Space Based Range Demonstration and Certification (SBRDC)

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Space Based Range (SBR) Goals and Objectives

SBR Goal:
Reduce the cost of operating and maintaining range systems supporting space launch vehicles while increasing range responsiveness

SBR Strategic Objective:
Demonstrate space based range technologies to provide more responsive, robust, and economical tracking and communication systems

- Responsive
  - Reduce launch turn-around times
  - Reduce launch delays and scrubs due to range instrumentation problems
  - Support multiple vehicles simultaneously
- Robust
  - Increase vehicle telemetry data rates
  - Increase launch trajectories
  - Launch from any spaceport in the world
- Economical
  - Reduce range operations and maintenance (O&M) costs by $50M per year by eliminating ground based down-range infrastructure

SBR Project Objectives

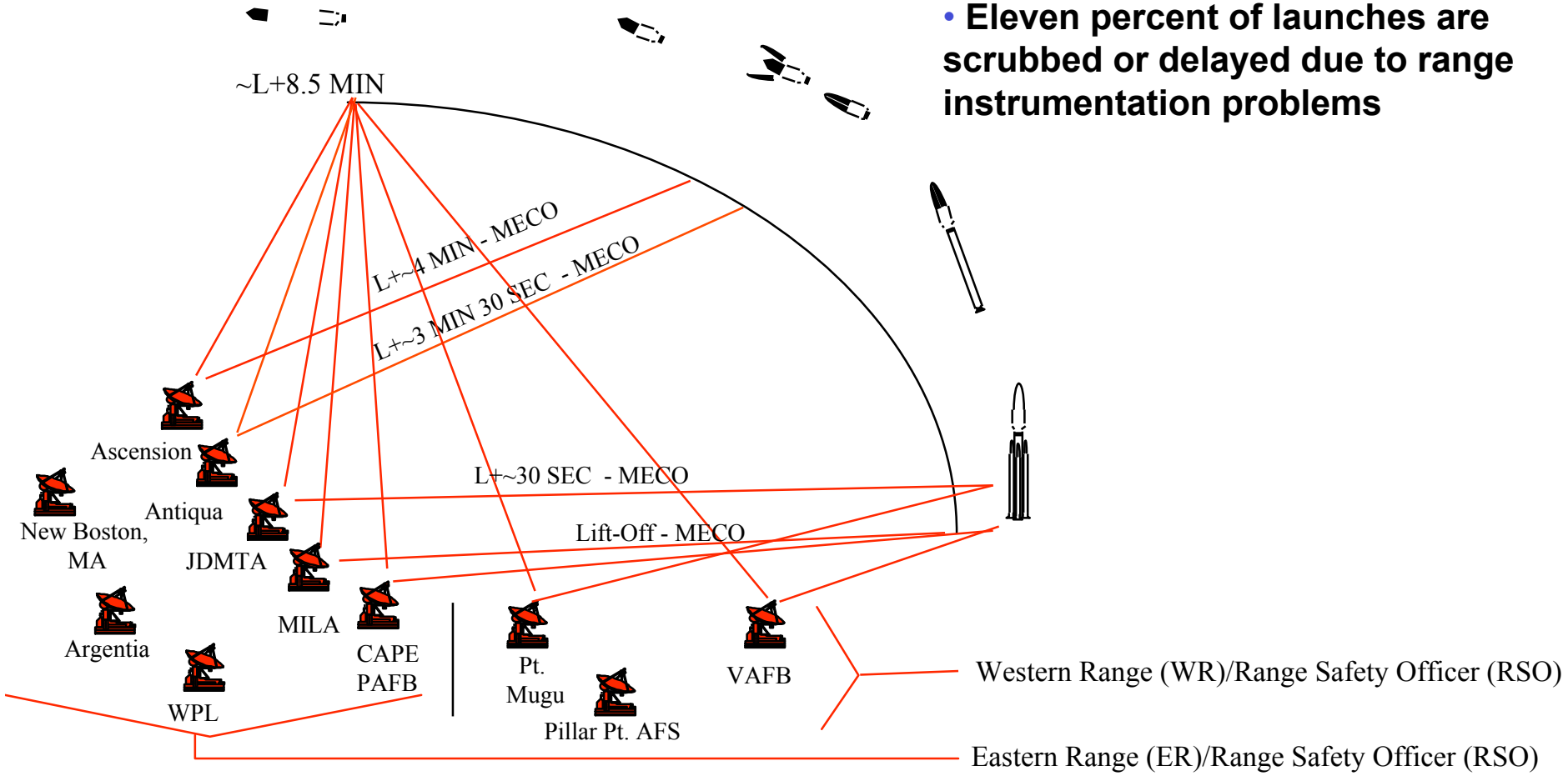
SBR Technology Development:

Develop, utilize, test, and demonstrate state-of-the-art technologies for Range Safety and Range User Systems.

- Range Safety System (Flight Termination, Vehicle Tracking, Key Flight Telemetry Data)
  - Support simultaneous forward links
  - Meet intent of range safety requirements
- Range User System (Video, Voice, Vehicle Data)
  - Maximize high data rate capabilities

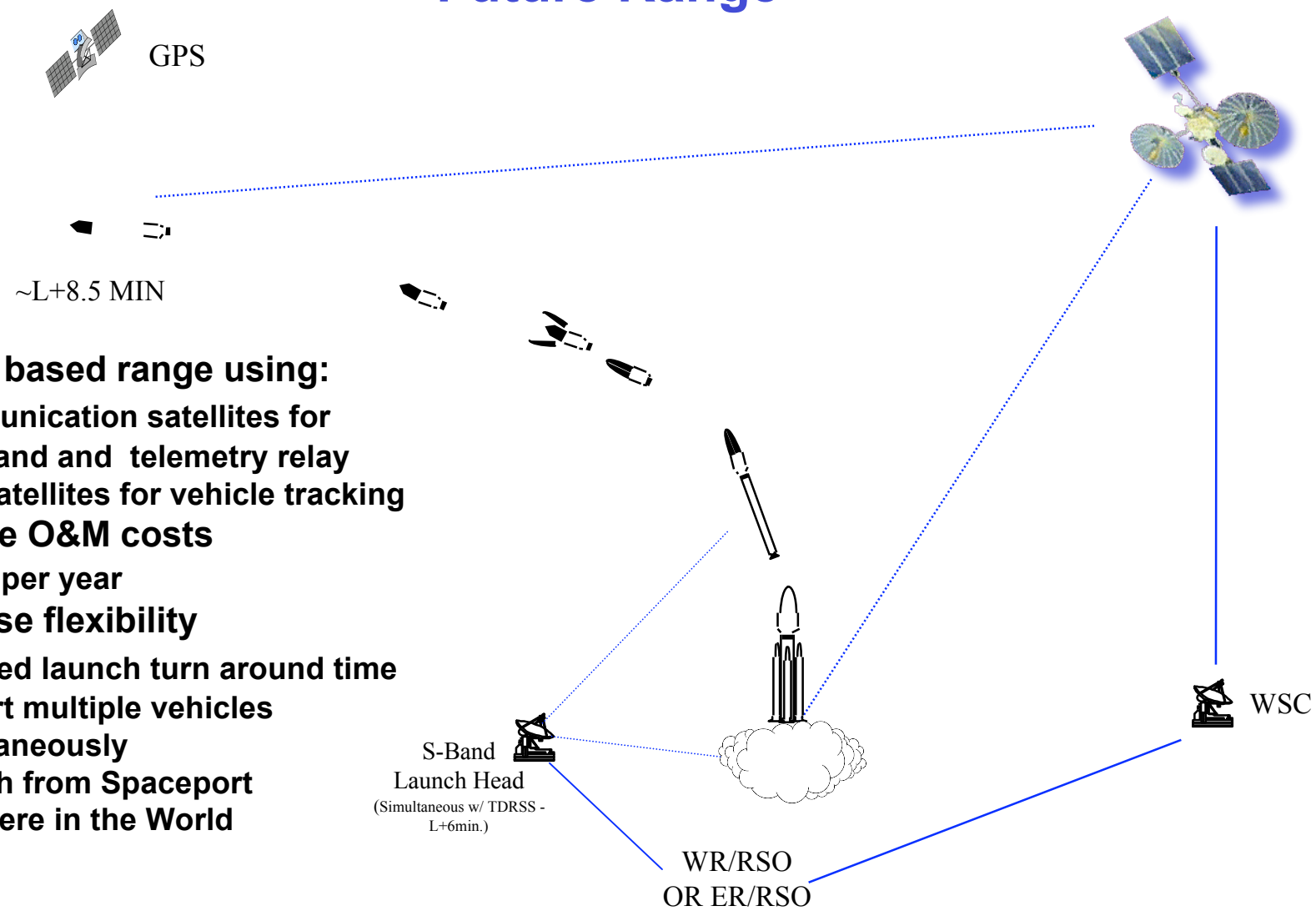
Today's United States Range

- **A complex ground based infrastructure consisting of:**
  - Radars
  - High power UHF transmitters
  - Telemetry receive stations
- **Very costly to operate and maintain**
- **Eleven percent of launches are scrubbed or delayed due to range instrumentation problems**

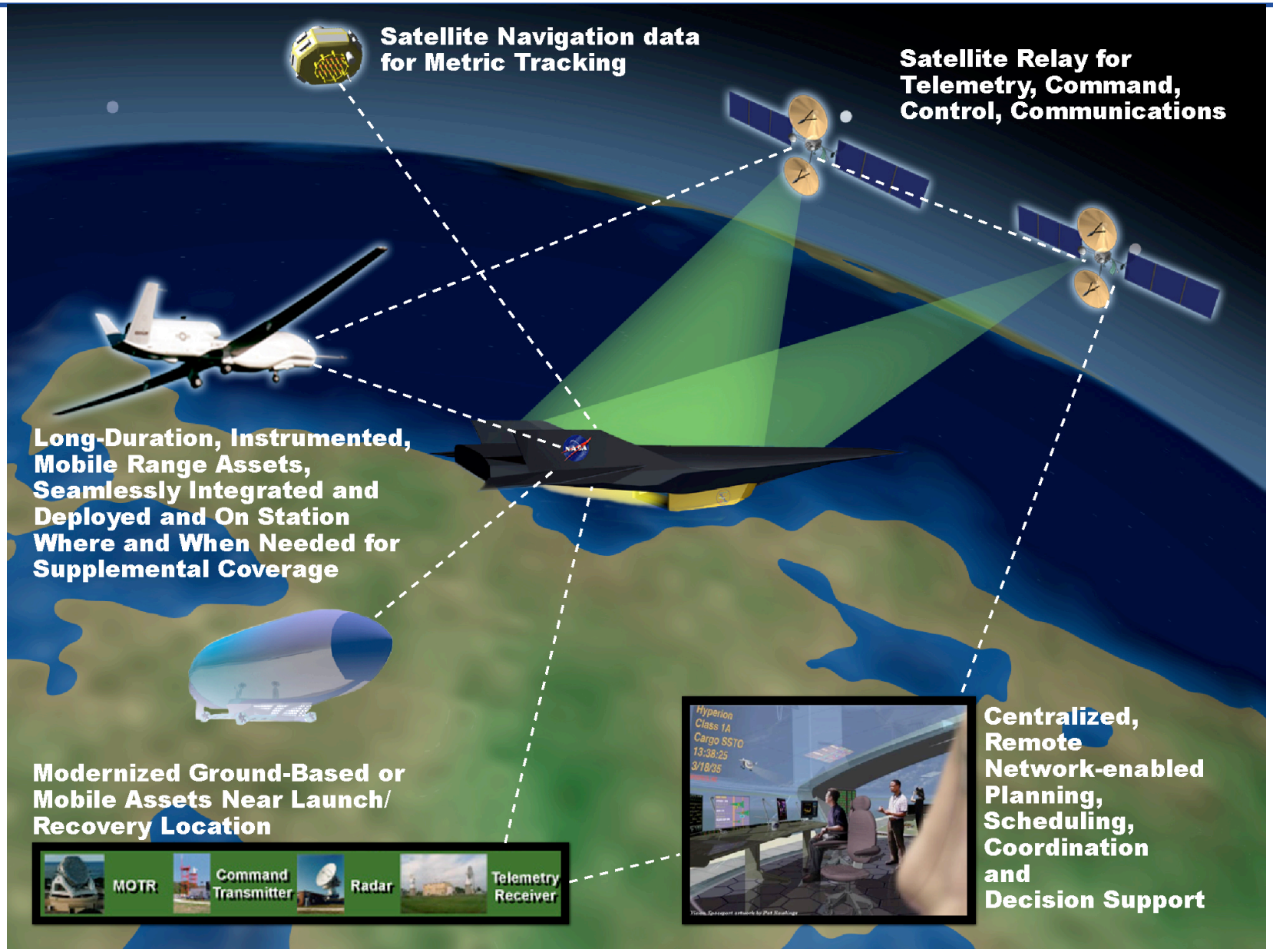


Future Range

- **Space based range using:**
  - **Communication satellites for command and telemetry relay**
  - **GPS satellites for vehicle tracking**
- **Reduce O&M costs**
  - **~$50M per year**
- **Increase flexibility**
  - **Reduced launch turn around time**
  - **Support multiple vehicles simultaneously**
  - **Launch from Spaceport anywhere in the World**



Another Vision for the Future Range



STARS Project Goals

- **STARS will utilize existing space-based platforms to provide reliable communications for flight termination commands, telemetry, and vehicle tracking for Range Safety and Range Users**
  - Tracking and Data Relay Satellite System (TDRSS) for command/data relay
  - Global Positioning System (GPS) for metric tracking
- **STARS will develop and utilize state of the art technologies that can be applied to Launch Vehicles:**
  - Multi-channel transceivers (TDRS/GPS)
  - Antennas (Ka/Ku-band phased array)
  - Data formatting (Error-correction, Encryption, Standard Protocols, Compression)
- **STARS will conduct a series of incremental proof of concept flight demonstrations to increase the Test Readiness Level (TRL)**
- **STARS team members will participate in the development of requirements for space based range full scale development**
- **STARS team members will support the United States Air Force (USAF) in the certification of the Range Safety System and the Range User System on the Operational Space-lift Ranges (i.e. ER and WR)**

STARS Content

- **STARS has four flight demonstrations planned**
  - **Flight Demo 1 – Completed successfully June 2003**
    - Proof of concept using F-15B as test vehicle
    - Range Safety (RS) System
      - Developed Low Power Transceiver (LPT) with basic flight termination receiver capabilities and low-rate return link
      - Developed Command & Data Handler (C&DH) for command decoding and telemetry formatting
      - Utilized commercial off-the-shelf (COTS) Ashtech Z-12 GPS receiver
      - Utilized Omni patch antennas (combined S-band/L-band receive antennas on top and bottom of the F-15B and S-band transmit antennas located on the top and bottom of the F-15B)
    - Range User (RU) System
      - Utilized COTS hardware transmitting up to 500 kbps data rate
      - Utilized Omni patch antennas (S-band transmit antennas only located on top and bottom of the F-15B)

STARS Configuration
Flight Demonstrations 1 & 2

GPS

F-15B

TDRS

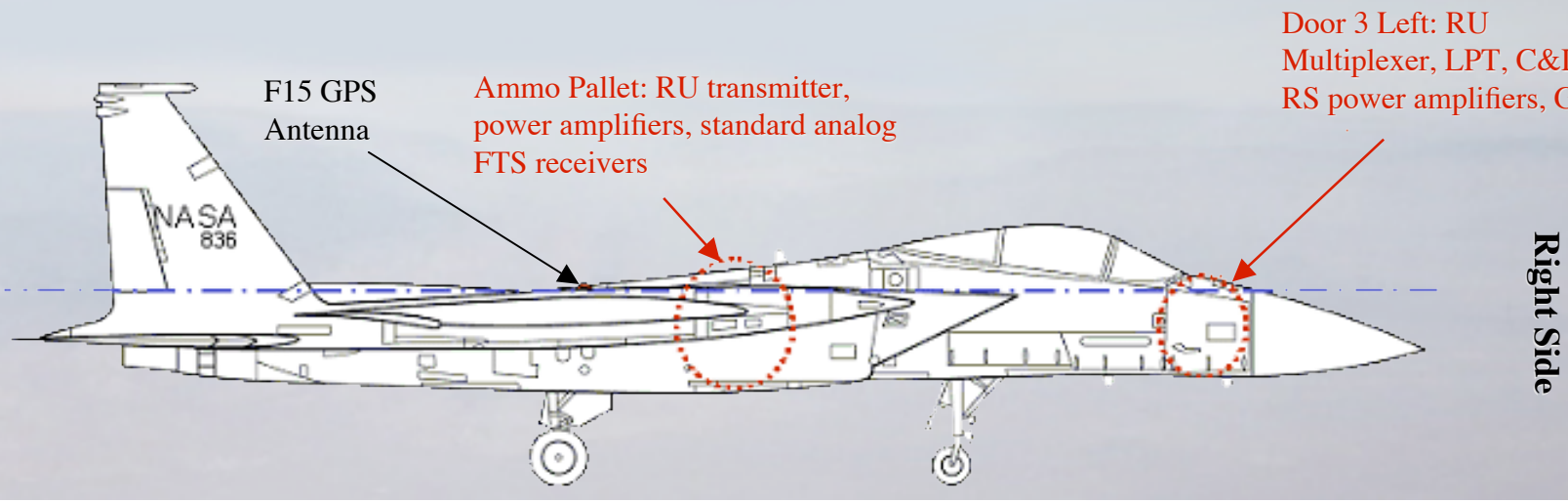
DFRC Aeronautical Test Facility

DFRC Mission Control Center

White Sands Complex

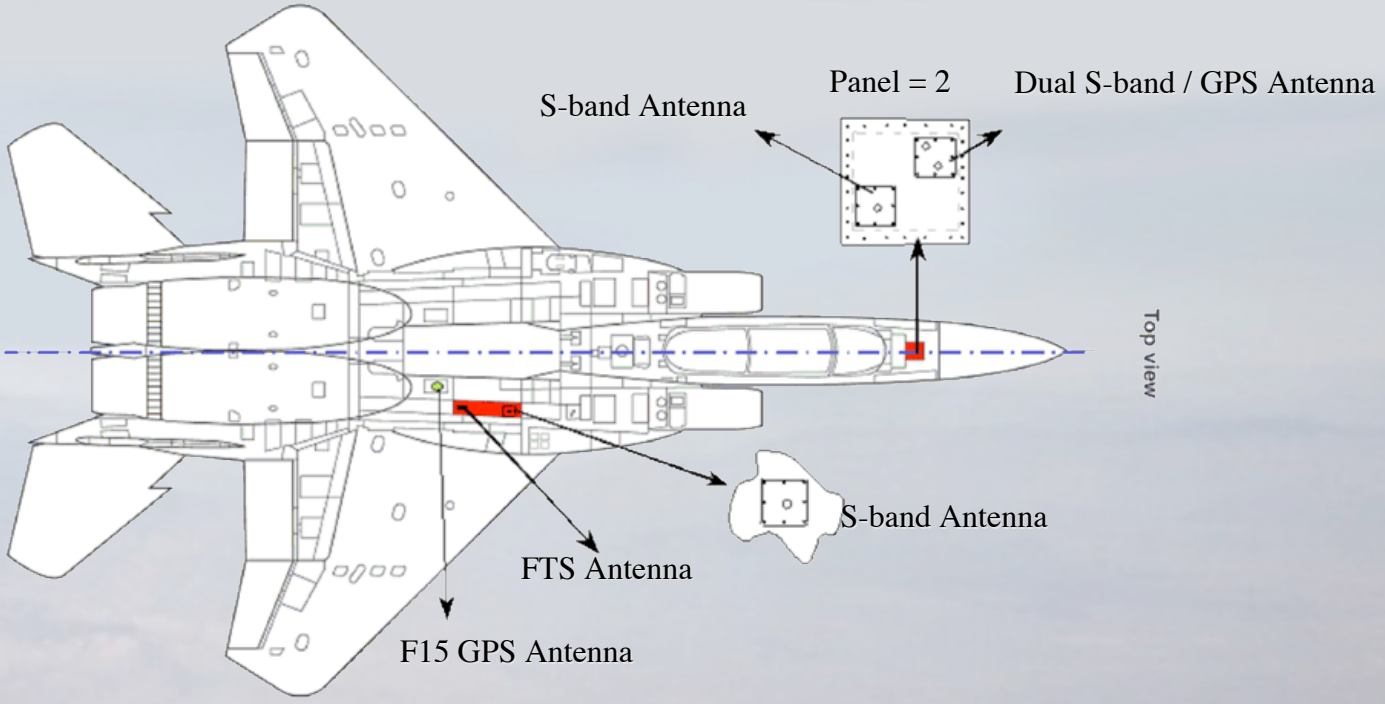
Hardware Locations

F-15B



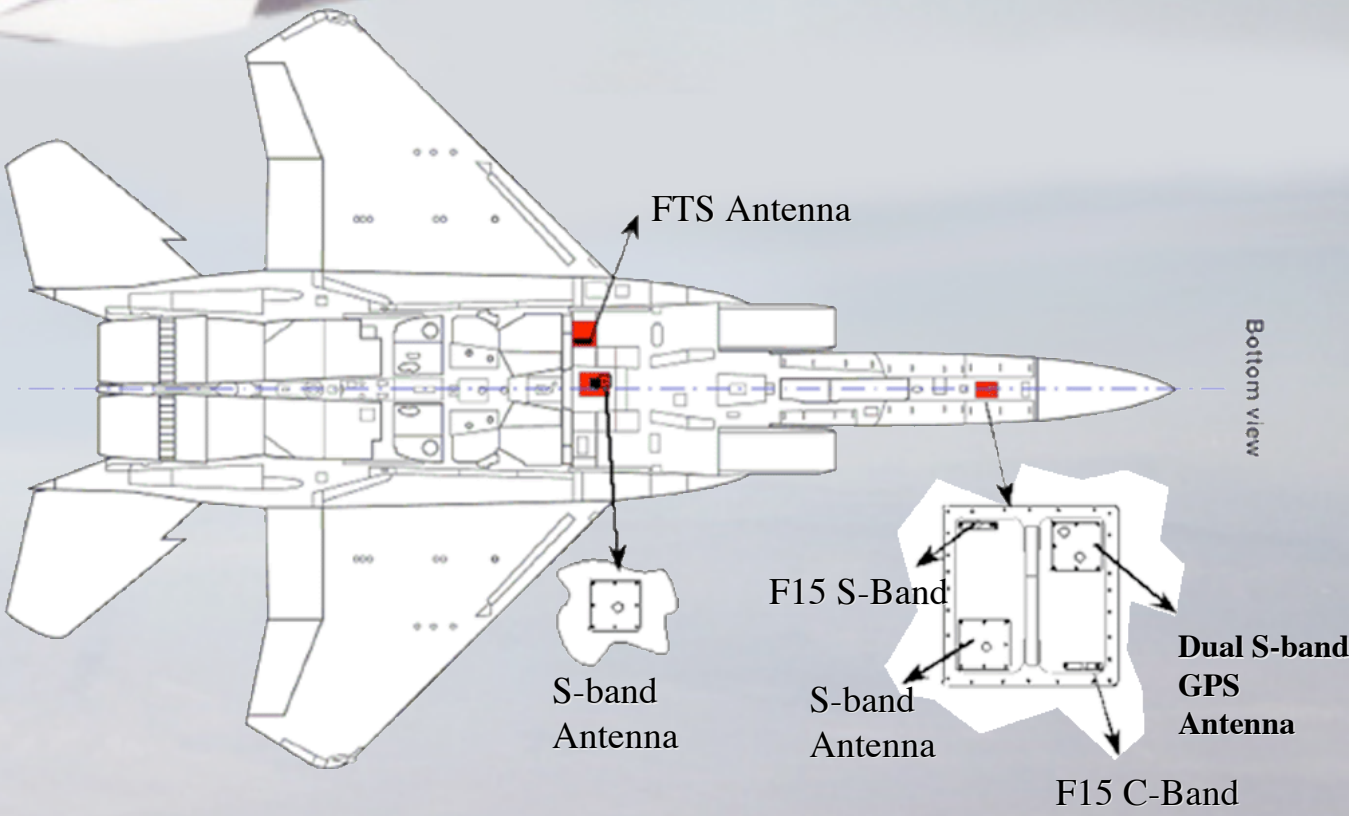
Antenna Locations

- **F-15B – Top View**



Antenna Locations

- **F-15B – Bottom View**



Spaceport And Range Technologies
STARS Objectives and Results

FD1 Test Objectives and Results:

♦Range Safety (RS)

- Verify link margin, acquisition/reacquisition, signal lock, Bit Error Rate (BER), and simultaneous forward links (satellite and launch head)
- Receive and process FTS commands (100% of all FTS commands were successfully initiated: over 300 Arm and Terminate commands were sent during the flight tests)
- Receive and process GPS metric tracking data
- Transmit tracking, telemetry, and status data from a high dynamic vehicle to DFRC via WSC (Data was also transmitted to Kennedy Space Center (KSC) and Wallops Flight Facility (WFF) in near real-time for monitoring)
- Process and display the RS return link data

➢ The objectives were satisfied, although the RS return link margin was less than predicted due to interferometer effects and surface wave interference

- Interferometer effects and surface wave interference will be corrected for FD2

♦Range User (RU)

- Verify link margin, acquisition/reacquisition, and signal lock
- Transmit RU data (video, voice, and telemetry) from a high dynamic vehicle to DFRC via WSC
- Process and display the RU return link data

➢ The objectives were satisfied, achieving higher link margin than predicted

Spaceport And Range Technologies
STARS FD2 Objectives

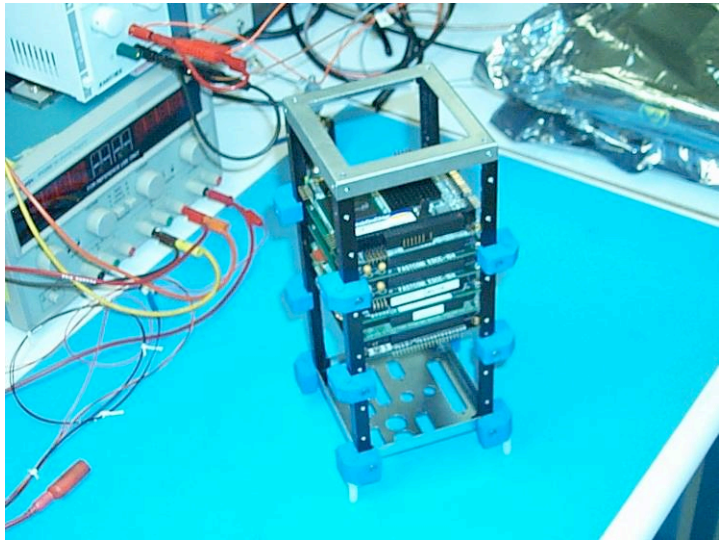
FD2 Test Objectives

- **Similar to FD1 with modified flight hardware**
- **Range Safety System**
  - Integrate the LPT, C&DH, and GPS receiver into single unit
  - Characterize latency, implement encryption on the forward link, implement Reed-Solomon encoding on both forward and return links
  - Verify link margin, acquisition/reacquisition, latency, signal lock, BER
  - Verify ability to send commands to transceiver and respond with flight termination action, measure the Signal to Noise ratio, test with 2 TDRS simultaneously, verify vehicle location (GPS with inertial navigation system (INS))
- **Range User System**
  - Develop Ku-band transmitter and Phased Array Antenna supporting 5 Mbps data rates
  - Integrate hardware on test aircraft with GPS/INS controller
  - Verify link margin, latency, acquisition/reacquisition performance, BER in dynamic environment, compression system performance, antenna capabilities & performance, antenna flight control interface and control algorithms performance
- **Schedule: 8 Test Flights on NASA F-15B, July 06**
- **Status**
  - All Range Safety and Range User hardware for Flight Demo 2 has been designed, developed and acceptance tested.
  - STARS RU hardware is currently in the integration and test phase prior to aircraft installation
  - Additional testing will occur after aircraft installation prior to flight testing

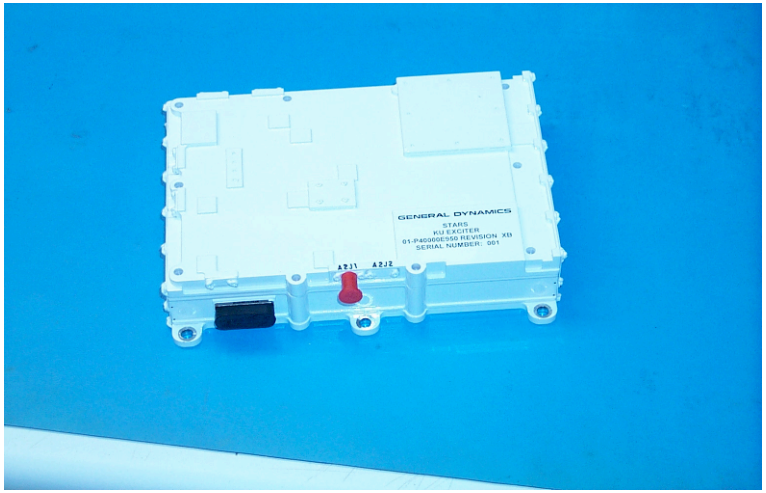
Range Safety Hardware

Range Safety Unit

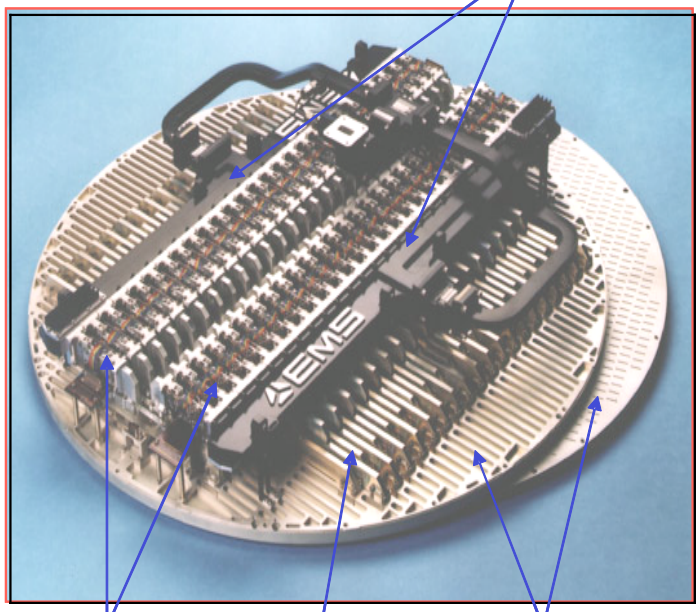
Range User Hardware



IP Formatter



Ku-band Transmitter



Ku-band Phased Array Antenna

Past/Future Flight Demo Plans

- **Global Flyer support – FY05 (Flight Demo 1a)**
  - STARS was asked to provide hardware to the Global Flyer program to provide continuous video during the 67 hour global flight
  - STARS Flight Demo #2 RS hardware was delivered January 13, 2005
  - Flight was successfully completed March 3, 2005
  - STARS system exceeded performance expectations. Eb/No's were greater than 10dB for most of the flight.

- **Flight Demo 3 – 2007**
  - Develop smaller, lighter version of the RSU for the Range Safety system
    - Use low cost transmitter (LCT) 2 developed in-house at NASA Wallops and port C&DH functionality into digital signal processor on LCT2
    - RSU dimensions would be roughly 5"x5"x6" (with internal high power amplifier)
    - RSU weight would be roughly 3 lbs
  - Perform flight test on a hypersonic vehicle over the horizon
    - Sounding rocket is baselined, however, possible opportunity on expendable launch vehicle (ELV)

- **Flight Demo 4 – 2008**
  - Develop Ka-band transmitter and phased array antenna for Range User system
  - Re-fly RSU design from Flight Demo 3 with enhancements
  - Perform flight test

QUESTIONS

- ???