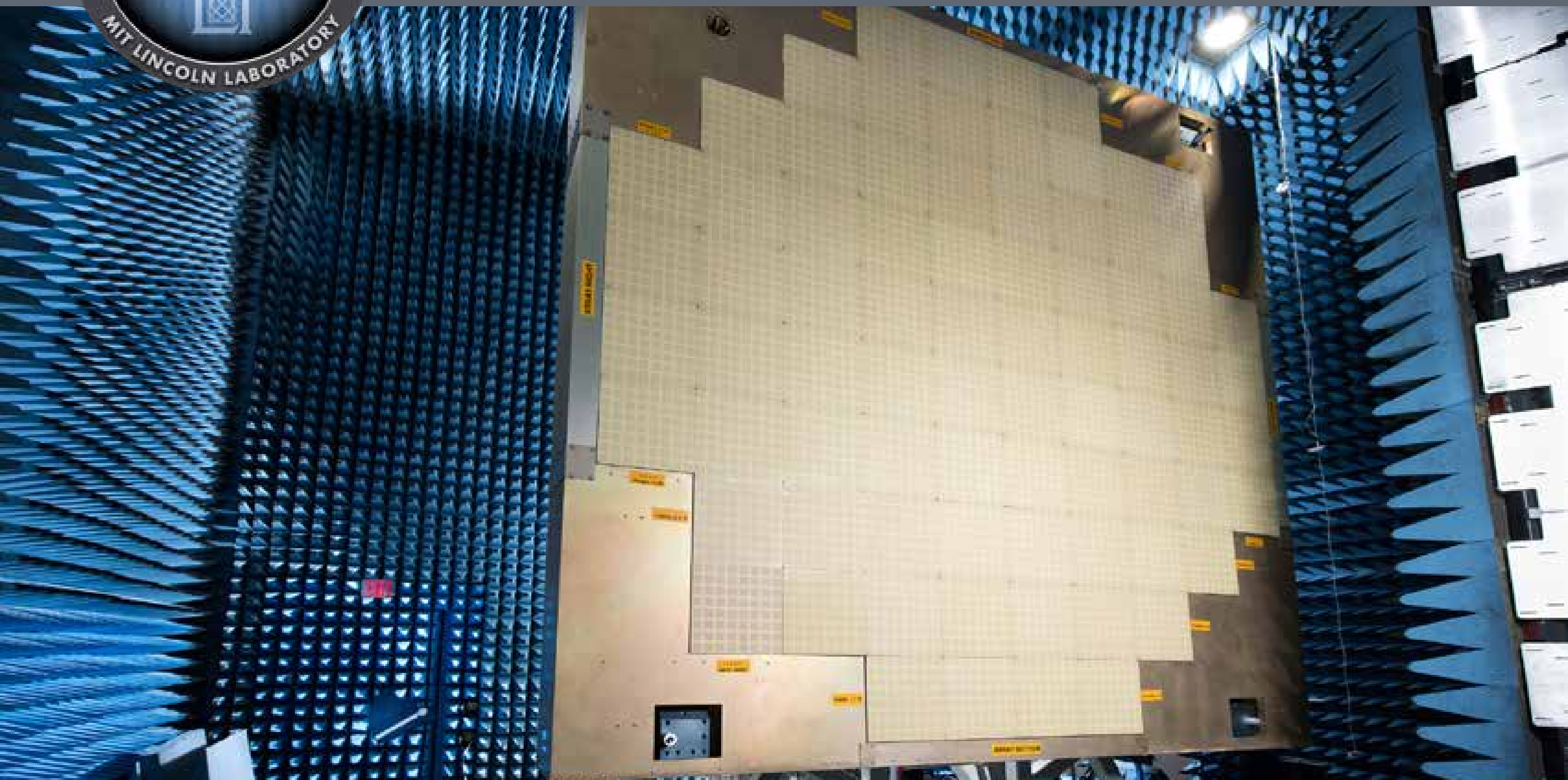
MIT LINCOLN LABORATORY

RF SYSTEMS TEST FACILITY

RF TECHNOLOGY, GROUP 86



PROVIDING RAPID PROTOTYPING AND RF MEASUREMENTS FOR ANTENNAS, RADAR TARGETS, AND ELECTROMAGNETIC SYSTEMS

For information on how to work with the RFSTF staff in advancing your research, email: RFSTF@LL.MIT.EDU

WELCOME TO MIT LINCOLN LABORATORY'S RF SYSTEMS TEST FACILITY

MIT LINCOLN LABORATORY'S RF SYSTEMS TEST FACILITY is a full-function research and development rapid prototyping facility with resources to design, fabricate, and measure antennas and radar targets for surface, airborne, and space applications.

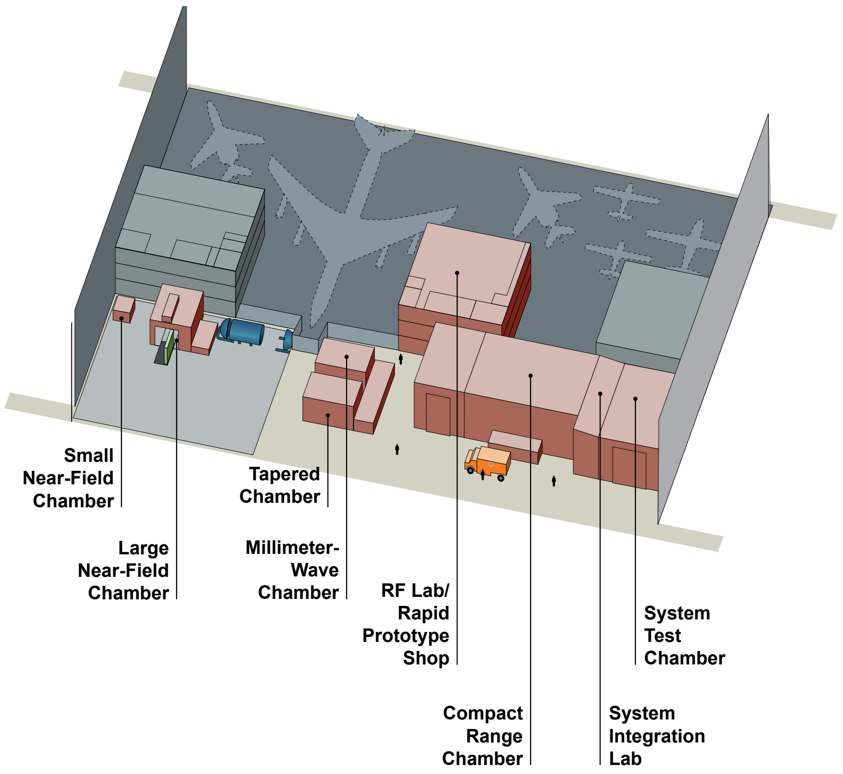
The Radiofrequency (RF) Systems Test Facility (RFSTF) is comprised of six anechoic chambers, a system integration lab (SIL), high-bay staging area rapid prototype shop, and RF laboratory. Mobile test vans and trailers are also available. The RFSTF is co-located with the MIT Lincoln Laboratory Flight Test Facility, which allows rapid integration of RF sensors with airborne platforms.

The six shielded anechoic chambers (tapered, millimeter-wave, system-test, compact range, small near-field scanner, and large near-field scanner) allow for antenna, radar cross section, and system tests and measurements over a wide frequency range. The two large system-test and compact range chambers can accommodate test articles weighing up to 2000 lbs, making use of an overhead crane (system-test chamber), or a rolling gantry with crane (compact range chamber). The large near-field scanner chamber is configured to measure large phased array antennas and reflector antennas. The small near-field scanner chamber is used primarily for calibrating and testing phased array antenna panels, but is also used in testing small reflector antennas.

The System Integration Lab (SIL), which also serves as the control room for the system-test chamber, contains test equipment to enable rapid prototyping and/or integration of systems before they are fully deployed and tested in the field. Provisions have been made in the SIL to fulfill a wide range of AC-power requirements.

The rapid prototyping shop has a wide variety of machining tools to fabricate antennas, target-mounting fixtures, and other mechanical pieces necessary to aid and assist in any testing in the facility. The shop also has a high-bay area with overhead crane, allowing for a wide range of mechanical work to be performed on larger devices and systems.

The RF Laboratory is a general-purpose area that can be configured to suit the needs of groups requiring lab space while conducting measurements or experiments at the RF Systems Test Facility.



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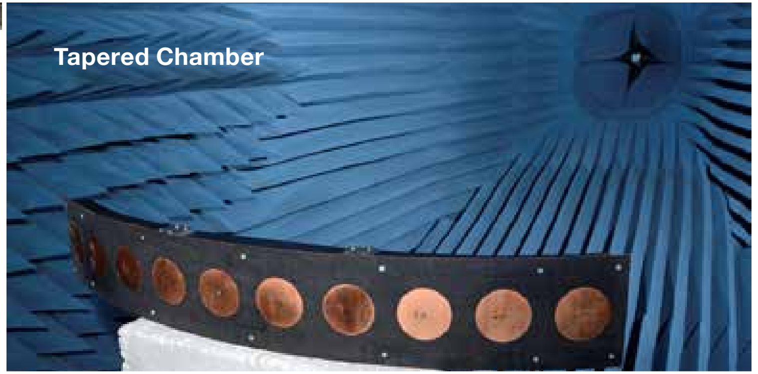
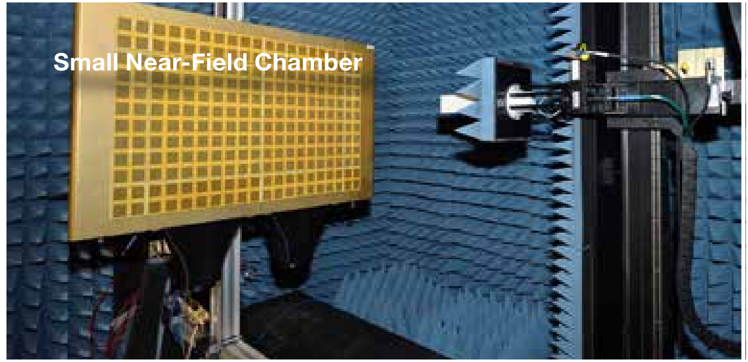
RAPID PROTOTYPING PROCESS FOR RF SYSTEMS

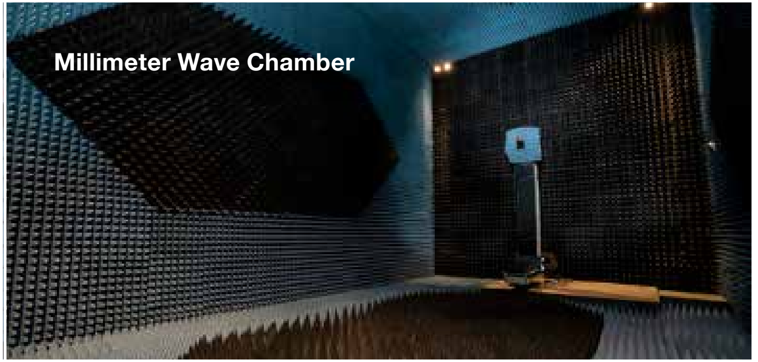
THE RF SYSTEMS TEST FACILITY is equipped with anechoic chambers and instrumentation for technical staff to rapidly develop new technology and prototype advanced communications, radar, and sensor systems. Component development begins in the Rapid Prototyping Shop, followed by component characterization in one of the smaller utility chambers, and then full system checkout in one of the large test chambers prior to field testing.

Component Development and Characterization

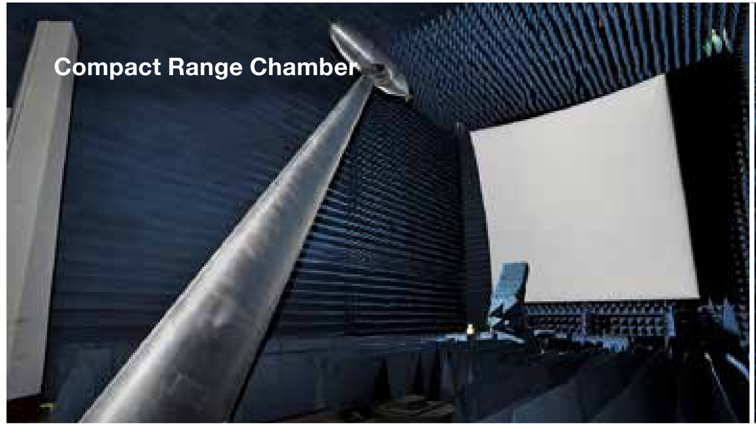

Rapid Prototyping Shop

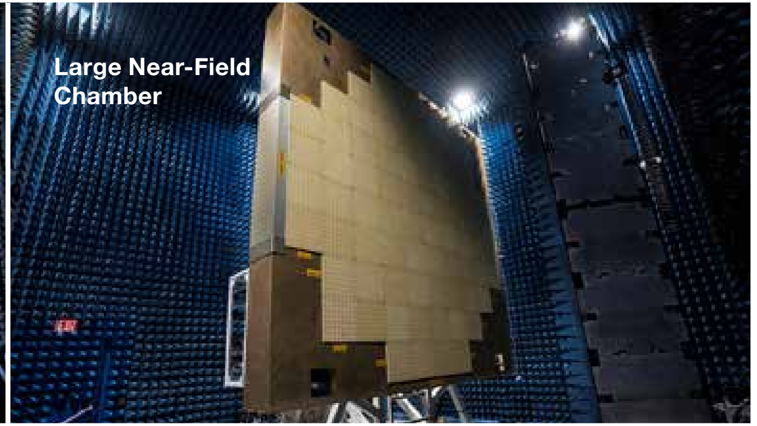

Tapered Chamber


Small Near-Field Chamber


Millimeter Wave Chamber

System Testing


Compact Range Chamber


Large Near-Field Chamber

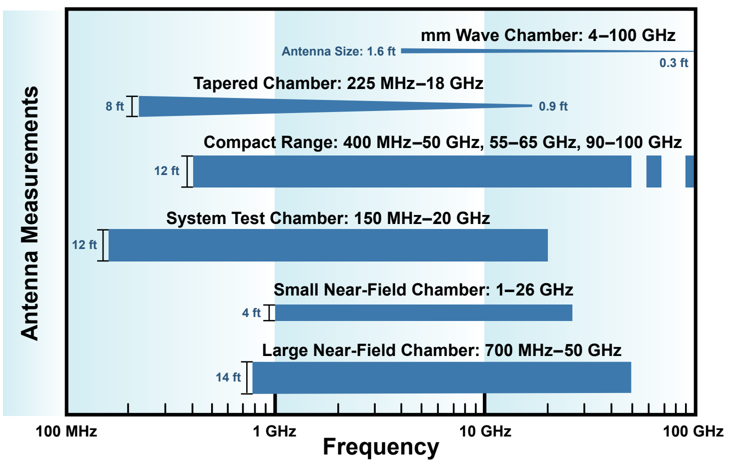

System Test Chamber

Field Measurements

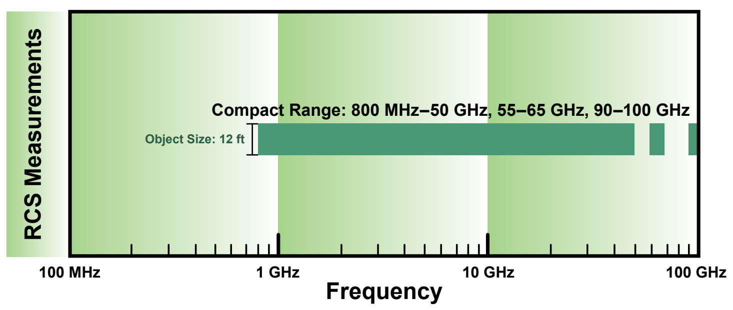
RF SPECTRUM CAPABILITY FOR ELECTROMAGNETIC SYSTEMS

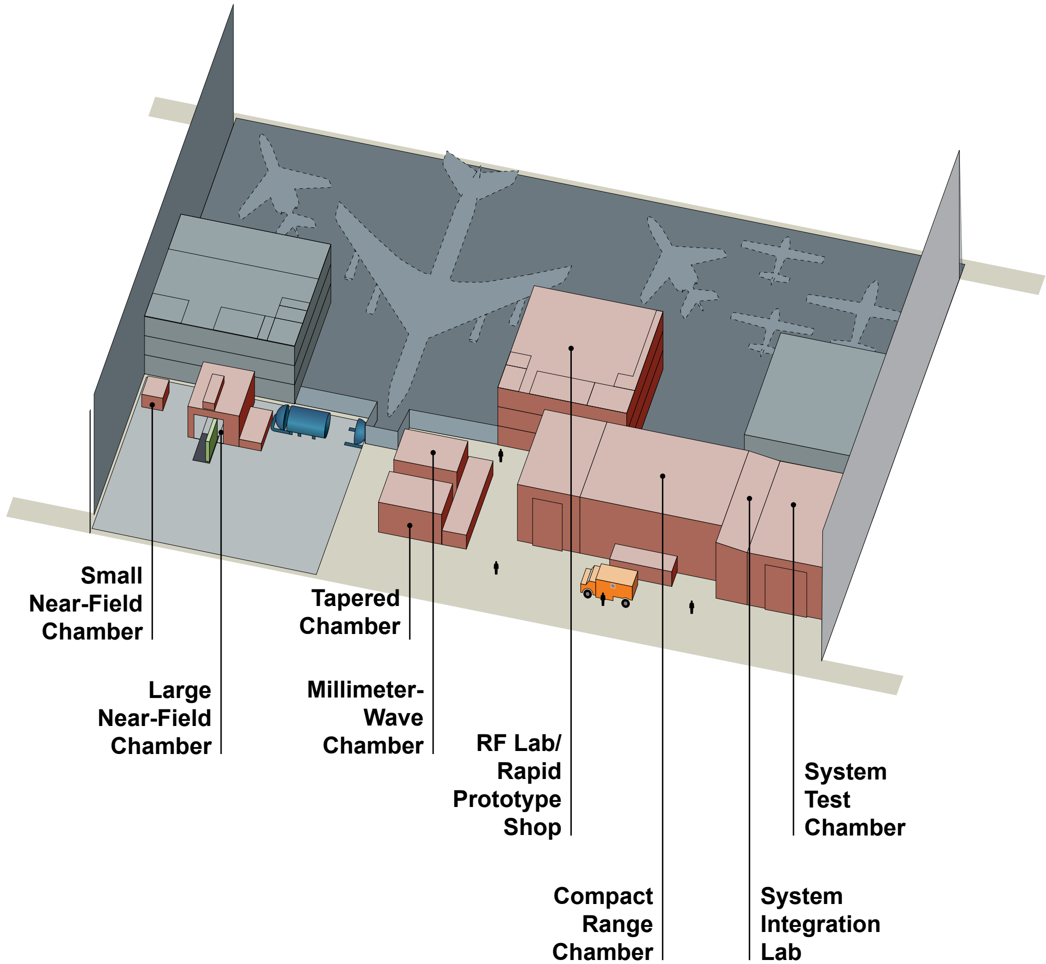
THE RF SYSTEMS TEST FACILITY is equipped with anechoic chambers and instrumentation covering a wide frequency range for technical staff to develop new technology and prototype advanced communications, radar, and sensor systems. At the RFSTF, antenna measurements can be performed over the range of 150 MHz to 100 GHz. Radar cross section (RCS) measurements can be performed from 800 MHz to 100 GHz. Depending on requirements, measurements at lower and higher frequencies can be performed as well.

Antenna Measurements



Radar Cross Section Measurements





COMPACT RANGE

THE COMPACT RANGE is a shielded anechoic chamber measuring 66 ft long by 44 ft wide by 38 ft high. The chamber's antenna system consists of a custom 24 ft by 24 ft rolled-edge reflector fed by an offset feed yielding a 12 ft by 12 ft by 12 ft quiet zone centered 19 ft above the floor. The operating frequency range is from 400 MHz to 100 GHz covered in seven bands: 400 MHz to 2 GHZ, 2–18 GHz, 18–26 GHz, 26–40 GHz, 40–50 GHz, 55–65 GHz, and 90–100 GHz.

The Compact Range was designed by The Ohio State University and has the ability to perform both radar cross section (RCS) measurements as well as antenna and electromagnetic interference (EMI) measurements. Antenna data can be collected from 400 MHz to 100 GHz while RCS measurements can be performed from 800 MHz to 100 GHz. Antennas being tested are either mounted to a metal ogive tower that has a polarization-over-azimuth-over-elevation axis located at the top of the ogive, or a large fiberglass tower consisting of an azimuth-over-elevation-over-tower-over-azimuth-over-elevation mount. Antenna size and weight usually dictate which mount is used. RCS measurements are typically performed on a custom-shaped foam pylon. There are several foam pylons to choose from depending on target size and weight.

The RF measurement system is a custom system designed and built by The Ohio State University. It has been updated and reconfigured by Lincoln Laboratory over the years and now uses a Keysight network analyzer as a receiver. Collection and control software was originally developed by The Ohio State University and has since been upgraded by Lincoln Laboratory to add features and improve performance. Both antenna and RCS measurements are pulsed in order to gate out unwanted reflections and multipath. Background subtraction is also employed when performing RCS measurements to minimize target pylon interference. Absorber treatment is a combination of pyramidal and wedge absorber on the floor, walls and ceiling.

The chamber is accessed on a gantry crane. The gantry has a scissor lift to raise personnel to the target area as well as a one-ton crane to lift heavier objects onto the mount.

Room temperature is kept constant to maintain RF stability as well as minimize compact range reflector antenna expansion and contraction.

RFSTF Compact Range System

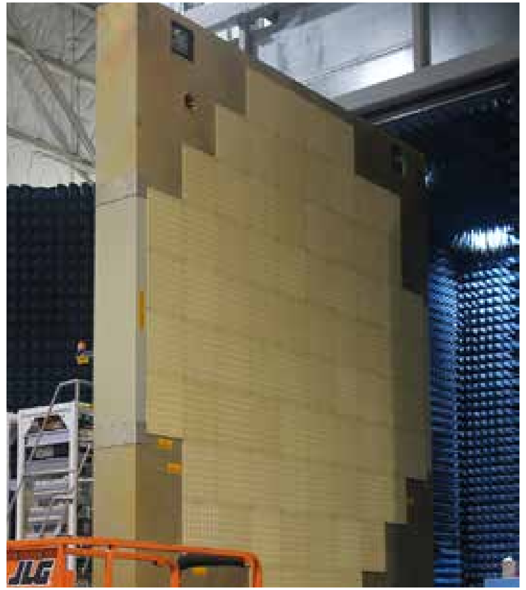
LARGE NEAR-FIELD SCANNER FACILITY

THE LARGE NEAR-FIELD SCANNER FACILITY has an Orbit-FR 18 ft by 18 ft vertical planar near-field scanner that is used to calibrate and measure gain radiation patterns of large phased array aperture antennas.

The scanner has four-axis automated control for x, y, z Cartesian coordinates and for probe polarization (vertical and horizontal polarization measurements). The shielded anechoic chamber interior dimensions are approximately 30 ft by 27 ft by 25 ft. An overhead crane installed in the chamber has a lifting capacity of 8000 lbs. The walls, floor, and ceiling are covered with 18-inch pyramidal absorber with unpainted tips. The scanner is optically aligned and designed to perform accurate scans from 700 MHz to 50 GHz.

An antenna assembly area is located adjacent to the anechoic chamber. The antenna under test is moved into and out of the chamber on a wheeled cart that is mounted on rails.

Phased Array Cart on Tracks



Phased Array Moving Into Chamber

Multifunction Phased Array Radar (MPAR) System in the RFSTF Large Near-Field Scanner Facility

SYSTEM TEST CHAMBER

THE SYSTEM TEST CHAMBER is shielded with dimensions 60 ft by 40 ft by 35 ft and is covered uniformly with 48-inch pyramidal absorber for general-purpose RF testing. This chamber is used, in part, for standard far-field antenna testing, spherical near-field antenna testing, and other measurements such as radar system testing and electromagnetic interference testing of RF systems.

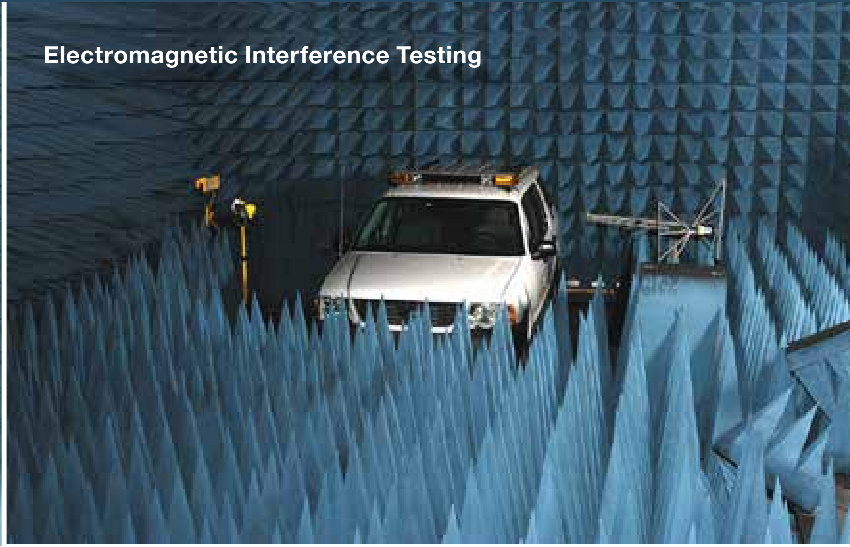
The antenna under test positioner consists of an azimuth over elevation positioner on a tower mounted on a linear slide above a lower azimuth positioner. The source tower is a linear positioner with a lifting capacity of 850 lbs that allows the source antenna to reach a maximum height of 15 ft. The source tower has a polarization positioner with a DC to 26.5 GHz rotary joint. To achieve accurate spherical near-field measurements, the coordinate systems of the source positioner and antenna under test positioner are laser aligned.

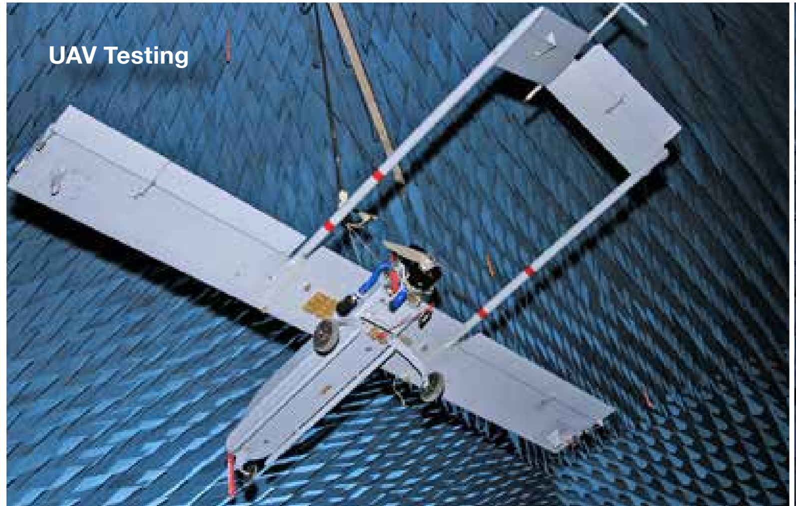
The antenna measurements system consists of MI Technologies turntables and Keysight RF equipment. The control and RF equipment are in an adjacent control room with a pair of cable troughs leading into the chamber. Antenna measurements are calibrated using antenna gain standards. The RF measurements system includes a 16-channel 100 MHz to 20 GHz multiplexer that is used to collect measured antenna under test data from multiple antenna elements or from subarrays.

The facility is designed so that ground vehicles can be driven into the chamber for RF testing. Additionally, for RF testing, air vehicles or other test articles can be suspended from an overhead crane. The anechoic chamber has large double doors and temporary ramps that allow vehicles to be driven into the chamber for antenna and EMI measurements.

An overhead crane rail system is used to suspend test articles such as unmanned air vehicles (UAVs) with nonconducting straps or ropes. This suspension system allows the test article to be located toward the center of the anechoic chamber—away from the walls that would otherwise affect the measurements, including reflection coefficient and mutual coupling between antennas. The insertion loss of large radome panels can also be tested by supporting the panel with the overhead crane.


Radar System Testing


Electromagnetic Interference Testing


UAV Testing

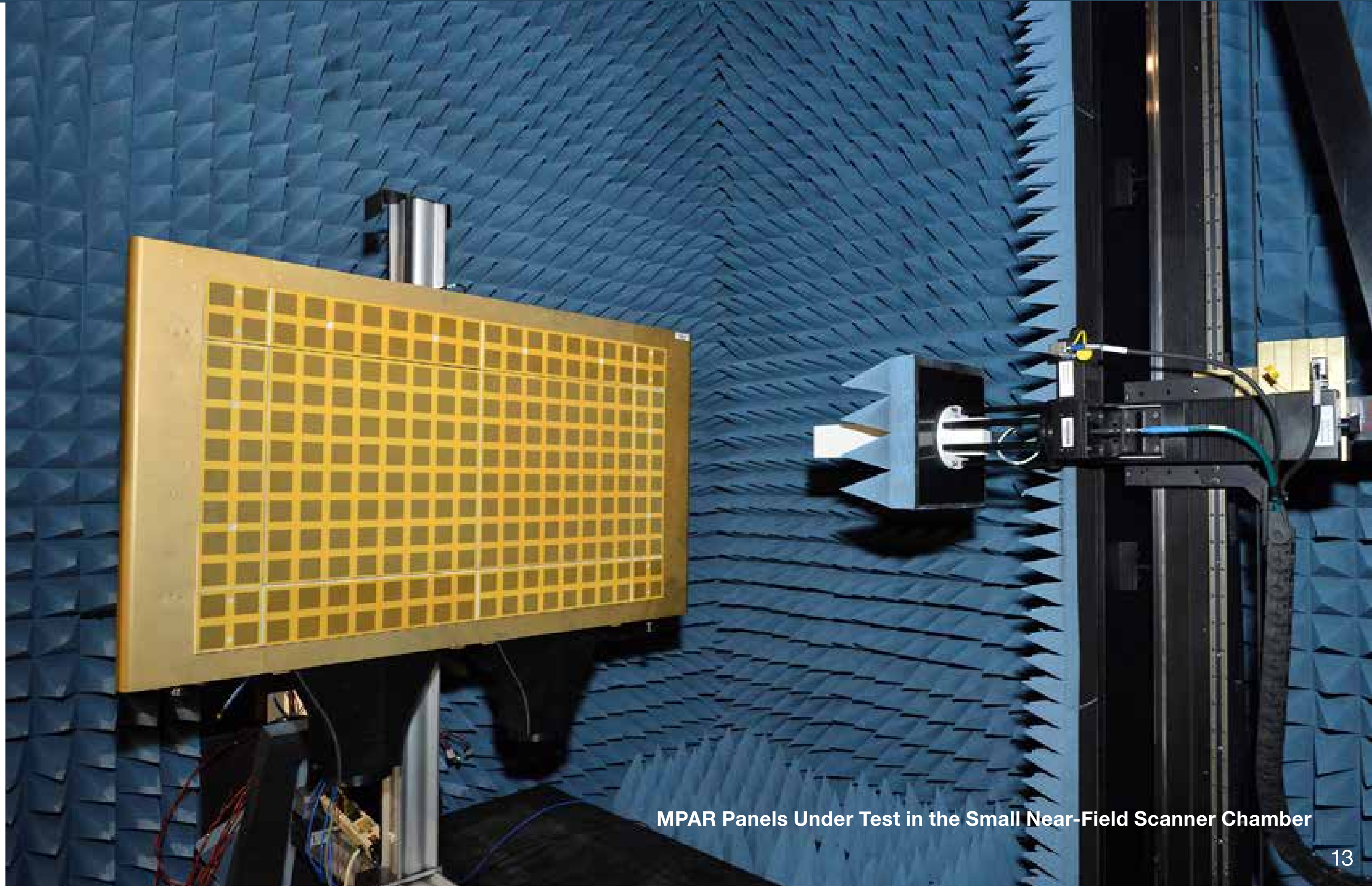

Radome Panel Testing

SMALL NEAR-FIELD SCANNER

THE SMALL NEAR-FIELD SCANNER has a Nearfield Systems 5 ft by 5 ft vertical planar near-field scanner and is used primarily to calibrate and measure gain radiation patterns of small phased array aperture antennas and small reflector antennas. The scanner has four-axis automated control for x, y, z Cartesian coordinates and probe polarization for vertical and horizontal polarization measurements.

The scanner is located in a shielded anechoic chamber with interior dimensions 12 ft by 12 ft by 12 ft with the walls, floor, and ceiling covered with 12-inch pyramidal absorber.

The automated probe moves parallel to the array face, horizontally in the x direction and vertically in the y direction, and moves perpendicular to the array face in the z direction. The rectangular probe is linearly polarized and is rotated by means of a polarization positioner to measure the voltage response to horizontal and vertical electric-field components for the antenna under test. The radiation pattern of the near-field probe with surrounding absorber is pre-measured, and is used to compensate and generate the far-field radiation pattern of the antenna under test.



MPAR Panels Under Test in the Small Near-Field Scanner Chamber

TAPERED CHAMBER

THE TAPERED CHAMBER is EMI-shielded and has a range length of 28 ft to the center of the test zone, with a rectangular section 14 ft by 14 ft in cross section by 16.8 ft in length. The tapered chamber utilizes an ultrawideband dual-polarized conical tip feed designed by The Ohio State University that operates over the 225 MHz to 3 GHz band, and at higher frequencies.

The walls of the tapered chamber are covered with wedge absorber varying in height from 8 inches near the conical tip to 18 inches approaching the test zone. The test zone region uses 24-inch pyramidal absorber. The back wall is covered with 6-ft pyramidal absorber.

The antenna under test positioner consists, in part, of a 24-inch manual linear slide along the boresight axis over a lower azimuth positioner. A mast is mounted above the linear slide, and an azimuth (polarization) over elevation positioner is mounted at the top of this mast. In some measurements requiring only azimuth rotation, the antenna under test is supported on a foam column mounted above the linear slide.

3D-Printed Copper-Plated Conformal Array Under Test in the Tapered Chamber

MILLIMETER WAVE CHAMBER

THE MILLIMETER WAVE CHAMBER is a rectangular anechoic chamber that is EMI-shielded and is used for testing small antennas (typically feed horns for reflector antennas) and small arrays from approximately 4–100 GHz. The chamber's interior dimensions are 30 ft length by 20 ft width by 18 ft height and a range length of 22 ft between the source antenna and antenna under test (AUT). To achieve good RF performance up to 100 GHz, the central portions of the walls, floor and ceiling are covered with unpainted 12-inch pyramidal absorber. Outside the central region, a blue-painted 8-inch pyramidal absorber is used.

The AUT positioner is a polarization over elevation positioner mounted on a tower attached to a 24-inch manual linear slide along the boresight axis over an azimuth positioner. The AUT positioner is optically aligned to facilitate accurate measurements of millimeter wave antennas. A tracking laser interferometer is used in the optical alignment process to align the lower azimuth, slide, elevation, and polarization positioners.

Millimeter Wave Chamber

RAPID PROTOTYPING SHOP

THE RAPID PROTOTYPING SHOP has a wide variety of machining tools including CNC Bridgeports, a CNC lathe, a 3D scanner and 3D printer to fabricate antennas, target-mounting fixtures, and other mechanical pieces necessary to aid and assist in any testing in the facility. The shop also has drill presses, grinders, and many hand tools. There is a high-bay area with overhead crane and benches, allowing for a wide range of mechanical work to be performed on larger devices and systems.

Shop personnel are well versed in SolidWorks and other CAD design programs used to design complex mechanical assemblies as well as generating files for the CNC equipment. Welding is also available for several materials, including aluminum and stainless steel.

Rapid Prototyping Shop

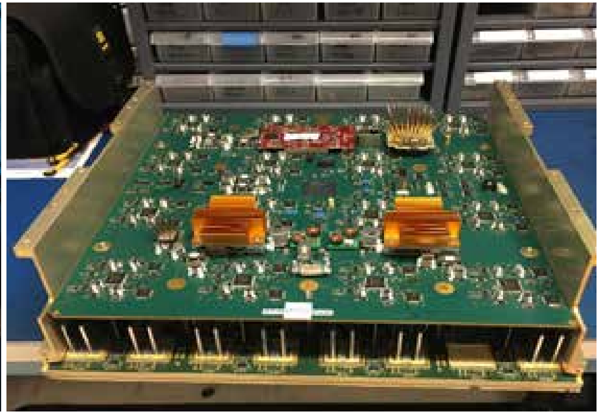
RF LAB

THE RF LAB provides support for chamber measurements through bench space and instrumentation for troubleshooting hardware as well as modifying hardware to be tested in one of the chambers. The RF lab is located on the third floor of the RFSTF and is accessible by a freight elevator, allowing for movement of large heavy items.

The RF lab is equipped with many types of measurement equipment, including network analyzers, spectrum analyzers, oscilloscopes, and signal sources. The space is supplied with humidified air to minimize static and has a bench with an antistatic station for testing static-sensitive devices.

Compressed air, soldering stations, and a high voltage bench are also available.

Field Microscope Used for PCB Assembly Inspection and Repair



Active Electronically Scanned Antenna Panel

AESA Panel Under Test

Contact Information/Map

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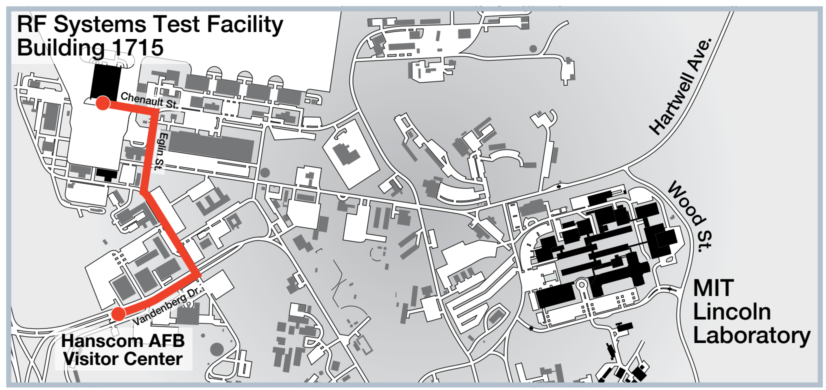

The MIT Lincoln Laboratory RF Systems Test Facility is located on Chenault Street, Building 1715, Hanscom Air Force Base, less than one mile from Lincoln Laboratory's main campus.

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