GLOBALSTAR SATELLITE NEAR-FIELD MEASUREMENT SYSTEMS

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ABSTRACT

NSI recently completed installation of two large 7m x 7m horizontal planar scanners to support the Globalstar satellite program test activity. These systems were installed at Alcatel in France, and Alenia in Italy. These two systems are similar to the NSI system installed at Space Systems/Loral in Palo Alto, CA. described in previous AMTA papers. The companies are part of the Globalstar satellite consortium, committed to launching a constellation of satellites for mobile telephone communications. The paper will summarize the hardware configuration and the unique features of the two new test systems including high power phased array testing and the interface to the Globalstar payload for active antenna control and payload testing. In addition, range data comparing all 3 test ranges will be shown.

1. INTRODUCTION

Globalstar is a low-earth-orbiting (LEO) satellite-based digital telecommunications system that will offer wireless telephone and other telecommunications services worldwide beginning in 1998. Globalstar will provide low-cost, high quality telephony and other digital telecommunications services such as data transmission, paging, facsimile and position location to areas currently under-served or not served by existing wireline and cellular telecommunications systems. Globalstar will begin launching satellites in the second half of 1997 and will commence initial commercial operations via a 24-satellite constellation in 1998. Full 48-satellite coverage will occur in the first half of 1999.

Each Globalstar satellite contains one S-band and one L-band antenna each of which provide 16 fixed contoured beams over the Earth, that collectively subtend an angle of 54 degrees with respect to the satellite nadir. Due to the large number of satellites, and the aggressive launch schedule, the near-field range design included a number of challenges. Hewlett Packard and NSI were selected to provide a test range to meet these challenges for the Globalstar system.

2. TEST RANGE CONFIGURATIONS

NSI implemented the new test ranges using the planar near-field scanning technique to provide the scan area required for the wide beam Globalstar requirements. The system was identical in size to a system NSI previously delivered to Space Systems/Loral (SS/L). This choice allowed several advantages including commonality among test ranges for the 3 partners, minimal development costs, and a shorter delivery time for the systems. Issues involved with design of large, precision near-field scanners are discussed further in the book “Nearfield Antenna Measurements”.[1]

The SS/L range uses separate dual-polarization probes at the S-band and L-band frequencies, but since the 2 new ranges would be used primarily for production testing, a new broadband probe covering both bands was designed and implemented. A test comparison between the ranges was performed with an antenna designated the “Grand Tour” (GT) antenna, described later. A comparison of the ranges is shown in the table below.

	SS/L	Alcatel	Alenia
Range delivery and commissioning	March 1993	October, 1995	December, 1995
Globalstar GT antenna testing done	January, 1996	March, 1996	April, 1996
AUT lift stage	SSL 2m travel	NSI 0.12m travel	manual only
Chamber height	13m	10m	5.8m
Scanner Size	7m x 7m	7m x 7m	7m x 7m
RF subsystem	HP 8530A	HP 8530A + payload I/F	HP 8530A + payload I/F
Probe used for GT tests	L-band CP probe S-band CP probe	L/S-band linear probe	L/S-band linear probe

3. SCANNER AND CONTROL SOFTWARE

The 7m by 7m scanner at SS/L has been described earlier in several referenced AMTA papers.[(2)(3)(4)] For the Alcatel and Alenia implementations, a lower probe height was chosen to match the configuration of the Globalstar satellite payload. This allowed a simpler support structure than the SS/L configuration. Scanner speeds up to 0.75 m/sec (30 inches per second) are possible, allowing a complete, 7m by 7m nearfield data acquisition at the S-band test frequency in under 30 minutes. At slower speeds, the system can acquire up to 320 multiplexed channels on the fly (16 beams, 10 frequencies, and 2 polarizations). The Alcatel system is shown in Figures 1 and 2.

4. RF SUBSYSTEM FOR ANTENNA AND PAYLOAD TESTING

The RF subsystem was based on Hewlett Packard's HP 85301 antenna measurement system. The heart of the system is the HP 8530A receiver, along with the dual HP 8360 sources. The custom content of the RF subsystem includes a computer controlled Transmit/Receive reversal unit, attenuation and power level control, 16 port high speed pin switch assemblies for S-band and L-band, and a high speed frequency converter designed to allow testing the antennas and their associated transponders in the payload at the appropriate transponder frequencies. The HP RF switching network, source frequency control, and receiver triggering, are controlled by NSI's DSP-based multiplexing software. This software allows real-time position correction for all beams with the probe scanning at maximum speed without suffering from position errors normally encountered in bi-directional scanning. Figure 2 shows the location of the HP equipment racks and figure 3 shows the RF equipment block diagram and interface to the NSI control electronics and computer

The probes were designed specifically to support the Globalstar frequency bands at 1.6 and 2.5 GHz. A dual-polarization design was required to minimize test time, and a single probe covering the full frequency band was desired to eliminate the need to change probes when changing between L-band and S-band antenna test modes. SS/L had (much earlier) chosen to optimize the probes at the individual bands, since their priority was less on high throughput production and more on design verification. The probes were calibrated at 3 frequencies per band, for gain and patterns.

5. SYSTEM VALIDATION

NSI performed a several week validation of each of the new ranges using the accepted NIST 18 term model[(5)]. A combination of analyses and "self-comparison" tests were performed to assess the system accuracy for testing the Globalstar antennas and payload. An engineering model of the Globalstar antenna was used for the evaluations, and 2 of the 16 beams were selected for analysis - beam 1 (on-axis) and beam 8 (beam tilted 44 ° off axis). The results of the 18 term budget analysis is shown in figure 4 for the beam 1 principal polarization. Included in the table are the gain and EIRP measurement uncertainty, and the pattern level uncertainty at various pattern levels. Further dscription of the EIRP measurement process is in a companion paper[(6)]. During the evaluation period there were also a number of trades performed, to determine a reasonable choice for certain of the test parameters. For instance, the AUT-to-probe spacing needed to be increased to minimize the AUT-to-probe mutual coupling, but kept within acceptable limits based on the effects of truncation of the off-axis beam. The use of the dual-Z scanning technique described in a prior NSI paper[(7)], helped control the mutual coupling errors. The results achieved were consistent with the goal of making the range suitable for high volume production testing on the Globalstar antennas and payload, and maintaining acceptable measurement accuracy.

6. RANGE COMPARISON TESTINGbbb

7. CONCLUSION

This paper has described the general characteristics of three test ranges used for design and production testing for the Globalstar satellite program. The Alcatel and Alenia ranges were based on the earlier SS/L range implemented by NSI and HP, and then further optimized for specific use on the Globalstar program with a custom RF subsystem, and RF probe design.

Tests between a “Grand Tour” antenna at the three test ranges show quite good agreement in the performance of the ranges, especially considering the compromises inherent in implementing state-of-the-art satellite antenna measurement facilities.

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6. Automated EIRP Measurements on a Near-Field Range by G.F. Masters, 1996 AMTA Symposium

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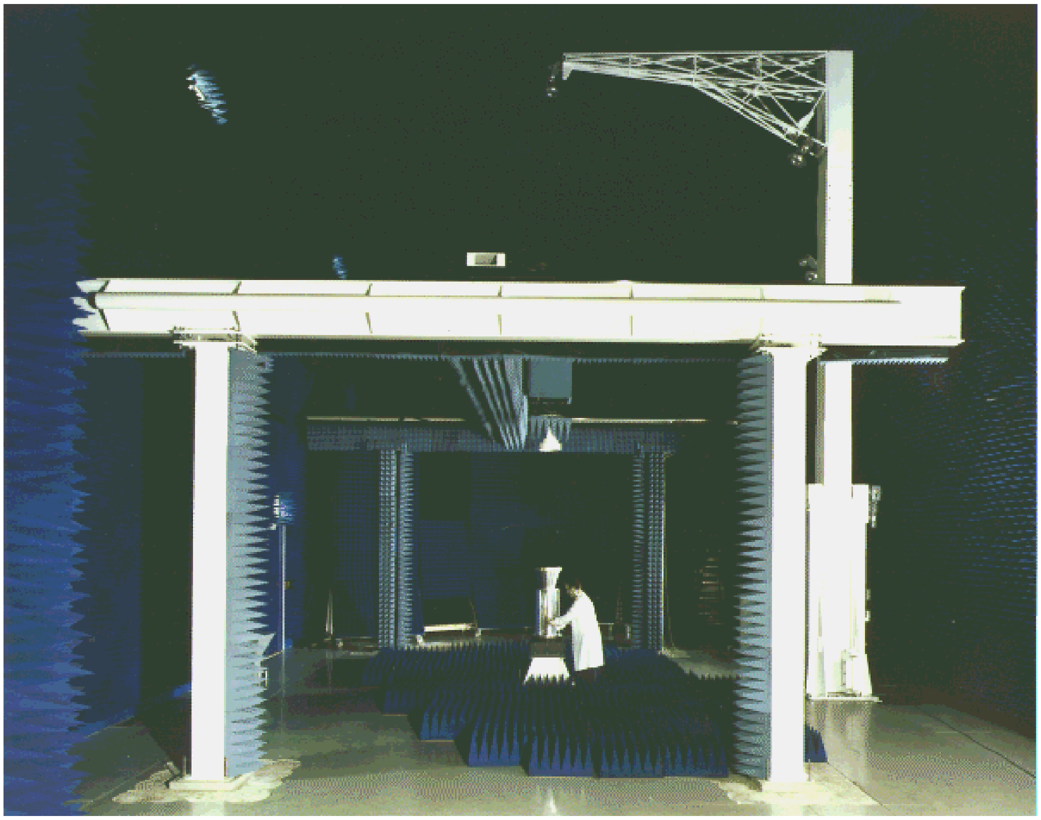


Figure 1 Alcatel NF Range Side View

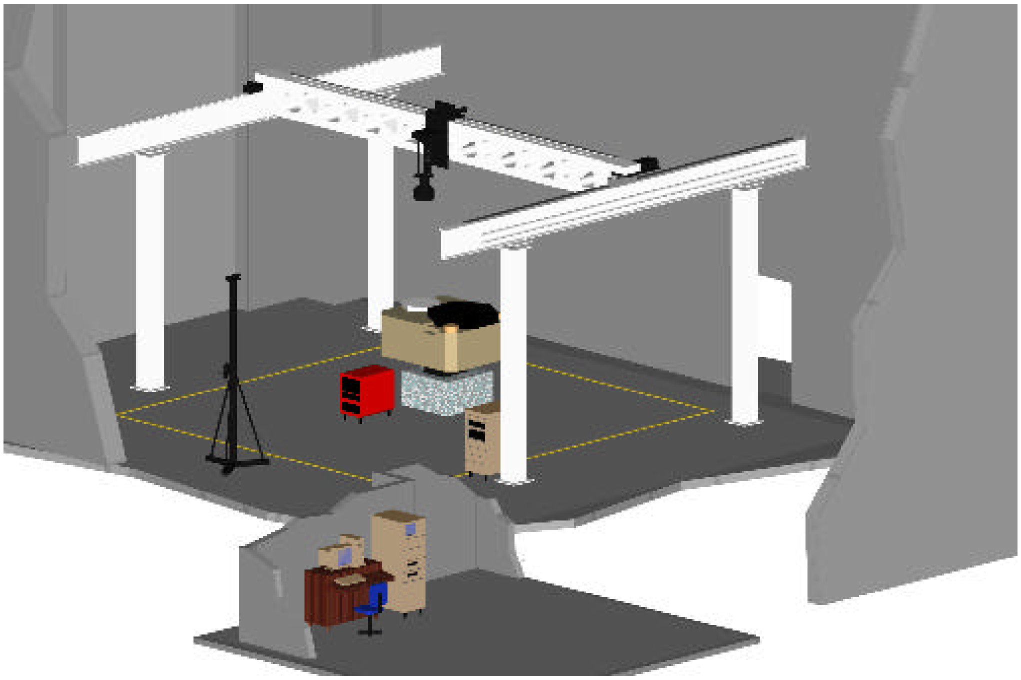


Figure 2 Alcatel Nearfield Range Showing HP Equipment and Control Room Location

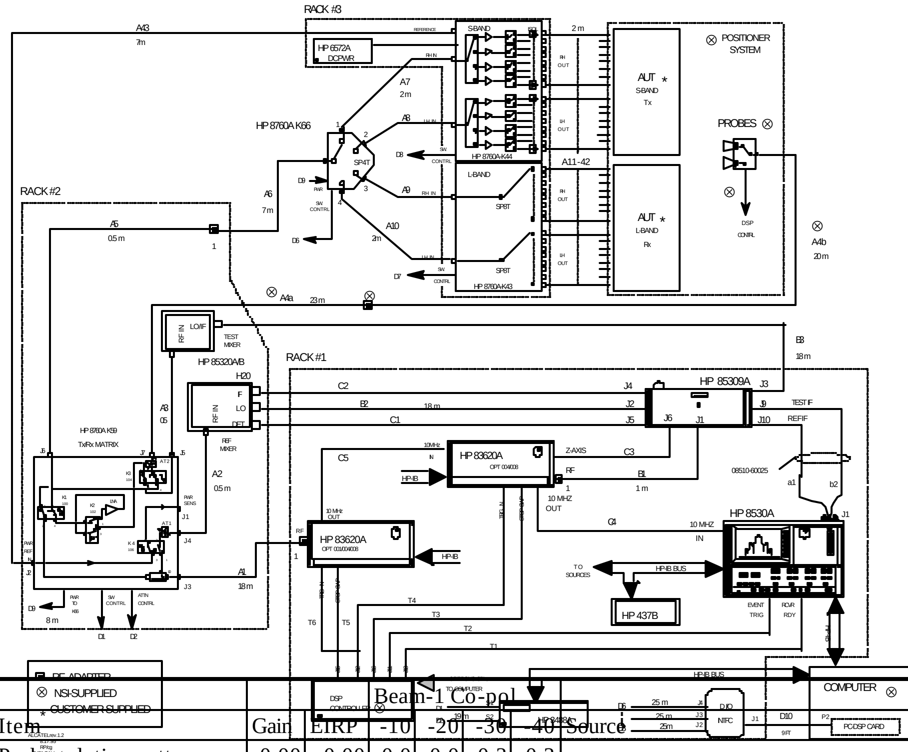
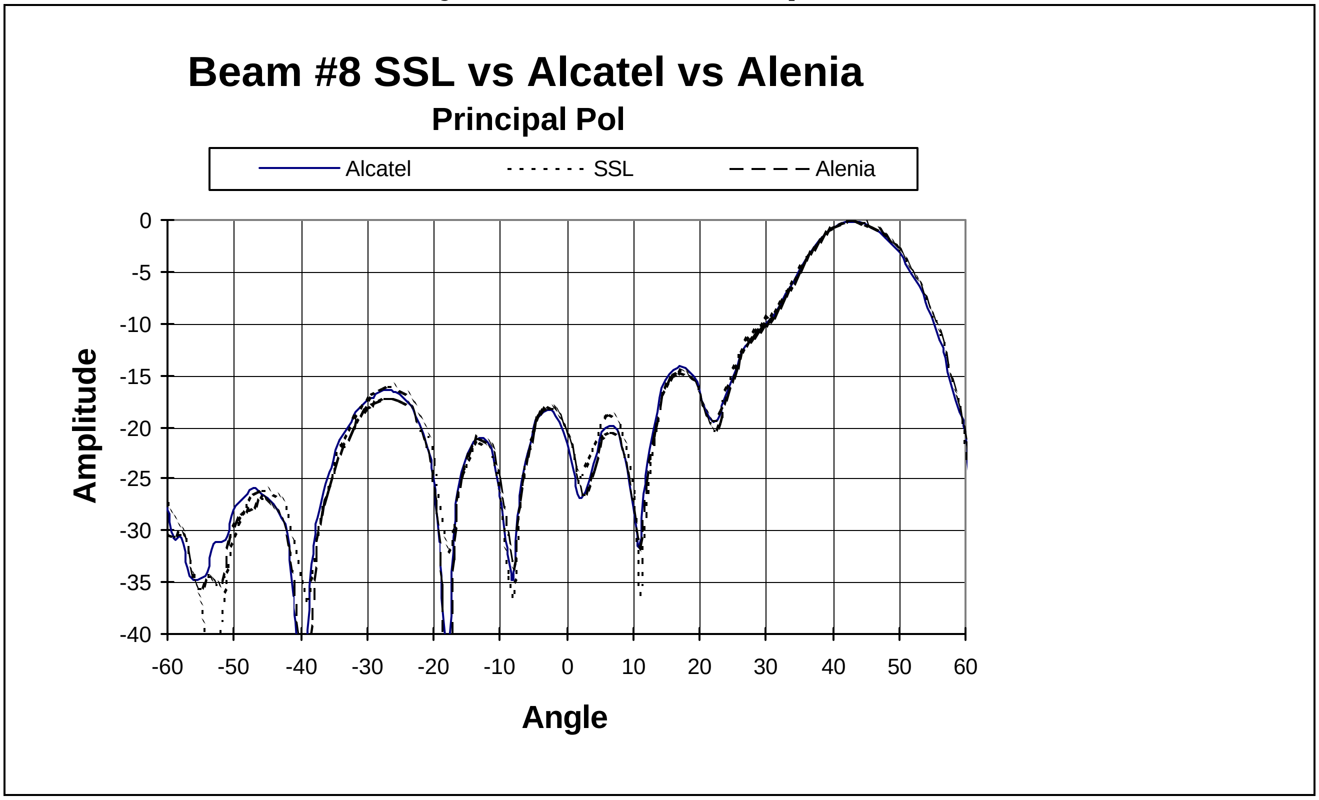


Figure 3 RF Block Diagram for Antenna Test Mode

		Beam-1 Co-pol						
Term	Item	Gain	EIRP	-10	-20	-30	-40	Source
1	Probe relative pattern	0.00	0.00	0.09	0.09	0.34	0.34	
2	Probe polarization ratio	0.00	0.00	0.01	0.04	0.14	0.40	
3	Probe gain	0.09	0.09	0.00	0.00	0.00	0.00	Does not affect relative measurements
4	Probe alignment	0.05	0.05	0.02	0.08	0.08	0.11	
5	Normalization constant	0.05	0.10	0.00	0.00	0.00	0.00	Repeatability of connectors and accuracy of attenuators
6	Impedance mismatch	0.05	0.06	0.00	0.00	0.00	0.00	Assumes a -30 dB match at all locations
7	AUT alignment	0.00	0.00	0.00	0.00	0.00	0.00	Does not affect relative measurements
8	Data point spacing	0.03	0.03	0.09	0.28	0.88	2.80	Compares Alenia file Gtour18, includes interpolation error
9	Measurement truncation	0.01	0.01	0.04	0.12	0.39	1.12	
10	XY errors	0.00	0.00	0.00	0.01	0.04	0.11	Based on a measured X-Y RMS error of 0.13mm
11	Z errors	0.00	0.00	0.00	0.01	0.02	0.06	Based on a measured Z RMS error of 0.07mm
12	Probe-AUT reflections	0.06	0.06	0.09	0.27	0.86	2.70	Compares Alenia file Gtour63
13	Receiver linearity	0.02	0.02	0.06	0.19	0.60	1.90	Simulation with HP8530 linearity specs.
14	Systematic phase	0.00	0.00	0.01	0.02	0.05	0.20	Based on cable phase tests. Files:Cable_x1.dat, Cable_y2.dat
15	Dynamic range	0.00	0.00	0.01	0.02	0.05	0.20	Measured 70 dB dynamic range
16	Room scattering	0.04	0.04	0.11	0.34	1.10	3.40	Based processing Gstar008 and comparing Z1Z3 vs. Z1aZ3a
17	Leakage and crosstalk	0.01	0.01	0.04	0.11	0.34	1.10	
18	Random errors	0.00	0.00	0.00	0.00	0.00	0.00	This term is already included in item 16
	RSS total	0.15	0.18	0.21	0.59	1.87	5.76	
	Specification	0.25	0.25	0.25	0.50	1.00	2.00	

ure 4 18 Term Error Budget - Beam 1 Principal Pol

Figure 5 "Grand Tour" Beam 8 Principal-Pol



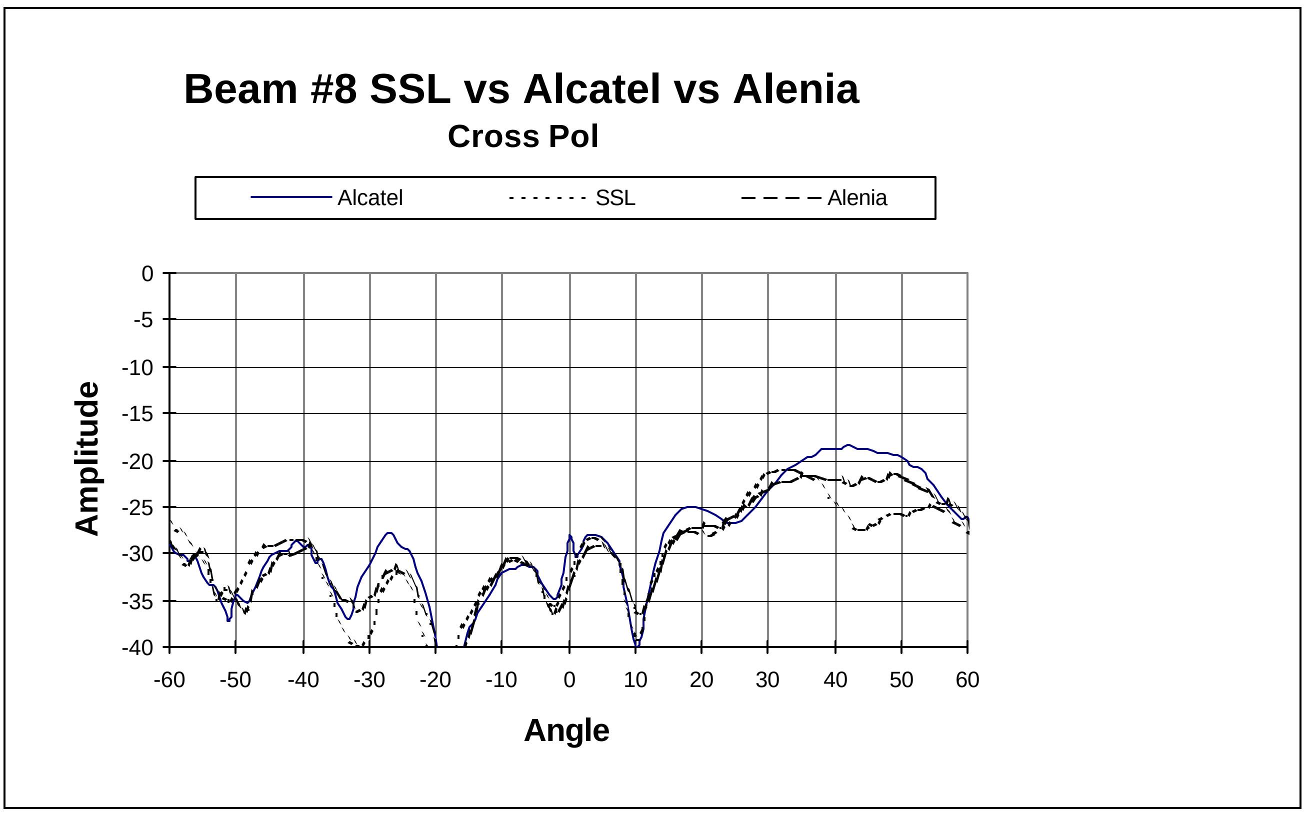


Figure 6 "Grand Tour" Beam 8 Cross-Pol