CONSIDERATIONS FOR UPGRADING A PRE-EXISTING NEAR-FIELD SYSTEM

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ABSTRACT

In the past, various companies have installed large permanent Near-field antenna measurements systems. In many instances, a test range has been constructed for a particular project or purpose. the conclusion of the project, the range may become dormant or under-utilized. In addition, a dormant range quickly becomes a potential source for spare parts. These factors combine quickly to render the once functioning range unless.

With the current industry emphasis on cost reduction, minimizing new capital purchases, and utilization of existing resources, an upgrade of a dormant test facility is a preferable path. NSI has recently upgraded an existing Near-field antenna measurement system at Hughes Space and Communications Co. Hereinafter referred to as Hughes S&C. This paper focuses upon the design considerations undertaken during the upgrade procedure.

Keywords: Near-field, Scanner, Interface, Receiver, Software, Upgrade

INTRODUCTION

The advent of low cost, portable Near-field Measurement System technology has drawn many companies into this method of antenna metrology1. This was a completely new method of testing for some of these companies. However, a few had already invested substantial capital to develop near-field measurement technology in-house. These were typically larger permanent facilities built for projects that could justify the expenditure. However, after project completion, some ranges become dormant due to lack of work. The focus of this paper is to examine the issues encountered during process of upgrading and restoring a dormant near-field range.

Upgrading an existing range provides an extremely cost effective method of increasing the test capability. If the main structure is largely intact, the facility can be upgraded and made functional for as little as 10 to 20% of the cost to build a new facility. Replacement of worn or missing mechanical parts and the interfacing to existing hardware is readily achievable.

NSI was contracted to restore a system at Hughes S&C to operation, installing new hardware as required and implementing NSI's PC-based Data Acquisition and Processing software. Full documentation for the system was included in addition to a detailed operators manual.

Following is a list of major considerations involved with Near-Field System upgrades. Several of these considerations will be discussed.

-Assessment if Project Scope

-Scanner Mechanical Integrity

-Accuracy

-Safety

-Equipment Interface

-Computer

-Software

-RF System

RANGE DESCRIPTION

The facility under examination is a Vertical Near-Field range located at Hughes S&C in El Segundo, California. This system possesses a vertical scanner with a 12' by 12' scan area housed inside an indoor anechoic chamber approximately 20 feet wide by 30 feet deep by 20 feet high (see Figure 1). In addition, the chamber also houses a Compact Range located at the end opposite the Near-Field Scanner. An HP 8530A Microwave Receiver is shared by both the Near-Field range and the Compact Range, Probe position information is provided by an HP 5501 Laser Interferometer System (see Figure 2).

The Near-Field range was originally built to support the Intesat V program with its last usage occurring sometime in the 1985 - 1986 time frame. After testing was completed, the range was not used with some of the equipment taken elsewhere. See Figure 3 and 4 for block diagrams.

ASSESSING THE PROJECT SCOPE

In order to determine the scope of this project, a detailed inspection of the facility was performed. In this particular case, the scanner itself was largely intact. This included the scanner drive mechanism (lead screw), structure, motors, HP 5501 Laser Interferometer, RF cables, and AUT Positioner (AZ over EL rotators). NSI provided the following hardware upgrades:

(1) New Servo Amplifier for X and Y Axis Motors

(2) New X and Y axis motors

(3) Indexing Switches

(4) 486/33 PC based Controller/Processor System

(5) NSI Data Acquisition/Processor Software including interfaces for the existing HP 5501 Laser Interferometer and interface to HP 8530A Microwave Receiver.

(6) C-Band Probe with motorized Roll an Z translation drives and motor controller.

(7) Hand-held keypad controller

ASSESSING THE PROJECT SCOPE

A close inspection of the scanner itself was performed. The X and Y Axes lead screws were connected via a flex coupling to separate DC Servo Motors. The initial plan to use the existing motors changed after discovering that the original motors were worn more severely than originally estimated.

The lead screws could be turned easily by hand showed no evidence of damage. However, oxidation has built up requiring cleaning and lubrication. The scanner support rails at the top and bottom were also cleaned and lubricated.

ACCURACY

During the scanner checkout phase, two parameters were examined in detailed. The Z-Plane planarity of the probe travel was measured and the Dynamic Servo Performed for both the X and Y axes turned. Servo Error is a measured parameter examined for both directions of scanner travel in either axis. This Servo Error parameter represents the difference between the predicted position vs. The actual position measured by the Laser Interferometer. This parameter is optimized to tune the Servo Performance during the integration of the Servo Amplifier, Scanner and Software. The X axis traveled at a speed of 3 inches per second (ips) and the Y axis traveled at a speed of 5 ips.

This does not affect the accuracy of the RF results since the receiver triggering is based upon the actual position measured from the Laser Interferometer. The positioning error due to the Laser Interferometer is 1.0 mil for the Y axis traveling at a velocity of 5ips and 0.6 mil for the X axis traveling at 3 ips.

The planarity of the scanner Z-plane was measured with a Theodolite sighting from the side of the scanner and measuring a 7 by 7 grid of points. The years of dormancy, which probably included some earthquakes, induced distortions. The RMS Z-planarity error could be reduced to 10 mils if the last 2 feet of the X axis were not used. Of course, NSI software performs Z-plane correction to minimize the effects of Scanner distortion. Realignment of the scanner would occur in the next phase of facility improvements.

SAFETY ISSUES

Operational safety is of prime concern. Three (30) “Kill” switches were added to the scanner to provide emergency shutdown of the scanner. There were none previously provided. The switches locations were: 1) On the Operators Console; 2) On the scanner near the Laser Head; and 3) On the back wall of the chamber. Two (2) sets of limit switches were implemented for both the X and Y axes. The innermost set of switches provided indexing functions as well as software triggered stops. The outermost switches acted autonomously to kill the Servo Amp on the occasion of overtravel.

EQUIPMENT INTERFACES

The interfaces that were required included:

1) PC to HP 5501 Laser Interferometer

2) PC to Servo Amp

3) PC to Hand Held Controller

4) PC to HP 8530A Receiver

These are described in the following paragraphs.

PC/LASER INTERFEROMETER INTERFACE

The PC was connected to the HP 5501 Laser interferometer receivers. The receivers for both the X and Y axes were connected to a Laser Quadrature Converter unit (LQC) developed by NSI which eliminated the need for the large original HP interface rack unit which had been accidentally surplused by Hughes.

The LQC was then connected to a DSP board in the PC. This combination of hardware allows the direct reading of the information from the interferometer receivers by the PC.

PC/SERVO AMPLIFIER INTERFACE

The PC was connected tot he Servo Amplifier via a DAC card. The DAC card provided an analog voltage to the Servo Amp to drive the DC servo motors. A Watchdog Timer Circuit was also included in the interface between the PC and the Servo Amp which shuts down the Servo Amp power in the event of computer failure. The Limit switches to kill the Servo Amp were directly wired from the switches to the amp.

The software indexing limit switches were directly connected to the PC via a digital I/O board.

PC/HAND HELD CONTROLLER INTERFACE

The RS-232 port of the PC was used to drive a hand held controller terminal. It functions as a remote terminal allowing the operator to walk inside the chamber and move the scanner precisely to any point. The controller features a numeric keypad with additional function keys and a two line LCD display.

PC/HP 8530A RECEIVER INTERFACE

This system sued a GPIB board used in NSI's standard systems. The event trigger to the Receiver is taken directly from the computer through a digital I/O board.

PC/PROBE ROLL/Z STAGE INTERFACE

The Roll and Z translation stages for the C-band probe are driven by low cost stepper motors. The PC is connected to these stages through an NSI Antenna Range Controller (ARC) Box. This box converts the PC's TTL signal's into the appropriate control for the stepper motors.

COMPUTER SYSTEM

The computer system is the heart of the Near-field Antenna Measurement system. It controls the Data Acquisition process with interfaces to motors, lasers and receivers. The PC that is performing both the data acquisition and processing tasks is an AST Power Premium 486/33SE model. It is a floor standing tower model with 8 MB of RAM, a 330 MB hard drive, 1.2 and 1.44 MB floppies and a Zenith 1495 14" monitor. It offered the most expansion slots of all vendors considered. Performance and cost effectiveness were important factors. This system provides a good combination of both.

The computer contains cards for performing digital input and output functions as well as a DAC card, DSP card and GPIB card. The system was installed with DOS 5.0.

The DSP card provides high speed processing capability necessary for the Laser Interferometer and multi-sequenced scan generator. This allows the measurement of complex scans when control of the remote hardware is required (see Reference 2, by G. Hindman and Dan Slater)

SOFTWARE

This system uses the standard NSI Near-Field Antenna Measurement Software Package, Version 3.3. The menu driven user interface provides a highly interactive environment and rapid response. This package also contains the interface support for DC Servo motor turning, Laser Interferometer Turin as well as stepper motor capabilities. The software performs bi-directional scanning and multiple parameter scan set up.2 The software can support the addition of multiport switches or beam forming networks at a later time.

Data processing is performed via FFT algorithms with a choice of either analytical probe models which include cosine and Open Ended Wavguide (OEWG) models, or NIST formatted measured files for probe compensation. The data is presented in a variety of formats including gray scale imaging, contour plots, 3D plots, E & H plane patterns, and ASCII files. Holographic processing is another powerful feature allowing the Test Operator to perform aperture diagnostics by examining the radiated field at any arbitrary point in X,Y and Z.

RF SYSTEM

The RF system used in the Hughes S&C Near-Field Antenna Measurement system is based on HP 8530A Microwave Receiver. The receiver is shared between the Compact Range and the Near-Field range. The HP 8530A provides excellent amplitude and phase accuracy, dynamic range, acquisition time, and excellent software support. Switching the receiver between the Compact Range and Near-Field system can be accomplished in a matter of minutes.

An HP 8511 Frequency Converter is utilized in addition to an HP 8360 series synthesizer which provides the signal source to the HP 8530A. The HP-8530A is capable of either 5000 measurements per second or 2500 measurements per second3, depending on the selection of the automatic gain ranging configuration. The receiver has an internal 100,000 point storage buffer for data triggered with the FASTCW triggering mode.

SUMMARY

The cost of refurbishing an existing Near-field facility that has been dormant or is in need of modernization can be as little as 10% of the cost to build a new facility. Hughes Space and Communications Co. now as a fully operational Near-field Range in its chamber with state-of-the-art software analysis capabilities and NSI is in the midst of upgrading another Hughes Near-field Range which was not dormant. In conclusion, the restoration of a dormant range or upgrade of a presently operating system is a good cost effective alternative for increasing capability while minimizing capital outlay.

REFERNCES

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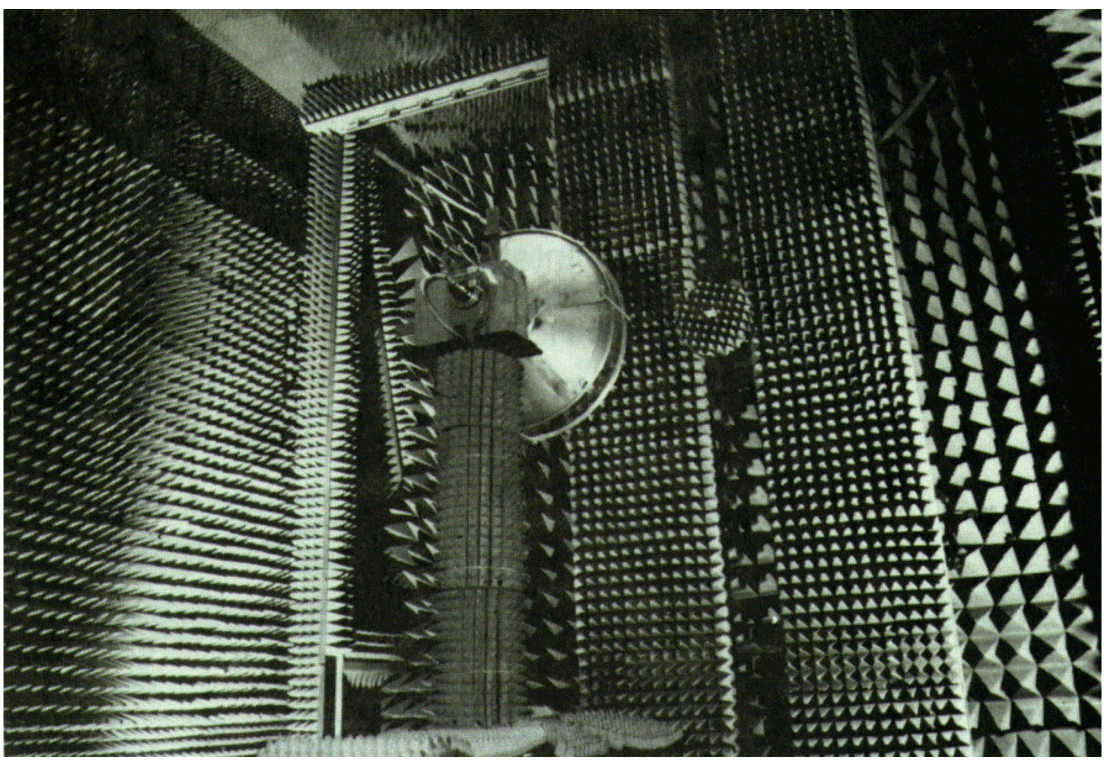

Figure 1 ***Hughes Space & Comm 12' x 12' Vertical Nearfield Scanner***

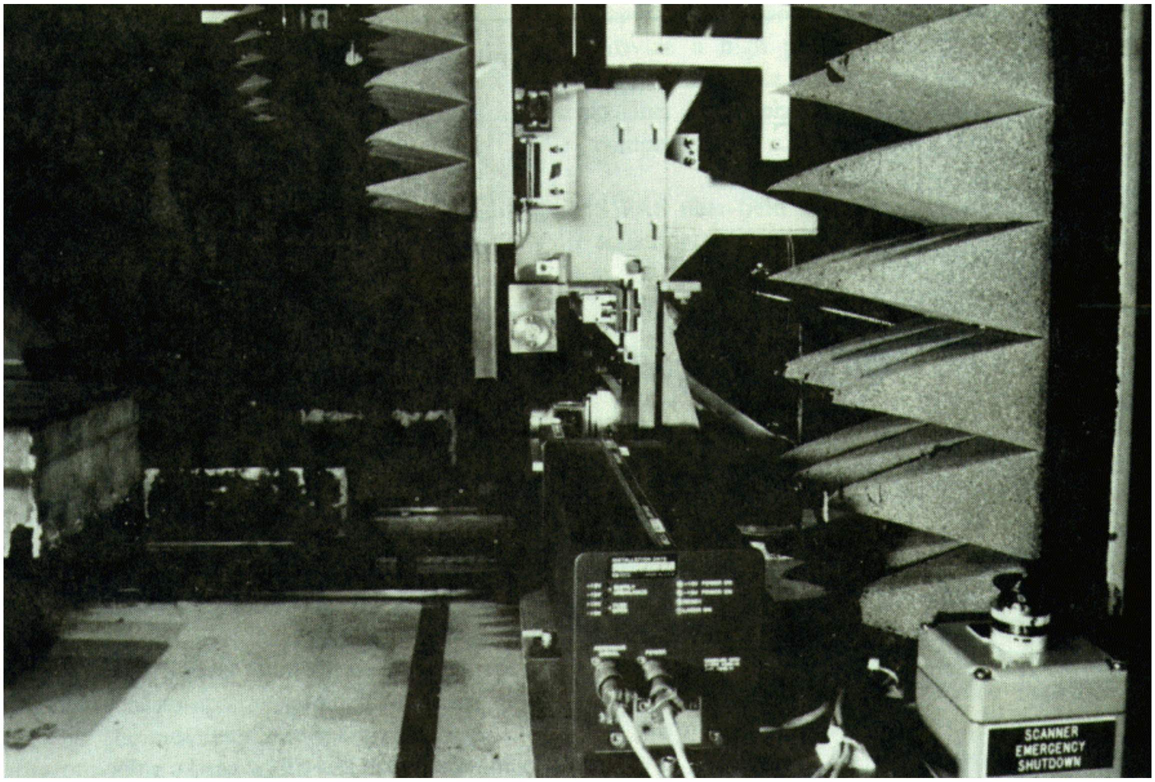

Figure 2 ***Hughes Space & Comm Nearfield Scanner Laser Interferometer***

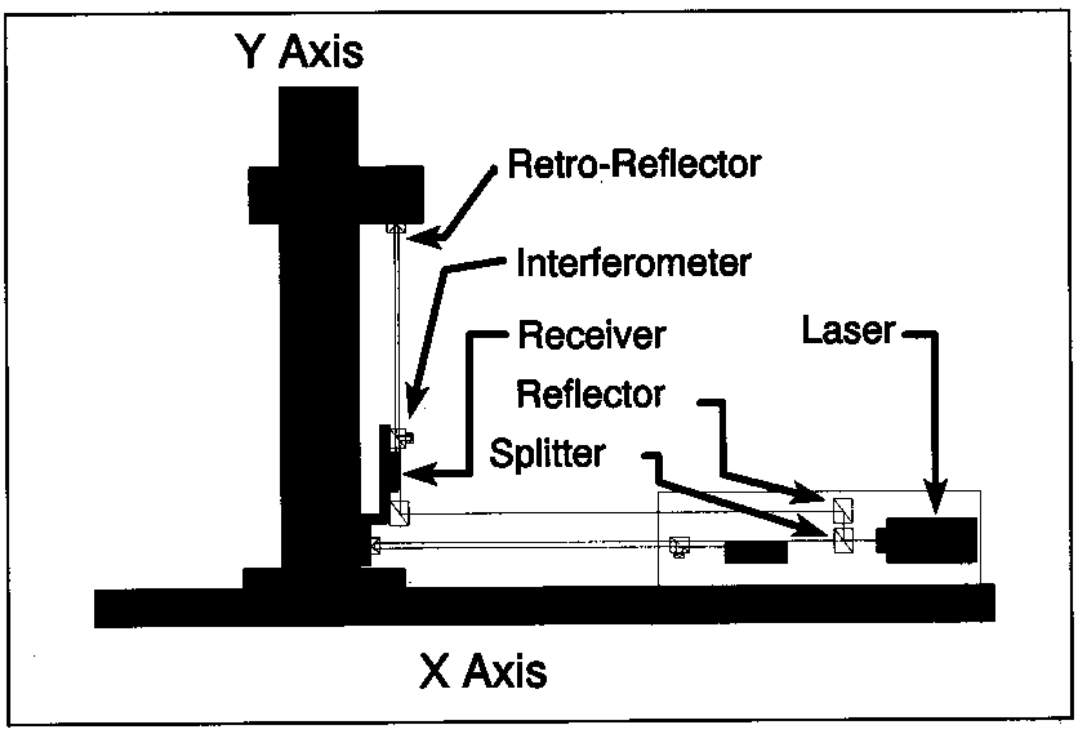

Figure 3 ***Hughes Scanner Laser Optics***

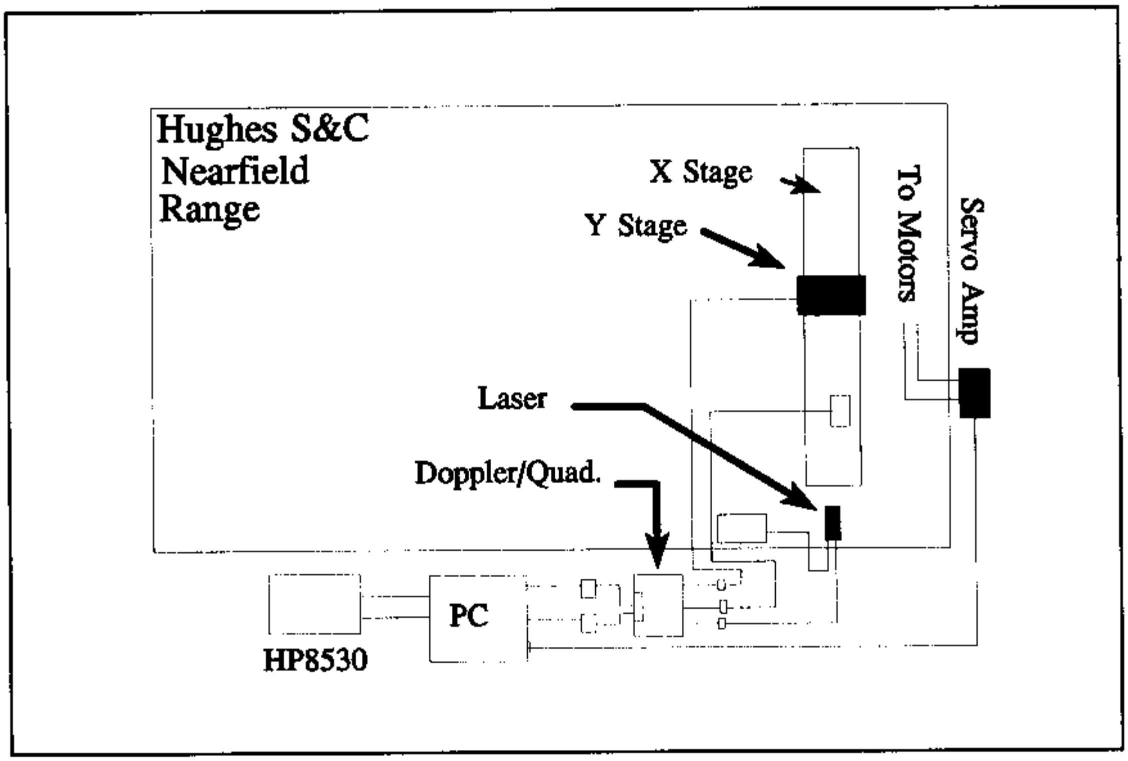

Figure 4 ***Hughes S&C Near-field Block Diagram***