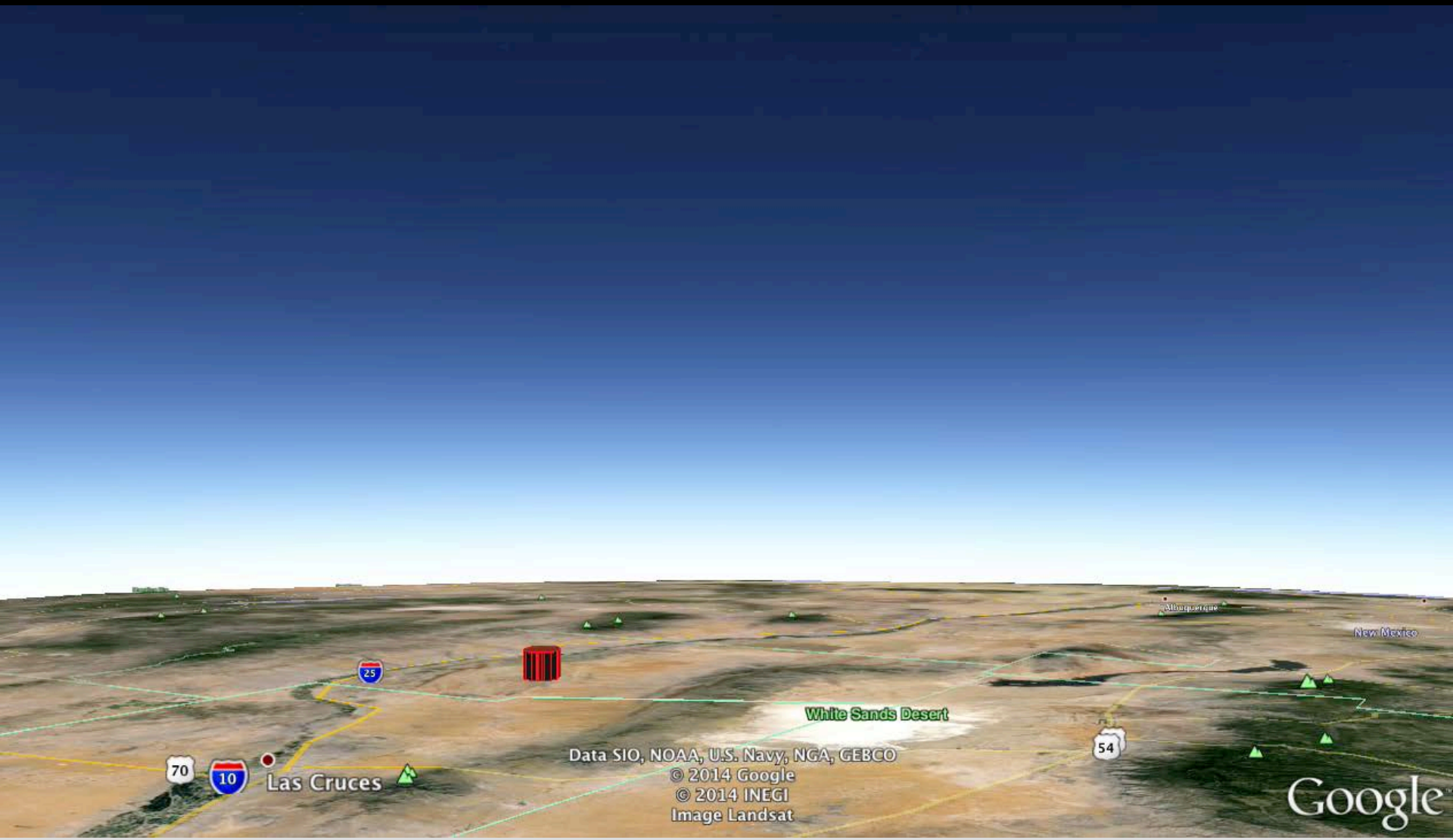
Activities:

Develop 4D Compact Envelope Technical Specifications

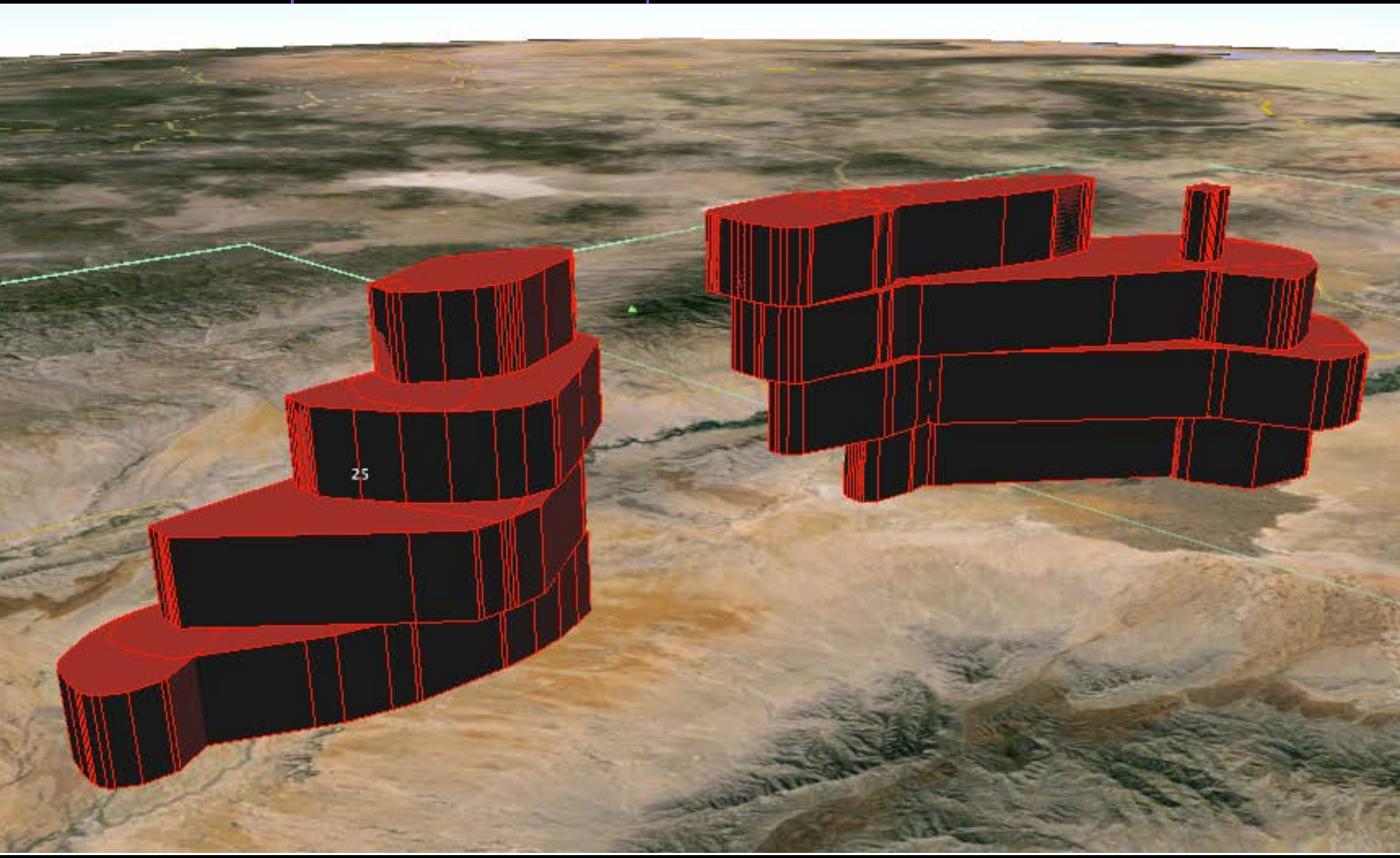
Develop Initial Air Traffic Operational Description

FY13
$140K

4D Compact Envelopes



4D Compact Envelopes



Develop Data Exchange Requirements

Objective:

Identify data and information exchange requirements for managing space vehicle operations in the NAS under NextGen.

Activities:

Mapping of SVO Scenarios to NextGen Operational Improvements

Initial Requirements Document for SVO in the NAS

FY14
$300K

MITRE CAASD

Operational Input

Objective:

Provide operational input to AIXM/FIXM Version 5.0 for SVO data elements

Activities:

Draft Proposal to FIXM Change Control Board
Develop SVO Scenario
SVO Scenario Cognitive Walkthrough
SVO Data Description Input
SVO Data Dictionary
SVO/FIXM Industry Workgroup Collaboration

FY14
$400K

Mini-Global II Demonstration

Objective:

Demonstrate a real-time space mission data exchange in a collaborative SWIM environment at Mini-Global II (April 2016)

Activities:

Develop an SVO Scenario for Mini-Global

Collaborate with Industry Stakeholders to Develop Information Exchange Capability

Test and Demonstrate Real-Time Data Exchange at Mini-Global II, NextGen Florida Test bed, September 2016

unfunded
$200K

the VOLPE center

MOSAIC ATM
Innovators for the Next Generation of Aviation