HSC's New Near-Field Measurement Facility

Antenna Measurement Techniques Association Conference
September 30 - October 3, 1996

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ABSTRACT

The Hughes Space and Communications Company (HSC) is in the process of completing the construction, installation and validation of two large horizontal near-field antenna measurement ranges. These new measurement systems are located in the existing HSC satellite factory building. These ranges will be used to measure various types of directive satellite antennas both at a unit level and at spacecraft level. The facility will accommodate mechanical integration of the test articles as well. This facility is the result of Hughes committing the time and money to create a state of the art antenna measurement facility that will be highly efficient and accurate. A detailed description of this facility's configuration, design and current status will be discussed herein.

Keywords: Near-field, Probe, Scanner, Stepper Motor, , Data Acquisition PC

1. Introduction

As the commercial satellite business booms, HSC has committed itself to producing state of the Receiver art satellites at competitive pricing. The key to success in this strategy is reduction of costs. Since antennas play a major role in the function and the critical path of a satellite build, it is desirable to build and test them in a cost effective manner. Near-field measurement systems are seen as an answer to the latter. The two new horizontal planar near-field ranges that HSC is installing will provide testing that can continue unabated regardless of the environment (except for California earthquakes). These ranges will provide additional capacity to support the growing amount of work for which HSC is under contract.

These (2) ranges will join a complement of ranges already including near-field ranges, Compact Ranges, Anechoic Chambers and Outdoor Far-field ranges.

The cost of installing a near-field antenna measurement system has dropped dramatically over the last ten years with the advent of vendors that offer such expertise. This factor makes the near-field antenna range a very viable contender in the choice of antenna measurement systems. Numerous companies and organizations have either built themselves or have had installed these types of systems. They include: Hughes (Radar, Ground Systems and Space), TRW, JPL, NIST (formerly NBS), Space Systems Loral, SPAR Aerospace, Raytheon, Lockheed Martin (Denver, CO), Georgia Tech and UCLA. The list continues to increase as this technique gains greater popularity.

2. Host Building

The two horizontal near-field ranges are located adjacent to one another within the HSC satellite factory building. about Existing bays were gutted, modified and rebuilt from the framing outwards to accommodate the two ranges. Range 1, which is the larger of the two, required a probe to floor height of 30 feet. The Range 2 probe to floor height was 16 feet (see Figures 1 ,2, and 3).

An overhead crane was already present in the bay that we used for Range 2. Part of the crane rails were removed to accommodate the range and the remaining portion retained to assist in the integration of antenna assemblies (see Figure 4). This is a 5 ton crane. Entry to the facility is accomplished by choice of (3) rollup doors. Temperature stability of the facility is very important since gradients will induce phase error in the RF cables. Since the cables are so long, the range is more susceptible to these effects. In order to make the facility thermally stable, we installed a separate air handler in addition to new vents and returns. The temperature requirement levied upon the Hughes Facilities Team was to keep the temperature uniform to within ± 1 degree Farenheit.

RF absorber is installed on the ceilings and on the upper portions of the nearby walls. In addition, the steel scanner support frames were covered with absorber. We also had one of our contractors install special pop-down sprinkler heads. One can observe just about a third of the many boxes of absorber required in this range in Figure 5. A combination of 24" and 12" were used in the facility.

The steel support frames were designed and provided by Hughes and its subcontractors. The steel support frames were designed to have no more than 0.005" of deflection as the scanner travels back and forth upon it. Cross bracing the support frame adds needed rigidity and earthquake safety. Separate # columns were installed for the Z-plane laser and the laser interferometer head. Catwalks were also a late addition to the steel frames but were much welcomed by the near-field system vendor. See Figure 6 for a view of the Range #2 Steel Supports.

3. Range 1

Both near-field systems, (which include the scanner, PC system, software and RF hardware), are provided by NSI (Nearfield Systems Inc.). The two system are nearly operationally identical with each other. The main difference is that Range #1 has a scan area that is nearly twice that of Range #2 in one direction. Therefore, I will cover the description of Range #1 in detail and briefly note the differences between the two systems in the Range #2 section.

The objective of these new ranges is to provide the capability of measuring large aperture type antennas, common to many spacecraft payloads. The ranges will be required to accommodate antennas with circular diameters reaching 16 feet and elliptical dimensions of even greater size.

Mechanical Subsystem - Scanners

Range #1 is the larger of the (2) systems with a scan plane of 22' x 40'. The NSI scanner is driven by stepper motors: one motor for the Y-axis and two motors to drive either side of the Y-axis bridge in the X direction. The Range #2 scanner has 22' by 22' scan plane. A picture of this scanner is shown at the vendor's machine shop in Figures 7 & 8. The stepper motors are powered by the Antenna Range Controller (ARC) box. This box contains the motor drivers and receives the computer commands. A picture of the ARC box can be seen in Figure 9. The scanner has 4-axes of motion. In addition to the X and Y axes, there are two remotely controlled Probe motion stages. There is a linear translator that allows the probe to move in and out along Z. This allows the operator to easily check for probe/AUT interaction. A rotation stage is also provided that allows the system to take dual polarization data. This is essential to check cross-polarization levels. These two stages are also stepper motor driven.

The stepper motor approach is a cost effective approach and accurate though it is an open loop system. For increased accuracy, NSI uses a laser interferometer to measure the absolute position of the probe and uses that information to trigger the receiver at the appropriate probe locations.

The NSI scanner itself is mated to the HSC provided steel supports and is leveled with a threaded rod arrangement. An example of this interface is shown in Figure 10.

Optical Subsystem

NSI also added two other optical systems for increased accuracy. They have added their Motion Tracking Interferometer (MTI®) which will actually correct errors in the X and Y axes. The second system is a spinning Z-plane laser and detector that can monitor the out-of-plane motion of the probe. This can be run either in an active (probe travel is corrected on the fly) or passive mode (interpolated data is used to perform phase correction).

Computer Subsystem

There are two PC's that are provided with the system: a data acquisition PC and a data processing PC. In addition to these PC's, a DEC workstation is also available to perform other types of analysis related to the testing of the various types of antennas.

Both the Data Acquisition and Processing computers are Pentium PC's running at 133 Mhz. The Processing PC does not contain any interfaces to the range system. It is only linked to the data acquisition PC for file transfer so that processing can occur while a scan is taken. The Data Acquisition PC is connected via the HP-IB bus to the receiver and positioner control box. The lasers are connected to the PC via a DSP card which also handles the timing logistics during a near-field measurement.

The NSI software is their latest 3.5.2 DOS version which is a menu driven system. Hughes is modifying its file transfer utility which will convert the processed far-field data to the appropriate Hughes format for further processing on our UNIX workstations.

RF Subsystem

The RF equipment is comprised of an HP 8530A receiver with dual sources and remote mixers. This configuration allows multi-frequency scanning with frequency in the inner loop. A standard National Instruments GPIB card is used to connect the Data Acquisition PC to the receiver. An HP 4-port PIN diode switch is provided to allow the multi-port measurements on the fly as well. The NSI software is flexible enough to place the frequency or the ports in any loop position in the scan generator.

The mixers are HP H50 coax mixers that provide performance from 2 to 50 Ghz. However, optimal performance for frequencies above 18 Ghz will require the use of waveguide harmonic mixers.

The probes initially provided with the range are all open-ended waveguide, linearly polarized. Dual port probes will be provided by individual projects that use the range per their specific requirements.

RF Cabling for the range is a combination of Andrews Heliax® cable for the fixed sections and Micro Coax™ cables for the moving portions. The cable movement is handled via cable tracks - one for the X-axis and one for the Y-axis.

RF absorber is provided on the ceiling of the range and on the side walls 10' down. Mobile absorber panels will be available to move around the AUT to reduce multipath effects if required. All steel support structure will be covered with absorber as well. The NSI scanner itself has easily removable absorber panels integrated into its design to make installation simple (see Figure 11).

AUT Tooling

Since the AUT (Antenna Under Test) will be in a "Cup Up" orientation, range tooling will be built to accomodate this configuration. Special considerations to make the support tooling stiff were given to the design of the equipment. In order to check range multipath effects, adjustments for AUT height will also be available.

Alignment in the Range

The AUT must be aligned to the range in two directions: theta and phi. The theta angle of zero degrees is orthogonal to gravity. Therefore, AUT alignment to the scanner, which itself is aligned to gravity is accomplished with a precision level or by theodolites. Phi rotation alignment brings the AUT axes into alignment with the scanner's X and Y axes. The scanner's X and Y axes are aligned orthogonal to one another at installation. The phi alignment of the AUT is performed by autocollimating a Theodolite on an optical cube attached to the AUT during the integration of the AUT. The alignment technician then rotates the AUT until it is brought into alignment with the Theodolite and hence, the scanner.

4. Range #2

Range #2 is virtuallly identical to Range #1 except that its scan area is smaller: 22' by 22'. Its height is also much lower. The probe to floor height is on the order of 16'. Therefore, this range is intended only for testing at the antenna level only while Range #1 can accommodate Spacecraft level testing if necessary.

5. Validation Plans

After the installation of each near-field system is accomplished, NSI will perform its own validation tests on the range. In addition to their own procedure, we will also require them to measure an antenna with known performance characteristics as a check of the overall performance integrity. Standard self-comparison testing will of course be performed to evaluate the error budget for the ranges.

6. Conclusions

A description of the new HSC near-field range facility has been described. Chamber 2 CATR modifications undertaken by HSC has been given. We look forward to using these ranges to their full potential while examining methods for increasing throughput. The near-field measurement technique is mature and of great value in the field of spacecraft antenna verification. Harvesting its potential fruits of increased efficiency will depend greatly on the ability to manage data, procedures, maintenance and streamlining processes that may bottleneck the measurement flow.

Hughes believes that this new near-field measurement facility will give the company the capability to make the high quality measurements required by the sophisticated antenna systems developed by R&D and production programs as we head into the next millenium.

7. Acknowledgments

The author would like to thank Jerry Zankich and Robert Ohls of Hughes Facilities for their managerial and architectural support throughtout this project and Greg Hindman of NSI for the detailed information regarding his company's near-field antenna ranges.

8. References

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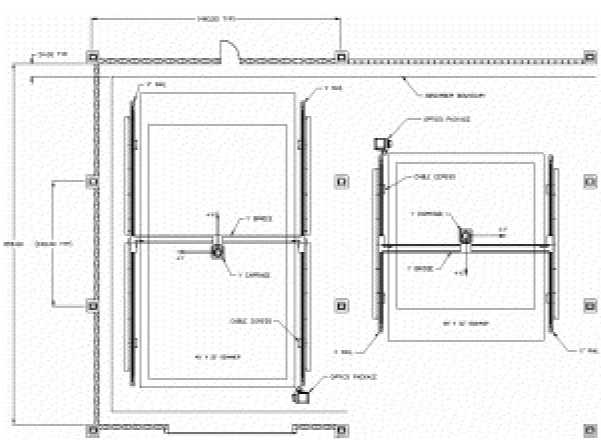

Figure 1 HSC Horizontal Near-field Facility - Plan View

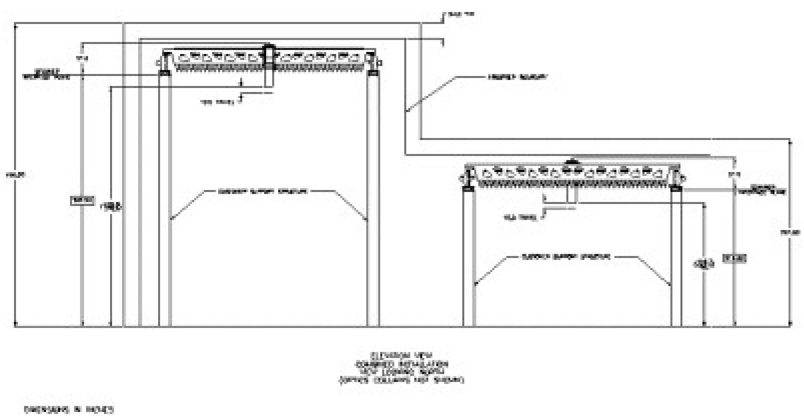

Figure 2 HSC Horizontal Near-field Facility - Elevation View

Figure 3. Range #1 Steel Support Frame

Figure 4. 5 Ton Overhead Crane


Figure 5. Boxes of RF Absorber


Figure 6. Range #2, Steel Support Frame


Figure 7. 22’ x 22’ Scanner @ Vendor Shop


Figure 8. 22' x 22' Scanner @ Vendor Shop


Figure 9. ARC Box Controller


Figure 10. Scanner Foot Mounting Pad

Figure 11. Absorber Panel Mounting

Figure 12. Range #2, Support Frame Absorber Installation