

NASA'S EXPERIMENTAL TEST RANGE (ETR)

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Abstract

NASA's Experimental Test Range (ETR) was recently completed at the Langley Research Center. ETR is an advanced indoor compact range test facility designed for performing antenna and electromagnetic scattering measurements. ETR utilizes a new dual chamber concept with a blended-edge main reflector and a Gregorian subreflector system, a test chamber design with the absorber type and placement selected for optimum performance, an advanced pulsed/CW radar with a superworkstation for fast and efficient data collection and processing, and a bridge crane for efficient model handling. Isolation from external radio frequency (RF) energy is provided by an RF shielded enclosure. Descriptions will be given of the different systems currently being used in the ETR and concepts for future upgrades will be discussed.

Introduction

A compact range is an indoor facility used for the measurement of antenna performance and electromagnetic scattering [1]. The measurement of antennas and/or scattering requires that the antenna or scattering body be illuminated by a uniform plane wave. The accuracy of the measurement is directly dependent on the quality of the field used to illuminate the test object. In order to achieve the desired quality of this field, new compact range test facilities have evolved through the years. Even though there have been approaches developed to improve certain aspects of the field, none of these techniques have simultaneously attacked the taper, ripple, and polarization errors, at least to satisfactory levels. In order to make a significant improvement in each of these categories, a new concept is needed. Analytical studies have shown that the new dual chamber concept [2,3], as shown in figure 1, where the main reflector and target zone are located in the main chamber and a Gregorian subreflector with associated feed assemblies in the other has, in principle, several advantages over other configurations. Among these advantages is the tendency to eliminate the diffracted fields from the subreflector and feed spillover. If the main reflector is designed to minimize edge diffraction [3,4] and the effect of the absorber treated coupling aperture between the two chambers can be minimized, the dual chamber system can potentially provide improved taper, ripple, and polarization performance in the target zone. The development of the ETR was an attempt to combine the new dual chamber concept [3], an advanced anechoic chamber design [5], and a state-of-the-art radar system [6] and data processing capability into an advanced test facility that would provide a "target zone" field quality superior to that achievable in existing indoor compact range test facilities. A main reflector size of 16' x 16' was chosen for the prototype system to evaluate the dual chamber concept.

Anechoic Chamber

The ETR (fig. 2), in its present configuration, has a 40'w x 40'h x 65'l anechoic chamber that was designed to operate over the 2 to 40 GHz frequency range. The radar absorber material (RAM) covering the chamber surfaces is 12-inches thick except the back wall which is covered with 24-inch material. The placement of the wedge and pyramidal shaped RAM was optimized for the best chamber performance. A bridge crane with a 2-ton capacity, for antenna/model insertion and removal, was installed in the chamber. The bridge crane support rails attached to the chamber side walls were covered with RAM, and the crane can be stored behind the back wall when not in use. The chamber, control room, and model handling area are inside of an RF shielded enclosure providing approximately 100 dB of attenuation to external RF signals. The prototype reflector system currently being evaluated in the chamber uses a 16' x 16' main reflector, however, the chamber design will accommodate a reflector as large as 25 to 30 feet square.

Reflector System

The ETR dual chamber reflector system utilizes a 16' x 16' main reflector with a 7.25 feet focal length. The parabolic center section has a concave edge contour (fig. 3) to which cosine-squared blended rolled edges are attached. The main reflector is located in the large chamber with an oversized Gregorian concave elliptic subreflector and associated feed located in a smaller chamber. The reflector system [3] was designed to provide an illumination with very small taper, ripple, and cross-polarization errors in the target zone. The calculated performance for the ETR system is shown in figure 4. The data shown are the magnitude of the total field along a vertical cut through the center of the target zone, located 20 feet away from the main origin for the geometry shown in figure 1. This system provides a target zone approximately 6'h x 8'w x 8'l. The main reflector and subreflector were designed by Ohio State University ElectroScience Laboratory personnel and fabricated at the NASA Langley Research Center. The main reflector was fabricated in seven pieces using a rigid 4 lb/ft³ polyurethane foam material, and the exterior surface was covered with an epoxy then silver painted to provide an electrically conducting surface. A thin layer of a white nonconducting paint was applied over the silver paint to protect the conductive surface. Figure 5 shows the reflector after final assembly and all the seams were covered with a copper conductive tape to provide electrical continuity between pieces and to reduce the potential for errors due to the seams. Optical targets were placed on the reflector surface and photogrammetry was used to measure the surface accuracy. The surface measurement data indicated the surface accuracy of the center section

was within 5 to 10 mils except a small area near the center that exceeded 10 mils. The fabrication technique used has the capability of providing accuracies on the order of 10 mils or less. Similar construction techniques were used for the subreflector. The subreflector was installed inside the small RAM-lined chamber with the broadband feed mounted at one end on a 4 axis positioner to provide the precision control needed for feed positioning.

Radar System and Data Processing

A compact range measurement facility has several advantages over other measurement ranges, however, it has the disadvantage of producing a large amount of unwanted returns or clutter. The measurement system must be able to distinguish between the target return and undesired scattering. A pulsed/CW radar takes advantage of the physical separation of target and clutter by generating short pulses and sampling after a delay corresponding to the target distance. A basic pulsed/CW radar cross section measurement system is shown in figure 6. The radar chosen for use in the ETR was developed at the Ohio State University ElectroScience Laboratory and is shown in figure 7. It is a pulsed/CW system and in its present configuration operates from 2 to 18 GHz and 26 to 36 GHz. It is capable of operating continuously over the entire 2 to 18 GHz frequency range with the use of a suitable broadband feed. A frequency scan from 2 to 18 GHz in 10 MHz increments consisting of 1600 data points and an integration number of 64 can be accomplished in approximately 30 seconds. The radar uses a Hewlett Packard 386 personal computer with menu-driven software for range control and data collection. The raw data are sent over a digital parallel I/O bus to a Tektronix XD/88-30 superworkstation for high speed processing. The Tektronix XD/88-30 provides a Unix platform with significant data calculation resources (approximately 17 MIPS); an advanced, flexible windowed operating environment (supporting X11); direct access to the VME data bus structure; helical scan ultra high density off-line magnetic data storage capability; and video in/out possibilities. The software currently being used for operation of the radar system, range control, data collection, and data processing was developed at the Ohio State University and improvements are continuing to be made to its capabilities.

ETR Status and Future Plans

All systems in the ETR are operating and an evaluation of the dual chamber system is underway. Preliminary probing of the target zone has identified some minor problems relative to the Gregorian subreflector edges and the RAM covered top on the Gregorian subreflector enclosure. The current subreflector design and fabrication was completed in 1987 and has untreated edges [7]. More recent designs [8] have improved performance by using serrated edges or treated the edges with resistance card material to reduce the edge diffraction levels incident on the main reflector. The top of the Gregorian subreflector enclosure, which includes the RAM treated coupling aperture, was found to be positioned too high creating excessive blockage for

the energy being transmitted between the sub-reflector and main reflector. Modifications are underway to correct these problems. Future plans include improvements to the radar system to provide more sensitivity, a new larger (e.g., 27-ft. square) reflector system providing a target zone of at least 8'h x 13'w x 13'l, and a new model support pylon with an in-model rotator.

Concluding Remarks

The current systems in use in the Experimental Test Range were described. These included: (1) anechoic chamber, (2) reflector system, (3) radar system, and (4) data processing. Minor problems that were identified during the preliminary evaluation of the reflector system were discussed and solutions to correct these problems are being implemented. Future plans for upgrading ETR to optimize the measurement capability were also discussed.

References

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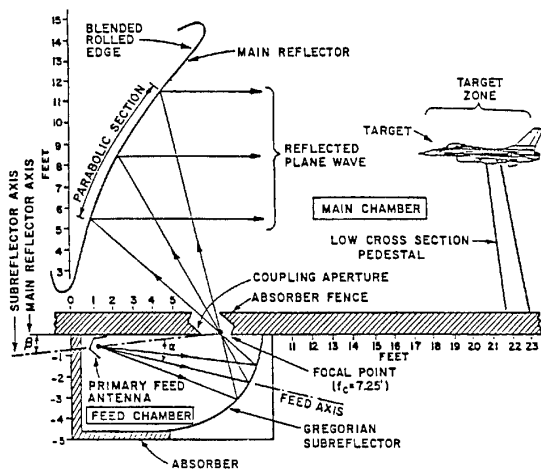


Figure 1.-Dual chamber compact range configuration.

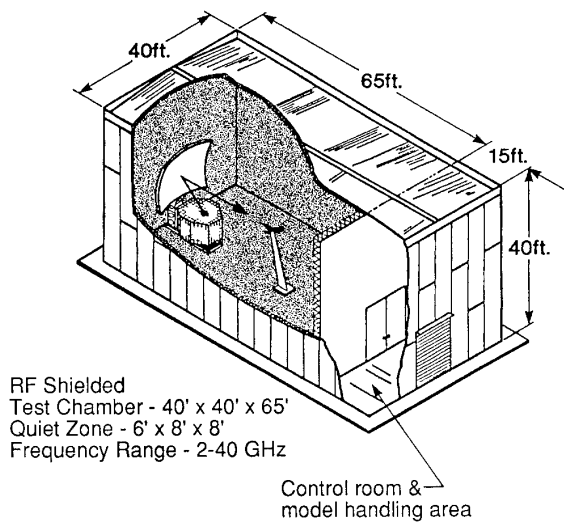


Figure 2.-Experimental Test Range

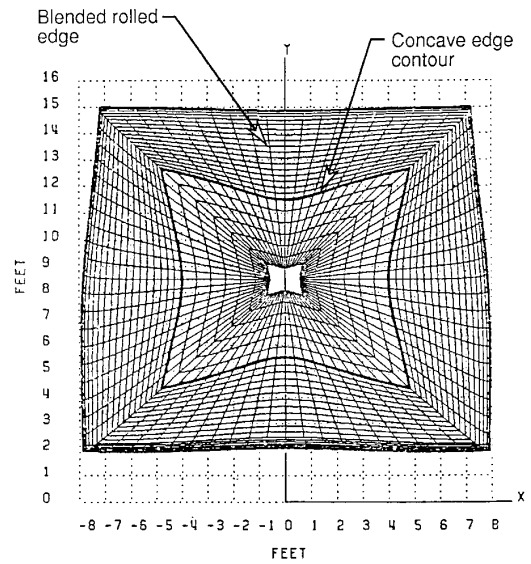


Figure 3.-Front view of main parabolic reflector with concave edge contour and cosine squared blended rolled edge.

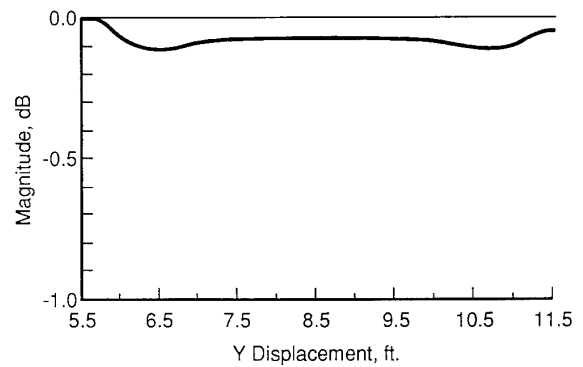


Figure 4.-Total field for a vertical cut through the center of the target zone at 6 GHz.

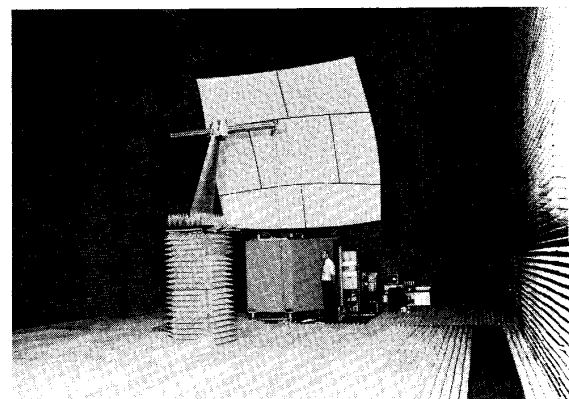


Figure 5.-ETR with dual reflector system installed.

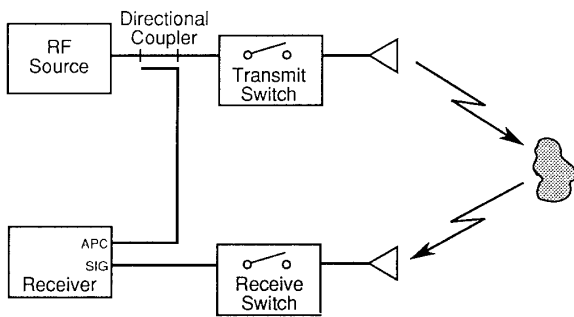


Figure 6.-Block diagram of basic pulsed/CW RCS measurement system.



Figure 7.-Pulsed/CW radar.