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Near-Imaging Field Tower Implementation (NIFTI)

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Introduction: The Naval Research Laboratory's Midway Research Center (MRC) located in Stafford, Virginia, has a mission to provide highly precise and repeatable signals for tailored, precision calibration and testing of national and tactical systems. Their numerous assets include three 60-ft diameter antennas, which are required to provide highly accurate RF signals. Because of their size and location, they are difficult to characterize through farfield measurements, which is as much as 25 miles away, nor is it possible through close-in nearfield measurements. A midrange calibration system has been designed and is being implemented that transforms these nearfield measurements into a farfield pattern. This provides corrected effective isotropic radiated power (EIRP), tilt angle, axial ratio, boresight, and gain, which can then be applied to the command and control system for the antennas. The Near Imaging Field Tower Implementation (NIFTI) system has proven itself during prototype tests to accurately derive farfield parameters from nearfield measurements.

Overview: The system was developed and tested using the Antenna Tracking Subsystem (ATS)-3 antenna. This antenna scans across a reflector that is mounted to an azimuth-over-elevation positioner at the Calibration Tower (Cal Tower), which is 884.5684 ft. away (Fig. 10). Nearfield amplitude and phase data are collected as the ATS-3 antenna generates a continuous wave (CW) tone and scans across the Cal Tower antenna in a series of eight cuts, each cut is 22.5 deg apart. Before this occurs though, the Bullseye (the point the NIFTI scan is centered on) is determined, which allows for amplitude and phase correction between each of the cuts. These data are then transformed to a farfield pattern using a Fourier transform (FT) technique (Fig. 11).

After postprocessing the nearfield data, the following information is stored and available for the user:

- Frequency—frequency that was entered by the operator
- Bias—site gain minus the calculated gain
- Feed input power—input power at the feed in dBm
- Axial ratio—calculated axial ratio in dB
- Polarization tilt—tilt in degrees from the horizontal
- Azimuth at peak gain—azimuth at peak gain
- Elevation at peak gain—elevation at peak gain
- Peak gain—peak gain in dB
- Peak EIRP—EIRP in dBm
- Average beam width—average beamwidth in deg
- Azimuth Nearfield Bullseye—azimuth in nearfield data
- Elevation Nearfield Bullseye—elevation in nearfield data
- Azimuth mispointing error—antenna azimuth pointing error
- Elevation mispointing error—antenna elevation pointing error
- Specified polarization—polarization entered by the operator
- Sensed polarization—polarization predicted by the antenna farfield calculator (afc)

This information is then used by the site to update the information contained in the Command and Control system to more accurately report the EIRP being transmitted out of the ATS. This information is then passed on to the client for use in their analysis.

Antenna Locations: By using the FT method, up to 0.5 deg of mis-centering can be tolerated with less than 0.1 dB of error.[2] To determine the locations of the antennas, NRL's Astrodynamics and Space Applications Office (Code 8103) surveyed control points and MRC assets by geodetic differential GPS survey methods.[3]

Capabilities: Through testing,[2] we have shown that we can detect boresight position to an accuracy of better than one-tenth of the 3 dB beamwidth at 18 GHz, or close to 0.005 deg. The overall RMS error for the system was calculated to range from 0.5 to 0.7 dB from 2.7 to 18 GHz, respectively. The power sensor calibration, phase errors, and sampling/truncation errors are the major contributors to this error. The RMS errors for all frequencies in feed power, gain, and EIRP are 0.76, 0.23, and 0.80 dB, respectively.

A separate calibration process occurs to calibrate the relative phase and amplitude to the network analyzer. This is needed to accurately determine the polarization axial ratio, tilt, and circular polarization of the 60-ft antennas. The calibration is done by mounting standard gain horns at 45-deg angles approximately 60 ft from the base of the Cal Tower to provide equal power to both horn ports.

System: The antenna used to collect the signals radiated from the ATS is a General Instruments (GI)

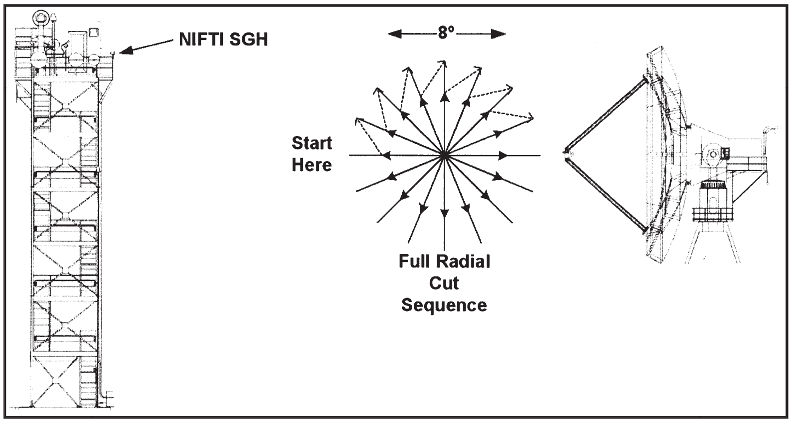

FIGURE 10
System diagram.

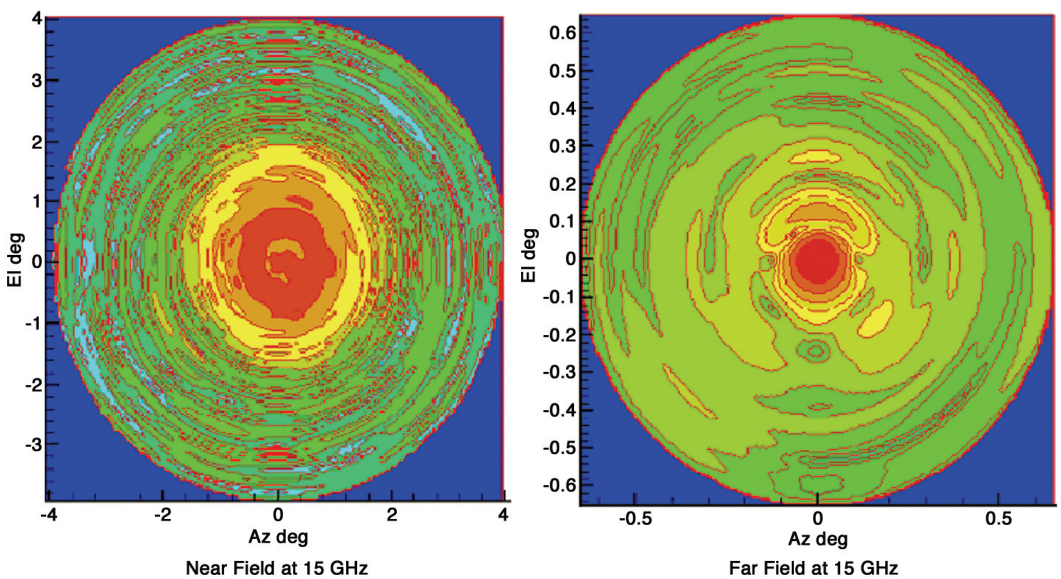

FIGURE 11
Nearfield and farfield contour plots.

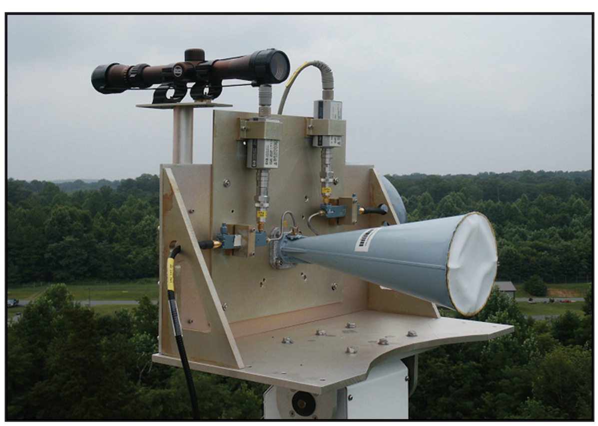

FIGURE 12
NIFTI horn assembly.

A6100 2-18 GHz dual-polarized, calibrated, gravity-referenced, circularly symmetric quad-ridged horn that is mounted on the northwest corner railing of the Cal Tower platform (Fig. 12). The horn gain and losses through the coupler were determined in the anechoic chamber and referenced to a standard gain horn (SGH). The antenna is mounted on top of an EDCS 3404a antenna control unit. Numerous pieces of test and measurement equipment were also installed in the Cal Tower as part of the NIFTI system. These include: National Instruments PXI-1045 chassis, National Instruments GPIB-ENET/100, Agilent E4419B power meter, Agilent 8341B sweep synthesizer, Agilent 8511A frequency converter, Agilent 8530A IF/detector (microwave receiver), Agilent 85395C display/processor, Datum fiber optic receiver, and Digital pulse generator.

Conclusion: NIFTI is an effective technique to calibrate EIRP, farfield directivity and beamwidth, polarization, and pointing information; it is also effective in determining azimuth/elevation encoder timing accuracies (necessary for accurate tracking), uncovering amplifier instabilities, and determining feed misalignments. Amplifier instabilities are also easily "seen" as spikes in the amplitude and phase of the nearfield data; the data collection system is also setup to do stability checks at the center of the nearfield pattern. Finally, beam mispointings in the farfield for focused feeds are indicative of feed misalignments, which can be accurately characterized with the use of either the farfield data or the nearfield phase asymmetry characteristics.

[Sponsored by SPAWAR]

References

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[2] W. Lippincott, T. Gutwein, M. Lundmark, and R. Eisenger, "Near-Field Remote Calibration Systems for MRC 60-ft Reflectors," internal NRL Code 8103 report, October 2004.

[3] J. Middour and A. Hope, "Report of the 2003/2004 Survey of Control Points and Assets at the Midway Research Center," internal NRL Code 8103 report, August 2004.