



7 July 2003

To: Thomas Thompson, Martin Pätzold

From: Sami Asmar & Aseel Anabtawi (RSSG)
Richard Simpson (Stanford University)

Subject: **Report on First DSN Radio Science Test Support for Mars Express**

The DSN Radio Science test for Mars Express on DOY 187 (6 July 2003) was successfully completed. This is the first in a series of activities that span the period DOY187 - DOY200. The tracking and data acquisition took place at DSS-43 (Canberra 70-m station) with support from the NOPE office, ESOC, and RSSG. The acquisition of open-loop Radio Science Receiver (RSR) data was conducted remotely by the RSSG.

This activity was intended to specifically test procedures outside of the normal operations for the purpose of the Mars Express Bi-static Radar (BSR) Radio Science experiments that study the electrical properties of the Martian surface. The BSR calibration procedures included Y-Factor measurements, cold sky and ambient load in the pre-cal and insertion of a 12 K noise diode at pre-selected times throughout the pass.

Although this pass was scheduled primarily to check end-to-end function of DSN 70-m systems to be used for BSR, it also included X-band uplink, X/X and X/S ranging, and various downlink modulation states.

RSR Configuration:

RSRs were configured for 16-bit samples and 25 kHz (complex) sampling rates; 100 kHz sub-channels were also set up in case they were needed for searching and monitoring. Disk space available before the tests was 54.2% (RSR1) and 58.8% (RSR2); it appeared that disk space was being used at the rate of about 3% per hour of recording.

Pre-Cal:

For pre-cal measurements (cold sky, noise diode, and ambient load), the following Fgain settings looked good (in retrospect) at DSS 43. Slightly different values were actually used for the test.

<u>UWV</u>	<u>RSR</u>	<u>Fgain</u>
X-RCP	1A	60
S-RCP	1B	63
X-LCP	2A	60
S-LCP	2B	63

The station reported a problem with the cabling to the Y-factor instrumentation that was fixed. Times shown below are approximate, because the noise diodes have to be switched on and off manually, and the RSR's were started and stopped manually. Ambient load temperatures were reported later (15:46); these were presumably the temperatures at the pre-cal time.

Ambient Load Temperature

S-band #1 19.69C
 S-band #2 19.88C
 X-band #1 20.81C

Tracking:

The spacecraft came up with X-band downlink ON via the high-gain antenna, COH ON (but no uplink). X-band telemetry ON (modulation index 1.25 and symbol rate 209715.2 sps), and (uplink) command rate set to 2000 bps.

The DSN generated predicts but only for X-band; RSSG generated predicts for S- and X-bands (for one-way) and compared RSSG X-band predicts with the DSN X-band predicts and found them to be very close. The following looked like good settings for tracking (Fgain is in dB):

UWV	RSR	Predicts	2-Way (TLM ON)		1-Way (TLM OFF)	
			Fgain	Offset	Fgain	Offset
X-RCP	1A	DSN 1-way	90	+7500	110	0
S-RCP	1B	RS 1-way	90	0	90	0
X-LCP	2A	DSN 1-way	70	+7500	70	0
S-RCP	2B	RS 1-way	60	0	60	0

Timeline:

13:40 Begin pre-cal (30 minute delay from time in SOE in order to obtain four closed loop receivers - rather than the two originally scheduled)

13:50 Pre-Pass Briefing by MEX MOPS; several questions by DSS 43

14:15 RSR configuration for pre-cal SNT measurements

UWV RSR Fgain

X-RCP 1A 60
 S-RCP 1B 60 (this turned out to be too little)
 X-LCP 2A 60
 S-LCP 2B 70 (this turned out to be too much)

14:18 RSR recording ON

14:21 Noise diodes ON

14:23 Add X-band ambient load (noise diodes remain ON)

14:24 Add S-band ambient loads (noise diodes remain on) some clipping on S-LCP

14:26 All noise diodes OFF

14:28 End of procedure

14:32 End RSR recording

- 14:49 Moving to point
- 14:57 X U/L transmitter ON
- 15:22 S-band ranging in lock
- 15:45 Re-configured RSR's and started recording simultaneously

<u>UWV</u>	<u>RSR</u>	<u>Predicts</u>	<u>Fgain</u>	<u>Offset</u>	<u>Plot Set</u>
X-RCP	1A	DSN 1-way	90	+7500	A
S-RCP	1B	RS 1-way	90	0	A
X-LCP	2A	DSN 1-way	70	+7500	B
S-LCP	2B	RS 1-way	60	0	B

The offsets placed the carrier near the center of each spectrum.

- 16:03 COH OFF; S-band carrier shifted to about -1500 Hz in spectra, X-band to about -9000 Hz
- 16:05 Removed frequency offsets; all carriers then at about -1500 Hz in their respective spectra (plot sets C and D)
- 16:15 Noise diodes ON
- 16:20 Noise diodes OFF
- 16:27 Accidentally stopped S-LCP recording (16:27:56 - 16:28:07)
- 17:04 X-band telemetry OFF (X-RCP saturates)
- 17:06 X-band Fgain reset to 110 (plot set E and F)
Spurs at >50 dBc appear around carrier at spacings of about 60 Hz
- 17:10 Noise diodes ON
- 17:15 Noise diodes OFF
- 18:05 X U/L transmitter OFF
- 18:20 Noise diodes ON (late)

The following Px/N0 readings were read from the displays to see whether any effects of the noise diodes could be detected in real time. Only S-LCP shows any signs of detection; in fact, the X-RCP levels suggest a *negative* correlation with noise diode state.

Px/N0 From Displays (dB)				
UTC	X-RCP	S-RCP	X-LCP	S-LCP
	RSR1A	RSR1B	RSR2A	RSR2B
18:22:00	83.33	72.27	59.67	47.37
18:22:30	83.56	72.32	60.64	47.45
18:23:00	83.25	72.20	58.91	47.39
18:23:30	83.43	72.28	61.16	47.55
18:24:00	83.46	72.42	59.83	47.56
18:24:30	83.34	72.44	57.62	47.50
18:25:00	83.20	72.40	58.45	47.14
18:25 Noise diodes OFF				
18:25:30	83.25	72.44	58.95	48.06
18:26:00	83.23	72.42	58.97	48.18
18:26:30	83.30	72.33	58.68	48.25
18:27:00	83.14	72.48	60.50	48.22
18:27:30	83.30	72.40	58.57	48.24

18:33 Plot set G and H
 19:00 Noise diodes ON
 19:05 Noise diodes OFF
 19:07 X-band telemetry ON (spurs at 60 Hz spacing replaced by dense "grass" in spectrum as much as 20 dB above original noise level)(plot sets I and J)
 20:07 X-band U/L transmitter ON, sweep ON
 After a couple minutes, the X-band carrier stabilizes at about -5000 Hz, S-band at about -3000 Hz.

Y-Factor Results

	<u>Y-Factor</u>	<u>T-Op</u>
<u>Precal</u>		
X1	12.618	16.378
X2	12.347	17.349
S1	10.66	25.373
S2	10.62	25.971

	<u>Y-Factor</u>	<u>T-Op</u>
<u>Postcal</u>		
X1	12.773	15.861
X2	12.589	16.533
S1	12.948	14.983
S2	10.649	25.753

There is a discrepancy with the S1 pre & post cal. We were pushed for time to investigate this but we will be able to check this during tomorrows maintenance period. Measurements were performed utilizing the LNA instrumentation rack.

DR

Action: **Originate DR** by [John Jaatinen](#) at 2003 187 16:23

Cause: DO - Documentation

SC/User: MEX - Mars Express

Antenna: DSS43

Pass Number: 35

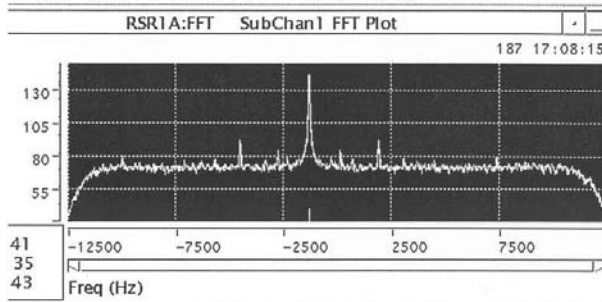
Assembly: [RSR1](#) - Full Spectrum Receiver RS1*

Outage Period: 2003 187 14:40 - 2003 187 14:54 (14 mins)

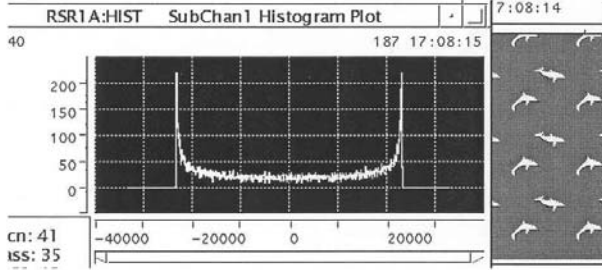
Description:

Late AOS due to problems with Radio Science configuration exercise. The first problem was that not enough time was scheduled to perform the exercise. Scheduled time was a 65 minutes for the precal, we needed at least 90 minutes. We found that we needed an extra 30 minutes to perform the radio science precal (10 minutes for RSR recording and 20 minutes for Y factor measurements on the four channels i.e. XRCP, XLCP, SRCP and SLCP channels). It was also determined during the exercise that many of the other precal activities could not be performed until the Radio science exercise was completed. For example, the transmitter was able to be warmed up during the exercise, but engineering support advised that a transmitter calibration could have had an effect on the Radio science SNT measurements, so the calibration was held off until the RS precal exercise was completed. The switching from cold sky to ambient loads on the microwave downlink paths also held us up on performing the ranging precals. The second problem was that the XLCP and SLCP paths to our noise instrumentation rack (used to perform the Y factor measurements) were not cabled correctly. This was a one off incident and should not occur on subsequent tests. We also ended the scheduled track early to allow us to perform the 30-minute Radio Science exercise postcals.

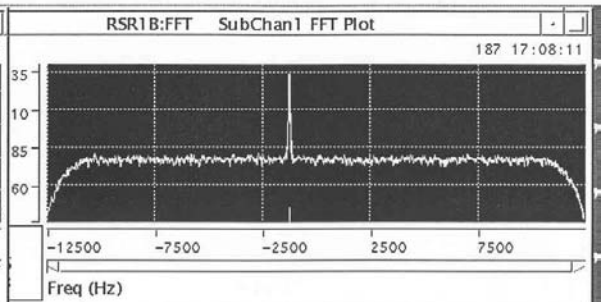
XRCP



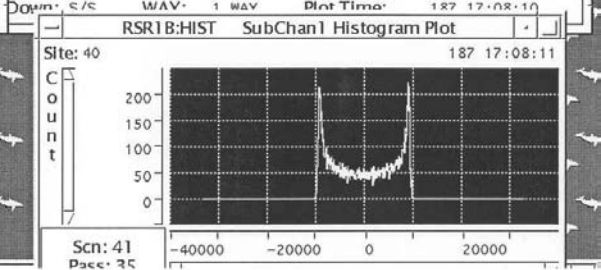
ected: YES FFTZF: 4 Bin Size (Hz): 6.10
dB-Hz): 83.41 FFTNA: 10 Resid Fq (Hz): -1269.53
e (sec): 0.410 FFTNP: 1024 Sky Fq (Hz): 8420360376.74



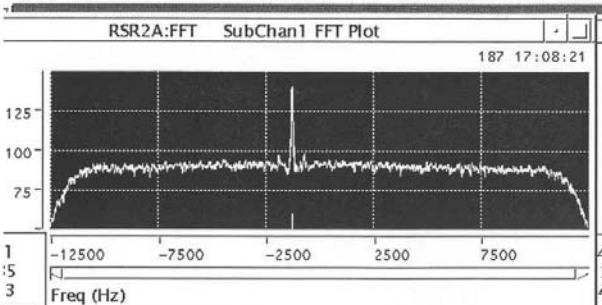
SRCP



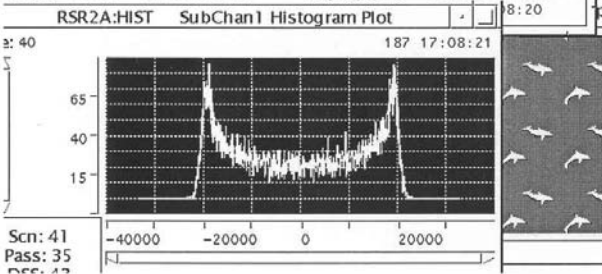
ected: YES FFTZF: 4 Bin Size (Hz): 6.10
dB-Hz): 72.30 FFTNA: 10 Resid Fq (Hz): -1226.81
e (sec): 0.410 FFTNP: 1024 Sky Fq (Hz): 2296461919.57



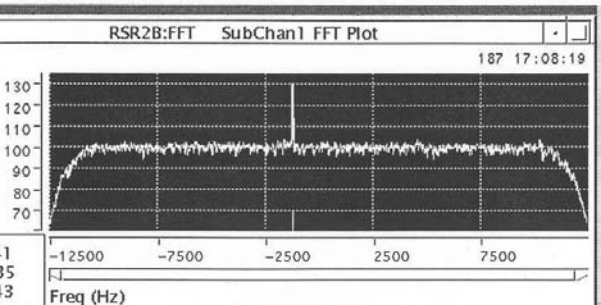
XLCP



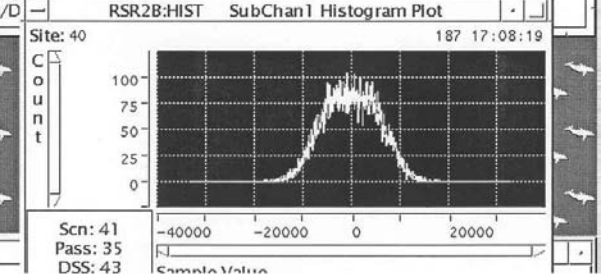
ected: YES FFTZF: 4 Bin Size (Hz): 6.10
dB-Hz): 65.55 FFTNA: 10 Resid Fq (Hz): -1263.43
e (sec): 0.410 FFTNP: 1024 Sky Fq (Hz): 8420360378.49



SLCP



ected: YES FFTZF: 4 Bin Size (Hz): 6.10
dB-Hz): 45.76 FFTNA: 10 Resid Fq (Hz): -1220.70
e (sec): 0.410 FFTNP: 1024 Sky Fq (Hz): 2296461919.57



Representative Power Spectra and histograms from DSN Radio Science Bistatic Radar Test (DOY 187, DSS-43, one-way, telemetry off)