Space-Based Range

Space-based range, formerly called *space-based range demonstration and certification* and *space-based telemetry and range safety*, is a multicenter NASA proof-of-concept project to determine if space-based communications can support the Range Safety functions (tracking data and flight termination signals) while also providing broadband Range User data (voice, video, and vehicle/payload data).

Space-based range is made up of the Range Safety and the Range User systems. The Range Safety system sends tracking data from the vehicle to the ground and receives flight termination commands from the ground. The Range User system sends high-data-rate vehicle telemetry from the vehicle to the ground. Both systems use NASA's Tracking and Data Relay Satellite System (TDRSS).

F15 Flights

Between November 2006 and February 2007, there were 11 space-based range flights on an F15-B at Dryden Flight Research Center. The primary goal for the Range User system was to test a 184-element TDRSS Ku-band (15 gigahertz) phased-array antenna with data rates of 5 and 10 megabits per second. The figure to the right shows the Range User antenna mounted behind the cockpit of an F15. The Range Safety system tested its ability to maintain lock with two TDRSS satellites simultaneously on a highly dynamic aircraft simulating an out-of-control launch vehicle and to transition between receiving forward commands from the launch head and TDRSS.

Because the Range Safety system used four S-band telemetry antennas (two forward and two return, with one set of each on the top and bottom of the aircraft), the antenna patterns were measured while they were mounted on the aircraft at the Benefield Anechoic Facility at Dryden Flight Research Facility.

The Range User antenna was electronically steerable in elevation and mechanically steerable in azimuth. The antenna was 29.5 inches in diameter, 13 inches deep, and weighed 119 pounds. Custom algorithms used the vehicle position and attitude to steer the antenna towards TDRSS. All the Range User flights used TDW (one of the TDRSS satellites) at 174º W longitude.

Data Results

The data was a combination of digitized, compressed black and white cockpit video, Range Safety tracking and transceiver data, and aircraft and antenna controller pulse-code modulated

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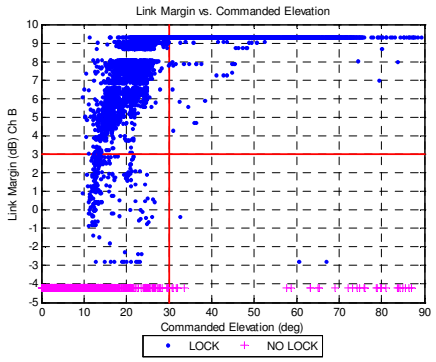
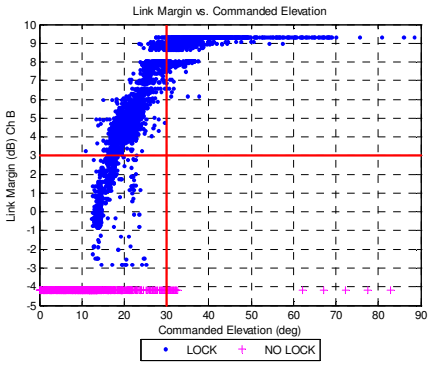
data streams; internal protocol data formatting was used. The antenna controller data stream was sampled at 1 hertz to correlate with the uncorrected error rates measured by the White Sands TDRSS ground station.

The figure below shows the link margins as a function of antenna elevation for a 5 and 10 megabits per second flight. It was not possible to measure link margins greater than 9 decibels, so it can only be said that the link margins were greater than 9 decibels for elevations above 30 degrees.

Link Margin vs. Antenna Elevation





5Mbps Flights (4)

- **No Lock conditions due to**
  - **TDRS passing through antenna zenith**
  - **Aircraft dynamics exceeding azimuth performance**

10Mbps Flights (2)

- **No Lock conditions due to**
  - **TDRS passing through antenna zenith**
  - **Delayed signal re-acquisition at beginning of test maneuver**

Note: No coverage was guaranteed by the manufacturer below 30º elevation.

The following table summarizes the percentage of locked frames for the Range User flights. The pointing error was typically much less than 1 degree. The measured data and video latency was about 0.4 seconds.

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Flight	% Locked at WSC	Notes
1	99.91%	5 megabits per second
2	88.16%	5 megabits per second, TDRSS Autotrack Problem
3	99.95%	5 megabits per second
4	98.16%	5 megabits per second, Intentionally exceeded antenna azimuth performance
5	99.78%	5 megabits per second
6	99.33%	10 megabits per second
7	99.89%	10 megabits per second

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The Range Safety system used the previously flown S-band transceiver to validate the 840 bits per second forward link and the 10 kilobits per second return link. Several “fly-away” maneuvers were done to test the transition from launch head to satellite for the forward links and showed that there was a reasonably smooth transition between the launch head and TDRSS within 10 to 20 kilometers of the launch head for a launch head power level of -84 dBm. The CA (coarse acquisition) code Global Positioning System receiver performed well and had very few dropouts, even during highly dynamic maneuvers.