

## Space-Based Range



Global Positioning  
System (GPS)  
Metric Tracking

Space-Based Range (SBR), previously known as Space-Based Telemetry and Range Safety (STARS), is a multicenter NASA proof-of-concept project to determine if space-based communications using NASA's Tracking and Data Relay Satellite System (TDRSS) can support the Range Safety functions of acquiring tracking data and generating flight termination signals, while also providing broadband Range User data such as voice, video, and vehicle/payload data.

There was a successful test of the Range Safety system at Wallops Flight Facility (WFF) on December 20, 2005, on a two-stage Terrier-Orion spin-stabilized sounding rocket. SBR transmitted GPS tracking data and maintained links with two TDRSS satellites simultaneously during the 10-min flight. The payload section deployed a parachute, landed in the Atlantic Ocean about 90 miles downrange from the launch site, and was successfully recovered.

During the Terrier-Orion tests flights, more than 99 percent of all forward commands and more than 95 percent of all return frames were successfully received and processed. The time latency necessary for a command to travel from WFF over landlines to White Sands Complex and then to the vehicle via TDRSS, be processed onboard, and then be sent back to WFF was between 1.0 s and 1.1 s. The forward-link margins for TDRS-10 (TDRS East [TDE]) were 11 dB to 12 dB  $\pm$  2 dB, and for TDRS-4 (TDRS Spare [TDS]) were 9 dB to 10 dB  $\pm$  1.5 dB. The return-link margins for both TDE and TDS were 6 dB to 8 dB  $\pm$  3 dB.

There were 11 flights on an F-15B at Dryden Flight Research Center (DFRC) between November 2006 and February 2007. The Range User system tested a 184-element TDRSS Ku-band (15 GHz) phased-array antenna with data rates of 5 Mbps and 10 Mbps. This data was a combination of black-and-white cockpit video, Range Safety tracking and transceiver data, and aircraft and antenna controller data streams. IP data formatting was used. The Range Safety system used the previously flown S-band transceiver to validate the forward and return links. Several “flyaway” maneuvers tested the transition from launch-head to satellite for the forward links.

Figures 1 through 3 show the phased-array antenna mounted on the F-15 and architecture of the sounding rocket. Figure 4 shows the Range User return link margins as functions of antenna elevation for 5-Mbps and 10-Mbps flights. Link margins greater than 9 dB could not be measured, so it can only be said that the link margins were greater than 9 dB for elevations above 30°.

During the F-15 test flights, custom algorithms used the vehicle position and attitude to steer the phased-array antenna toward TDRSS West (TDW) at 174° W longitude with a pointing error typically much less than 1°. The measured data and video latency for the Range User system was about 0.4 s. More than 99 percent of the Range User frames were locked for both 5 Mbps and 10 Mbps when the antenna azimuth performance was within nominal operating parameters and more than 98 percent when these parameters were intentionally exceeded. There was a reasonably smooth transition between the Range Safety launch-head and satellite



Figure 1. Sounding rocket launch.

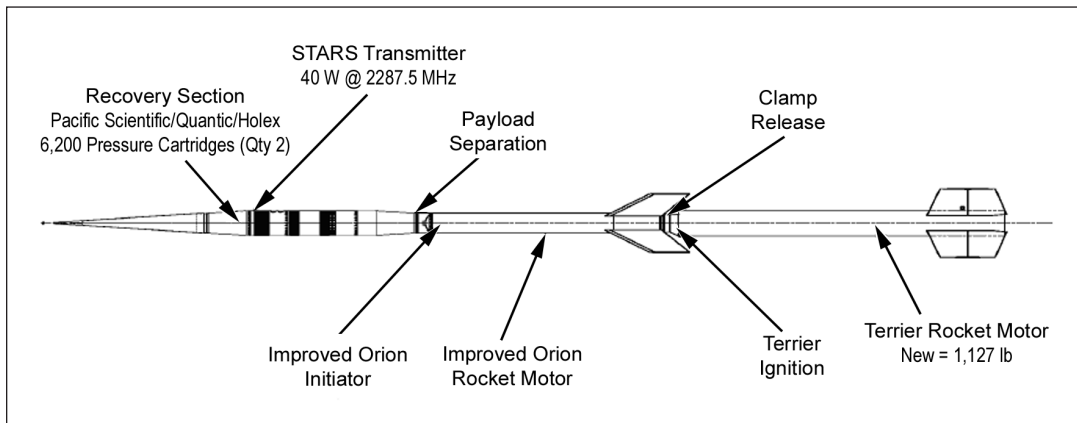


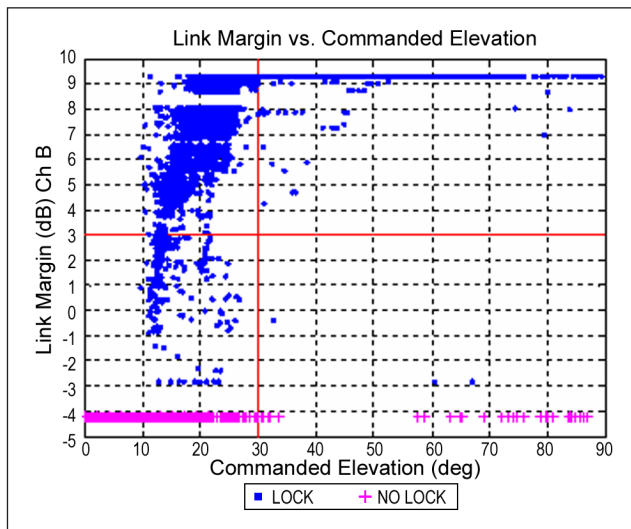
Figure 2. Sounding rocket.

forward links within 10 km to 20 km of the launch-head for a launch-head power level of  $-84$  dBm. The antenna pattern of the four S-band telemetry Range Safety antennas on the F-15 (two forward and two return, with one set of each on the top and bottom of the F-15) was measured at the Benefield Anechoic Facility at DFR.

Contact: Dr. James C. Simpson <[James.C.Simpson@nasa.gov](mailto:James.C.Simpson@nasa.gov)>, NASA-KSC, (321) 867-6937

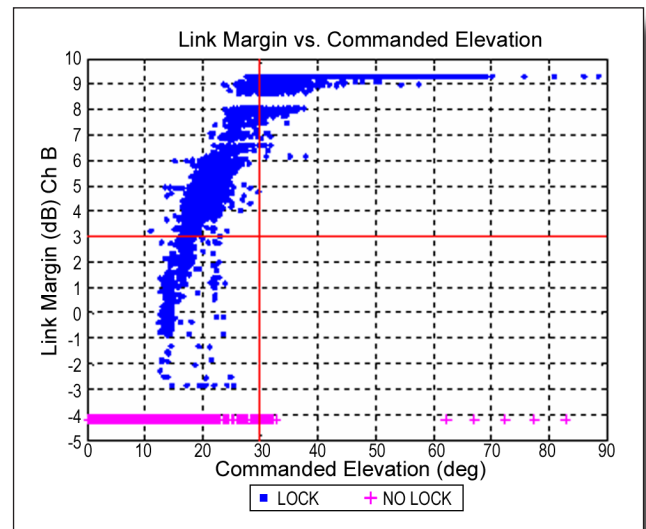


Figure 3. Phased-array antenna on the F15.



5-Mbps Flight

5-Mbps Flight No-lock conditions caused when TDRS passed through the antenna zenith and the aircraft dynamics exceeded azimuth performance.



10-Mbps Flight

No-lock conditions caused when TDRS passed through the antenna zenith and signal reacquisition was delayed at the beginning of the test maneuver.

Figure 4. Link margin results for 5- and 10-Mbps flights. Note: No coverage was guaranteed by the manufacturer below  $30^\circ$  elevation.