Custom Integrated Antennas

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Custom Integrated Antenna Design →
Antenna Performance Analysis →
Custom RF Test Labs

CIA Overview

- Custom Integrated Antennas (CIA) is a sole proprietorship doing business in Johnson County Kentucky and is solely owned and operated by Timothy Milam. CIA specializes in antenna design and integration for small wearable, hand held, and otherwise portable wireless products. Frequencies covered are primarily 150 MHz to 8.5 GHz, although lower frequencies have been developed.

- My internal antenna design and integration career started in February 1994 and since then I have been continually involved with antenna development and associated wireless technology tasks, even when I had departmental and divisional management responsibilities during my first 6 years in the technology industry.

- In January 2001 I decided to focus all my efforts on antenna design and integration and since then have had several hundred of antenna design and integration projects with more than 175 companies. CIA has an in house, anechoic antenna measurement chamber, Copper Mountain Technologies S5085 VNA, and all the other tools and equipment (some specialized) to perform the primary consulting tasks I am involved with, which does include more than antenna design in many cases. CIA also has established relationships with third party antenna and wireless test facilities if that is a client requirement.

CIA Overview (Antennas)

Materials Used	
Various PCB/FPC Substrates	Wire
Various Plastic and Plating Processes	Various Sheet Metal and Plating
Ceramic Substrates	Tubing

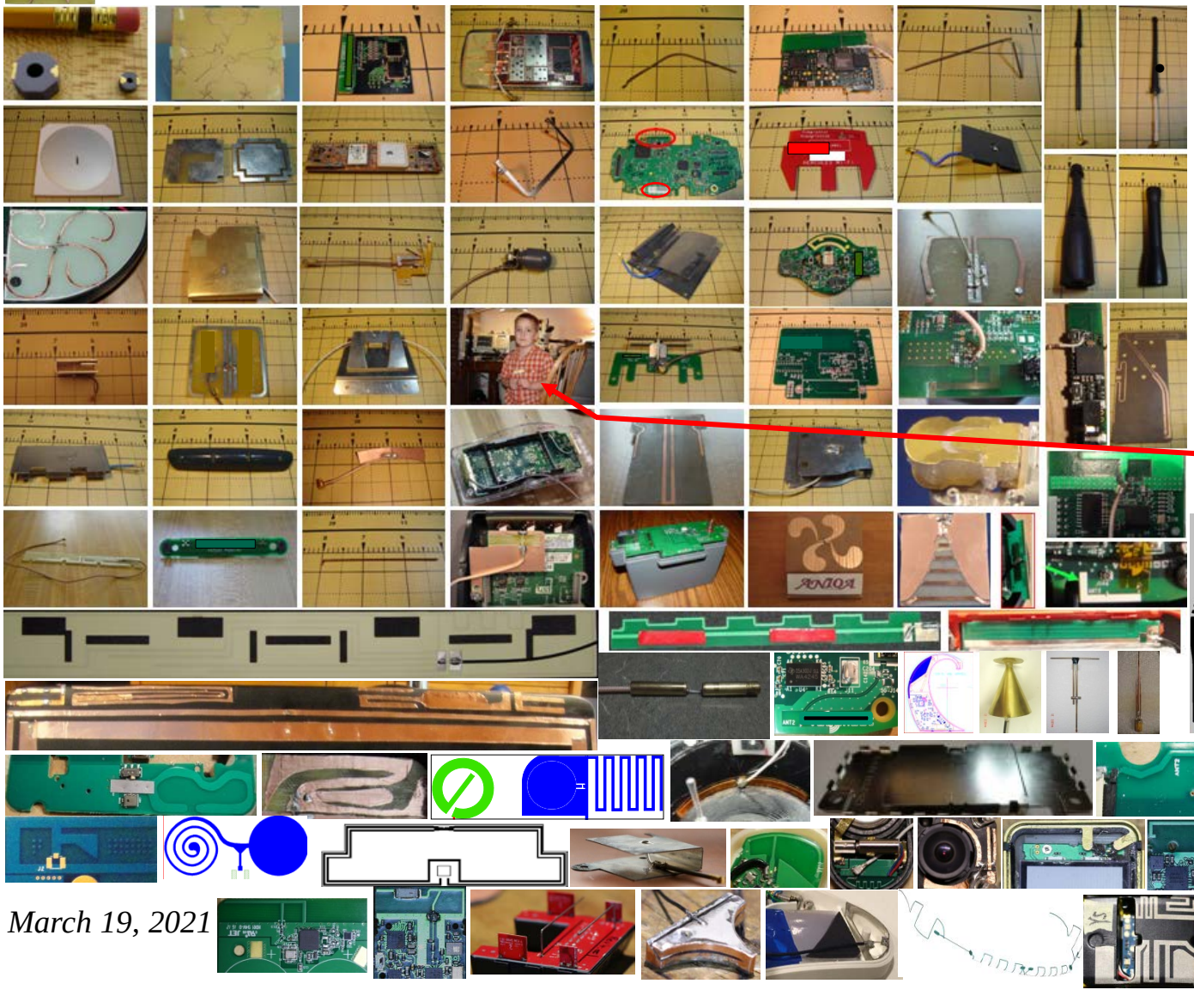
Types of Antennas Developed	
Planer Inverted F (PIFA)	Dipoles and monopoles
Meander Line	Multi-band
Patch • circular and linear polarization, conformal	Conformal • Stamped metal, plated plastic, and flexible printed circuit
Wide-band	Helical
Spiral	Planer Array
Log Periodic	Yagi

- CIA designs and integrates custom antenna technology into a wide range of portable products from notebook computers to various headset/ear bud configurations to specialized industrial grade wearable computing systems to IOT sensors and security systems, and much more (Concept to Production and beyond).

- CIA specializes in conformal three dimensional antenna geometries to better utilize available space within the target product, but planar (PCB and FPC) designs are also common. CIA also designs externally mounted antennas on occasion. See slide 4 for a few examples of antennas developed at CIA.

- The goal of an antenna project is to provide the client with antenna technology that fits inside the target product, is inexpensive to manufacture, easily assembled during the product manufacturing phase, fulfills the radiation performance requirements to facilitate optimum wireless connectivity for the given application.

Examples of CIA Antennas

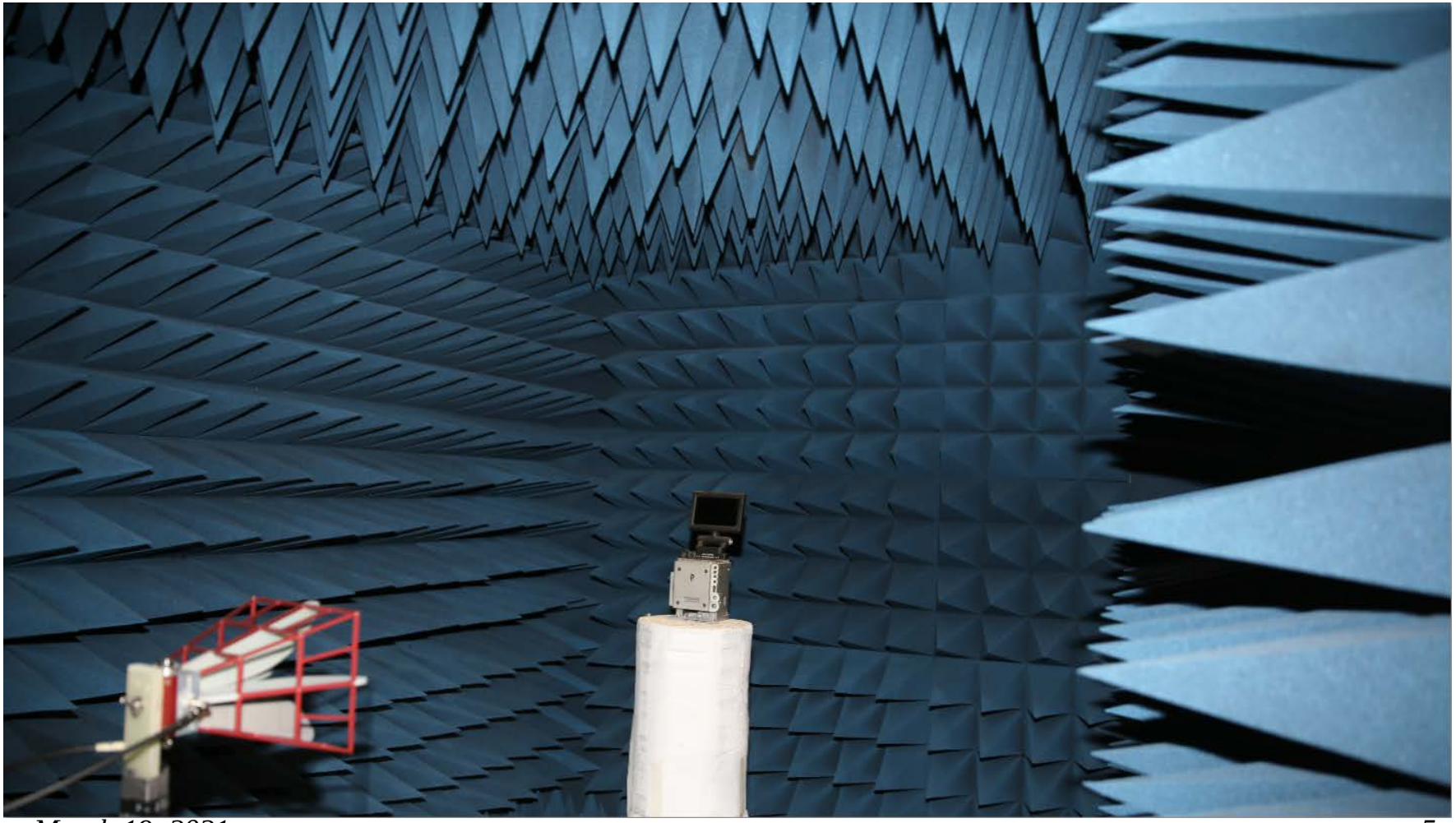


Shown here are several antennas in various states of development (drawings, prototypes, and production parts) that have been developed by CIA – none shown to scale.

- Some company names have been blotted out for confidentiality.
- This is my grandson, Christopher, when he was 7 years old, holding his first antenna. He's 20 now!
- Over 400 designs; 89% embedded/integrated inside a product housing.
- These pictures are only a small sampling of the types of antennas created and therefore not all inclusive of the designs created by CIA

CIA Anechoic Chamber

CIA's Anechoic Antenna Measurement Chamber, designed and built by CIA at CIA's facility in Butcher Hollow, Van Lear, KY.



Brief Outline of an Antenna Integration Program

Phase 0 Initial Contact and Proposal

- The client contacts Custom Integrated Antennas (CIA) and initial discussion of the antenna/product requirements are discussed. Then detailed design documentation is provided to CIA for feasibility and detailed antenna design purposes. Initial concepts are developed and communicated to the client and when the path forward is approved, move on to Phase I.

Phase I Feasibility Study

- It is very important to engage an antenna integration expert early in the product concept development phase of the design cycle. Working with the client's product concept team to understand the requirements of the product, antenna concepts will be developed that fit into the product's overall form factor and aesthetics profile and can be fine tuned to meet the product's wireless performance requirements. In some cases a relatively quick feasibility study may be required to set the best path forward.

Phase II Prototype Development

- A more refined prototype antenna will be developed based on information from Phase I. Prototype development typically includes building a rough "mock product" with materials on hand or in the best case printed housings. Internal components can be fabricated with materials on hand also. The first prototypes are hand built, but in good enough quality to allow for an initial performance and manufacturability assessment. Preliminary mechanical DXF drawings are typically provided for client mechanical engineering review and inclusion in the product 3D model. Some iteration may be required based on client feedback and tradeoffs.

Phase III Antenna Optimization and Pre-Production Validation

- The preproduction prototype is built based on Phase II results and typically this will be fabricated by the expected production manufacturer, but sometimes additional prototyping steps may be necessary due to unforeseen product changes. Ultimately the preproduction antenna should be fabricated with finer precision and by the manufacturer to lock in certain dimensions early. The preproduction prototypes will be used for detailed modifications if needed. This pre-production version of the antenna will look like the final product in all but, the finest of dimensional details. The goal of this phase is to provide the mechanical engineers with sufficient detail to finish the product design, order tooling, and finalize product documentation.

Phase IV Productization and Manufacturing

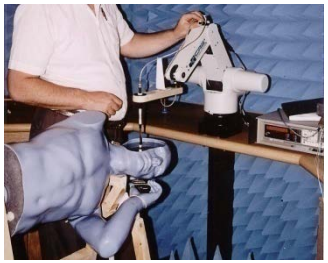
- Typically, the client may have a preferred manufacturer in mind for the antenna and CIA will work with that manufacturer to ensure the antenna is built so that it meets or exceeds all performance and reliability requirements on a repeatable basis no matter the production volume. CIA also may also work with the manufacturer to ensure that the proper QA measures are in place to guarantee that the antenna continues to be manufactured properly and identifies any problems, such as worn tooling, problems with newly sourced materials or parts, etc.

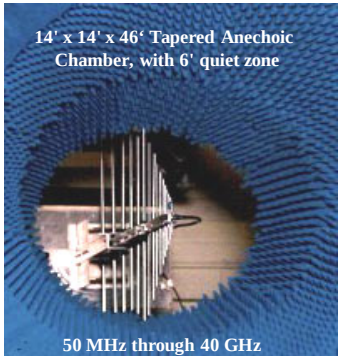
- Each antenna integration project is different, but the very broad high-level outline above is typical. CIA can customize each project to include all of part of the above.

Third Party Independent RF Measurements

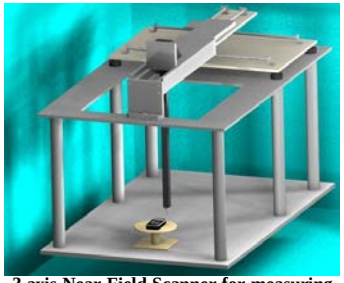

Satimo Stargate-64 3D Antenna Measurement Range


Far Field semi-anechoic chamber for radiated emissions testing


Near Field Probe and human torso phantom for measuring SAR


14' x 14' x 46' Tapered Anechoic Chamber, with 6' quiet zone

50 MHz through 40 GHz


3 axis Near Field Scanner for measuring low intensity near field perturbations


GTEM for EMC Radiated Emissions and Immunity Testing

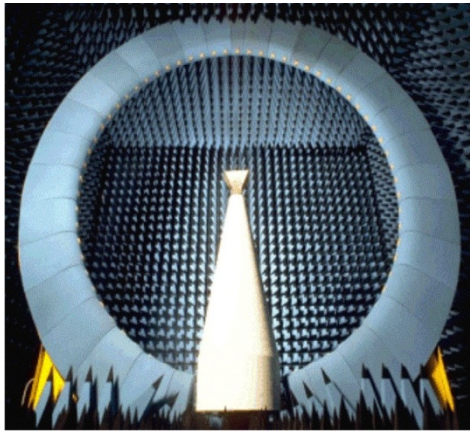
- CIA performs all "in process" antenna testing in house to save money and time for the client. This allows for real time test/tweak process whereby changes to the antenna can be tested quickly to determine impact on radiated performance during the design process.
- CIA also has long-term relationships with several test facilities that provide 3D testing of various antenna or device performance parameters.
- Three of these facilities operate state of the art three dimensional antenna radiation pattern measurement labs.
  - The equipment typically used for small devices is a indoor, controlled environment, Satimo Stargate-64 range (pictured far left - top).
  - Other types of chambers and outdoor ranges are available for measurement of larger antennas.
  - Measurements can be performed on the device by itself on a Styrofoam pedestal or other platform or while the human user holds/wears the device as it is intended to be used.
- Near and far field measurements around the body have also been performed at CIA's facility. The main purpose of these measurements were to characterize isolation and (or) link margin between two wireless devices communicating with each other while being worn or held by a human user.

Third Party 3D Patterns

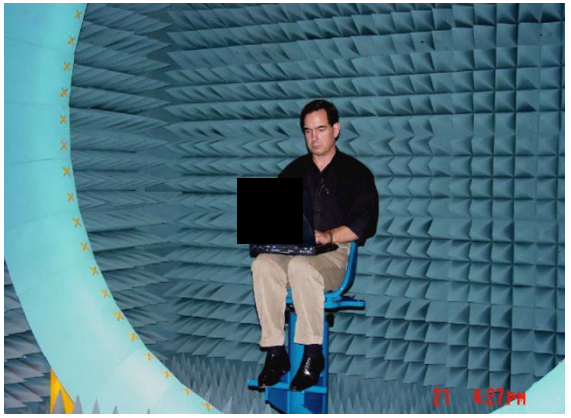
Measurement Data Includes:
- Swept Gain and Efficiency
- Multiple Frequencies
- Proximity effect of the human user

Accuracy of gain measurements:
- +/- 1.0 dB from 400 MHz to 800 MHz
- +/- 0.6 dB from 800 MHz to 1 GHz
- +/- 0.5 dB from 1 GHz to 6 GHz.

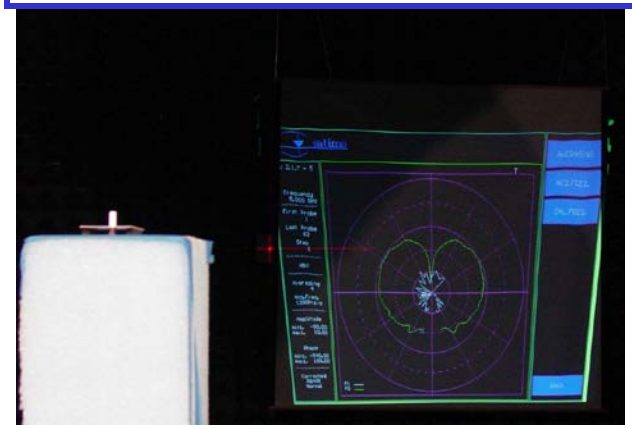
Maximum Dimensions AUT:
- 1 .7 m @ 800 MHz
- 2.4 m @ 1 .5 GHz
- 1 . m @ 3.2 GHz
- 0.5 m @ 6 GHz.
  - Full-size human test subjects of up to 240 lb can be tested.
- Analyzed and raw data is provided on a CD-ROM for easy access and AAI is available for on site presentation



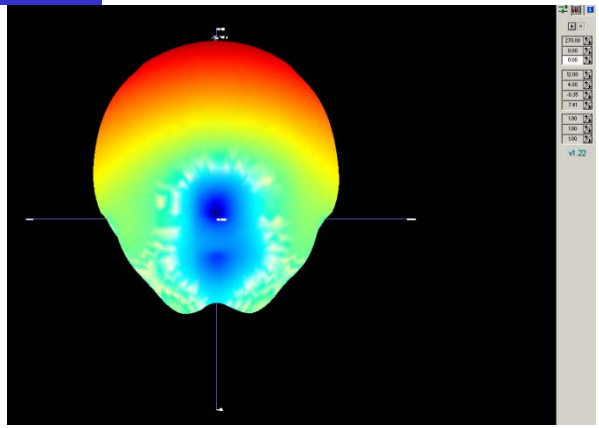
Horn Antenna on a conical Styrofoam Pedestal in a Satimo Stargate-64 Range



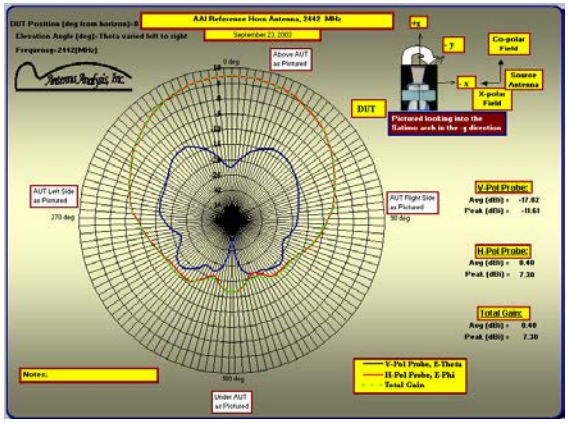
Test Subject (Tim Milam) in a chair with notebook computer. Test Subject can also Stand on a Platform.



Real time 2D elevation pattern projection of a monopole antenna, on the wall of one of the Stargate-64 chambers used by CIA



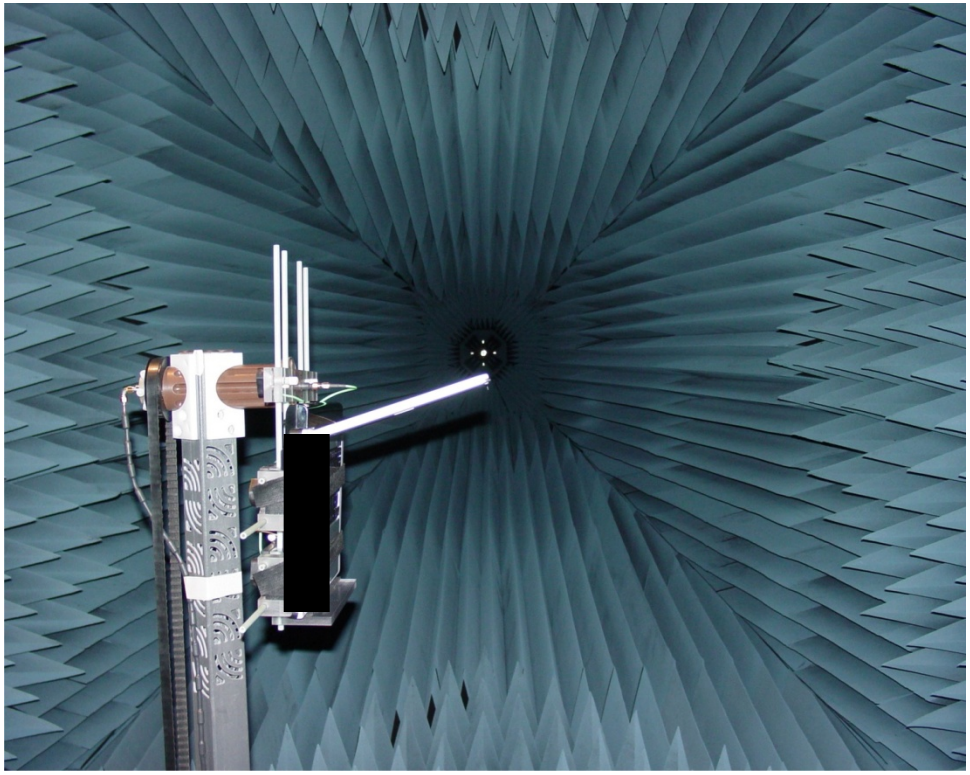
3D OGL representation of a med gain horn antenna pattern. OGL files are animation files of the 3D pattern that can be manipulated on a computer display for viewing at any angle.



CIA's 2D representation of the azimuth pattern of a med gain horn antenna, including other useful information on the 2D plots

March 19, 2021

Custom RF Test Facilities



AAI was responsible for the design, construction, validation, as well as the user and maintenance documentation for the tapered anechoic chamber pictured here. It is capable of 3D antenna pattern measurement as well as very detailed radio communication performance analysis that includes bit error rate and throughput vs. attenuation which can be translated into throughput vs. range for varying real world usage environments.

- CIA has extensive experience testing antenna patterns and radio communication performance.
- Therefore, an offshoot of much research and years of experience allows CIA to design and develop custom wireless test facilities based on clients' unique requirements.
- Facilities can be self-contained indoor anechoic chambers (tapered or rectangular) or outdoor (open field) facilities.

Thank You

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