INNOVATIVE MECHANICAL DESIGNS FOR SCANNERS

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ABSTRACT

Nearfield Systems Incorporated (NSI) provides antenna measurement systems to domestic and foreign, commercial and government customers with sophisticated requirements that demand custom solutions for RF, mechanical, thermal or software applications. NSI is continuously adapting existing designs to seek cost effective solutions for each customer's demanding specification. This paper discusses numerous near-field scanner designs to meet a variety of applications. Presented are designs for several vertical planar scanners, horizontal scanners, tilted planar scanners, and special scanners designed to attach to structures to test antennas in-situ.

Keywords: **Design, Facility Descriptions, Near-Field, and Scanners.**

1. INTRODUCTION

This paper discusses numerous features recently developed at Nearfield Systems Incorporated on customer projects using innovative concepts for mechanical design. Various antenna types require different near-field scanner sizes, topologies and orientations.

2. VERTICAL SCANNERS

NSI offers a variety of accurate, fast and affordable vertical planar near-field scanners ranging in size from 0.9m x 0.9m (3' x 3') to 35m x 16m (115' x 52'). All current scanners are designed using an inverted "T" tower configuration. In this configuration, a vertical tower rides on two precision rails mounted to a rigid base unit. NSI abandoned the "box-frame" design in 1992 for the inverted "T" design.

The inverted "T" design has advantages over "box-frame" designs:

- **Higher reliability** due to simplified drive system. Most "box-frame" designs require coordinated drive systems (right, left, top, and bottom).
- **Easier setup and alignment** by allowing for a greater degree of factory alignment. Most NSI scanners use a kinematic 3 point mounting system for easy system installation.
- **Reduced RF scattering** by means of a simplified mechanical structure with a reduced number of structural elements.
- **Reduced mechanical errors** due to changing probe loads since the load path of the payload is more direct.
- **Reduced thermal effects** due to a more compact mechanical structure.

Figure 1 shows a NSI model 233L 0.9 x 0.9m vertical planar scanner. This is a portable scanner designed with an aluminum base and tower. The scanner can be used to make measurements of higher gain (>15 dBi) antennas over a frequency range of S to mmWave frequencies. The model 233L scanner has a planarity of <0.076mm (0.003") RMS

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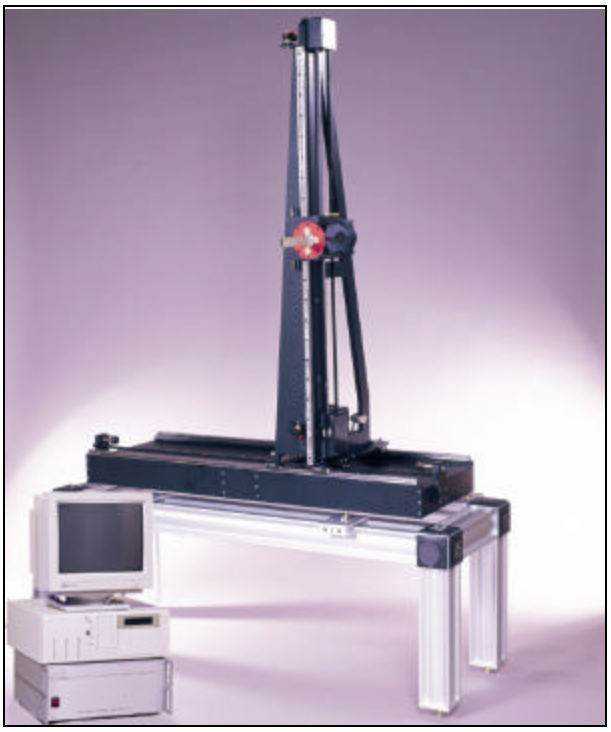

Figure 1 0.9m X 0.9m Vertical Planar Scanner

The Model 255L 1.5m x 1.5m scanner shown in figure 2 is similar in design to the 233L above and is used for larger apertures.

Figure 2 1.5m X 1.5m Vertical Scanner

Larger standard scanner models such as the Model 288L 2.4m x 2.4m (8' x 8') scanner are also available.

Antenna apertures up to 4m x 3m can be accommodated with the NSI model 1209 vertical scanner shown in Figure 3. This scanner is also based on the inverted T" design and is constructed of steel. An optional optics correction subsystem is shown and can provide probe scan planarity of <0.025mm (0.001") RMS over the entire scan plane.

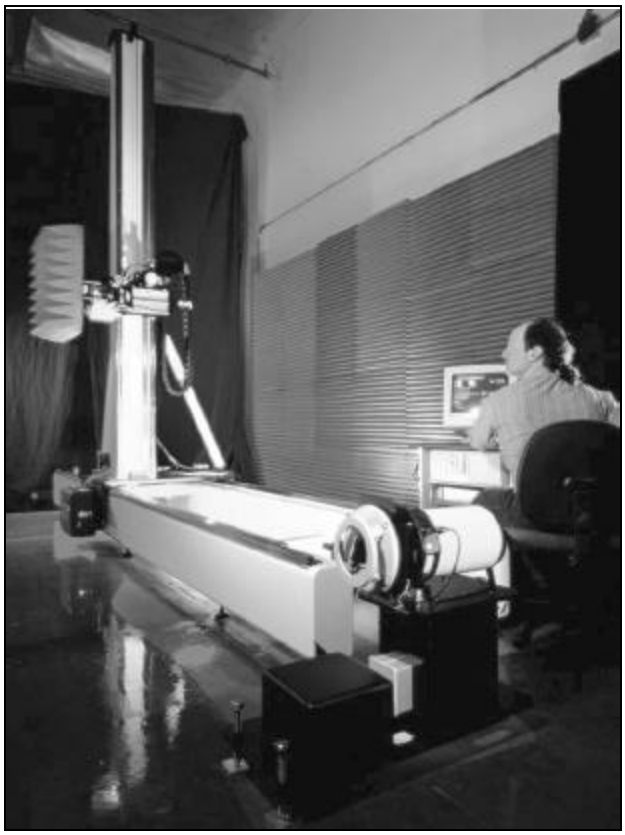

Figure 3 4m X 3m Vertical Planar Scanner

NSI will deliver a 9m x 6m combination vertical planar and cylindrical near-field scanner to the Royal Netherlands Navy (RNN) during 3Q97. This system will be used to characterize large shipboard antennas at high power. A picture of the RNN system under construction along with a concept rendering is shown in Figures 4 and 5.

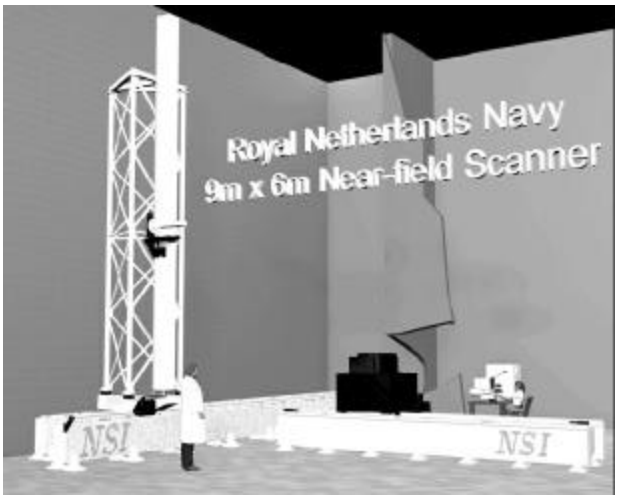

Figure 4 Rnn Combination Vertical Planar And Cylindrical System

Figure 5 Rnn System In Final Assembly In California

For the largest apertures, scanners up to 35m x 16m (115' x 52') have been delivered. As of this writing, the largest planar near-field scanner in the world is being installed in Japan. This scanner builds on the years of mechanical and applications experience developed at NSI and will provide a scan area that will accommodate the largest ground based radar antennas and reflectors. The scanner is designed to have a corrected planarity of <0.2mm (0.008") RMS over the entire scan plane. The scanner was delivered with a RF subsystem capable of operation from 1-50 GHz. A concept drawing of the scanner is shown in Figure 6. A photograph of the scanner being assembled at NSI's facilities in California is also shown in Figure 7.

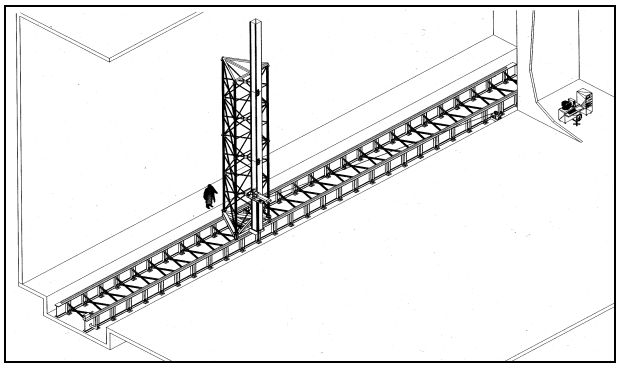

Figure 6 35m x 16m Vertical Planar Scanner

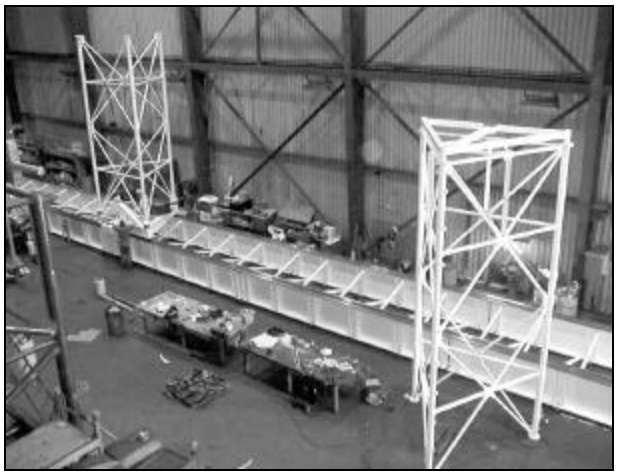

Figure 7 35m x 16m Scanner Undergoing Assembly In California

3. HORIZONTAL PLANAR SCANNERS

Horizontal planar scanners are used for testing zenith oriented antennas. Typical applications are for testing satellite antennas that are subject to gravity effects. Horizontal near-field ranges have numerous benefits over traditional compact and outdoor ranges. These benefits include:

- Complete characterization of antenna
- Minimal real-estate requirements
- Lower cost than compact range
- Co-located with spacecraft assembly area
- High accuracy and high test throughput
- No motion of test antenna or satellite
- More symmetrical gravity effects on antennas.

Figures 8 and 9 show side-by-side 7m x 7m (22' x 22') and 12m x 7m ranges installed by NSI at Hughes Space and Communications Co. in El Segundo, CA.

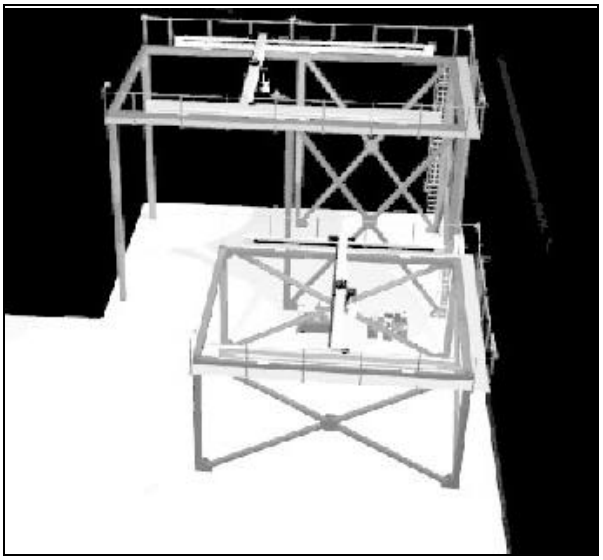

Figure 8 Hughes 12m X 7m And 7m X 7m Horizontal Near-Field Ranges

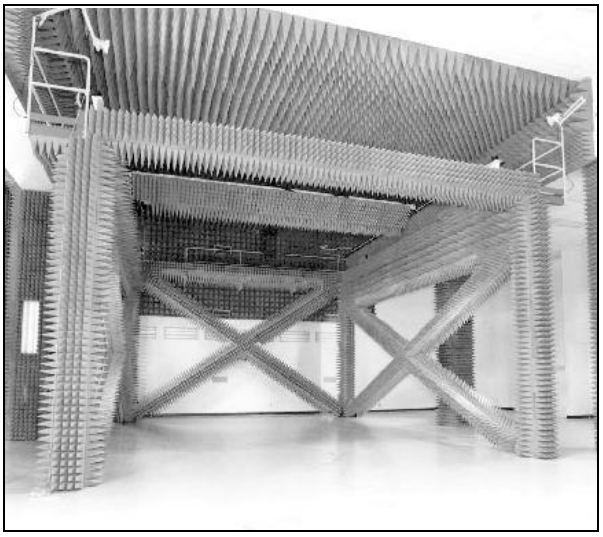

Figure 9 Hughes 7m X 7m Horizontal Near-Field Range

Figure 10 shows a 14m x 7.8m (46' x 26') horizontal near field test range that was recently installed by NSI at Lockheed Martin's Sunnyvale, CA facility. This system is being used to test commercial satellite antennas.

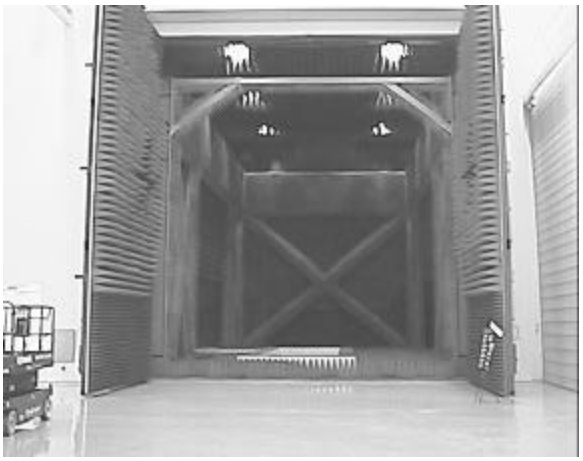

Figure 10 Lockheed Martin 14m X 7.8m (46'x 26') Nf Range

4. SPECIAL APPLICATION PLANAR SCANNERS

Special scanners have been developed to meet specific custom applications. Figure 11 shows a special-purpose lightweight scanner that was developed for an aerospace company. The requirement was for a small lightweight scanner to be used for testing feed antennas on the spacecraft. The main requirements were to cover a scan area of 0.6m x 0.6m (2' x 2') and weigh less than 13kg (30 pounds). The weight requirement was dictated by the support capacity of the spacecraft mounting points.

Figure 11 Custom Lightweight 0.6m X 0.6m Planar Scanner

Figure 12 shows the large 4.2m x 4.2m (14' x 14') Aegis antennas on board a U.S. Navy destroyer. NSI is under contract to deliver a scanner designed for in-situ testing of the large Aegis array antennas. The scanner is designed

to be assembled pierside and lifted into place by a construction crane. The scanner system is fully integrated with an anechoic shield and includes a self-contained environmental control system. The scanner system is being designed to mount to various cruisers and destroyers that have Aegis phased array antennas.

Figure 12 Aegis Array On US Navy Destroyer

Figure 13 shows a concept drawing of the scanner that would attach to the face of the array.

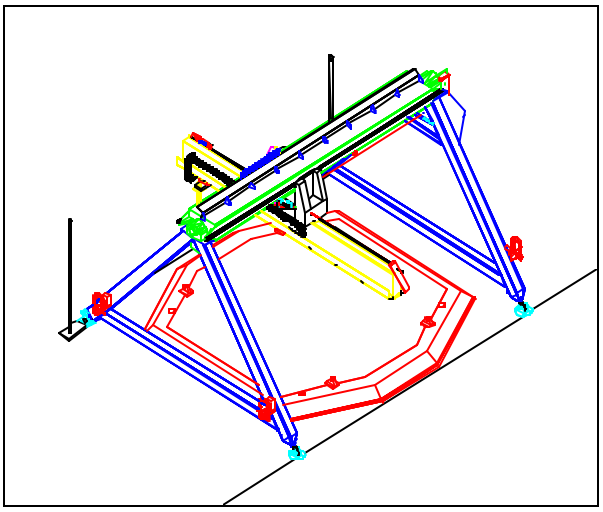

Figure 13 Planar NF Scanner Used For Testing Aegis Antennas

Figure 14 shows a novel planar near-field scanner that is currently under development for the U.S. Airforce. This scanner is designed to accommodate various ground based radar antennas. These antennas have various sizes and are at various tilt angles. The scanner NSI designed can be both raised and tilted to match the aperture of the antenna under test.

Figure 14 US Airforce Tiltable Planar Near-Field

Testing of sub-millimeter wave frequencies has been accomplished using specially designed planar scanners. Testing at these frequencies requires extremely high planarity and thermal stability. Figure 15 shows a specially developed planar scanner that was used to test NASA's sub-millimeter wave satellite SWAS. The mission of this satellite is to measure the emissions from intergalactic gas clouds. The test frequency range was 540-560 GHz. NSI built and delivered a granite base scanner that achieved a planarity of <5.0 microns (0.0002") RMS. Special thermal compensation techniques were developed on this program to minimize the phase change in the measurement cables, scanner and the AUT.

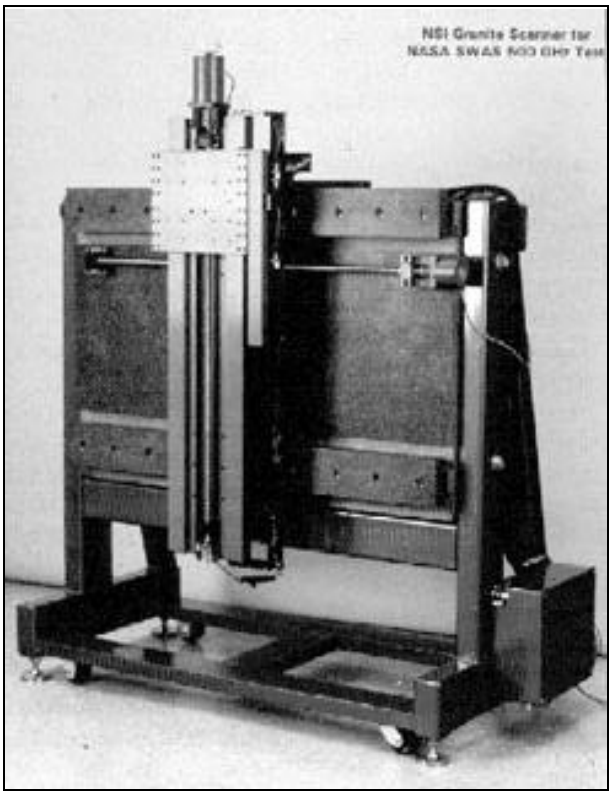

Figure 15 550 GHz vertical planar scanner

5. SUMMARY

Various near-field scanners have been developed to test a wide range of measurement applications. Planar scanner types encompass vertical, horizontal, and tilted types. Special custom scanner have also been built or are in fabrication for sub millimeter wave applications at 550 GHz and for testing large phased array antennas in-situ on board Navy ships.

References

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2. Greg Hindman and Dan Slater, "An Automated Test Sequencer for High Volume Near-Field Measurements," Antenna Measurement Techniques Association (AMTA) symposium, October 1993.