

EM Technology Databases

- Radome materials
- RAM

Technology Assessment Studies

- Radar target identification
- Inflatable radomes
- Signature studies
- Metamaterial applications

Reference: Cross-Indexed Bibliography

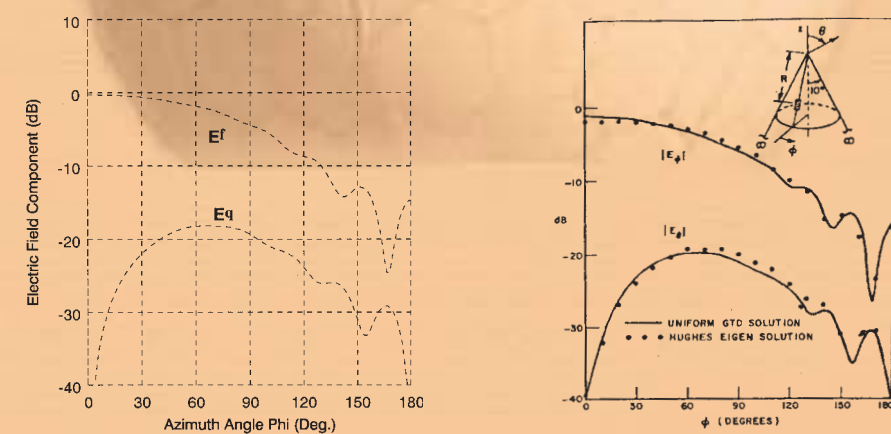
- Radome (40 years)
- RAM (40 years)
- RCS studies (40 years)
- IR signature studies (40 years)

Two Books

- *Radar Absorbing Materials: From Theory to Design and Characterization*. Kluwer Academic Publishers, Norwell, Boston, USA, (ISBN: 0792 397 533), 209 p., 1996.
- *Ray Tracing over Generalized Surfaces*. (A comprehensive handbook)

EM Application Software Packages

- RCS package
- RAM design and analysis package
- *Aavrita*, a user-friendly radome design and analysis package
- EM design and analysis software for
 - Airborne/ ground-based radome
 - Narrowband/ broadband radome
 - Monolithic/ sandwich radome
- GTD-based airborne antennas analysis software for
 - Aircraft, missile, SLV-mounted antennas
 - Antenna patterns, mutual coupling, antenna siting applications
- 3-D Ray tracing software



Standards in CEM computation - Validation of code (left) against a reference (right) precedes any predictions

Computational Electromagnetics Laboratory

R&D Activities

- Radar cross section (RCS) studies and RCS reduction
- Radar absorbing materials (RAM) and structures (RAS)
- Infrared (IR) signature studies
- EM analysis for airborne antennas (for aircraft, missiles and satellites)
- EM design and analysis of radomes (for aircraft, missiles and on ground)
- Ray tracing and surface modelling

R&D Perspective

NAL undertakes RCS and EM applications projects on turn-key basis. *Computational Electromagnetics Laboratory (CEM Lab.)* is associated with the EM aspects in these inter-divisional projects.

Certification Support

The *CEM Lab.* has extensive experience with military and civil aerospace certification procedures. Comprehensive documentations (QTP, QTR, ATP, ATR etc.) are also prepared in consultation with the customer and certification agencies such as CEMILAC, DGCA and CRI for the design and development projects undertaken by NAL.

Recent Sponsors

- AR&DB, New Delhi
- CABS, Bangalore
- CCADD, Bangalore
- DRDL, Hyderabad
- DST, New Delhi
- HAL, Bangalore
- IAF HQ, New Delhi
- IMD, New Delhi
- Indian Navy, New Delhi
- ISRO, Bangalore
- LRDE, Bangalore



ISO 9001:2000
Certified

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Radar Cross Section (RCS) and Electromagnetic Capabilities at NAL



Experimental Microwave Facility

EM Design Centre



NAL Microwave Anechoic Chamber

Open range EM test of 13 m DWR radome developed by NAL

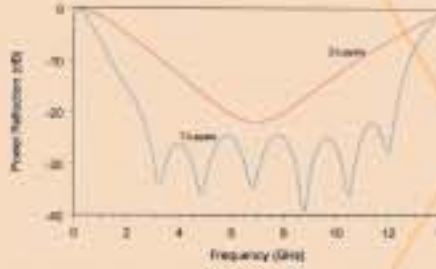


ISO 9001:2000
Certified

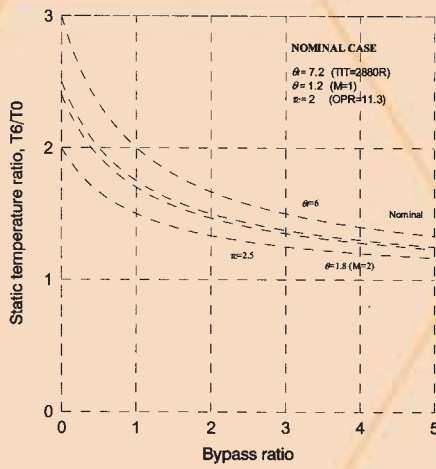
Computational Electromagnetics Laboratory
Aerospace Electronics & Systems Division
National Aerospace Laboratories
Bangalore 560 017, India



RCS measurements at NAL Microwave Anechoic Chamber (NAL-MAC)



RAM design for wideband performance



IR signature studies



13 m dia DWR radome at ISRO's Satish Dhawan Space Centre, Sriharikota

Radar Cross Section (RCS) Studies

- RCS design studies of aerospace vehicles
Aircraft, missiles, helicopters, hovering platforms
- Low observables: Radar absorbing material (RAM) design and analysis for RCS reduction
- Infrared (IR) signature studies
- Integrated approach to RCS and IR signature reduction
- RCS measurements at NAL Microwave Anechoic Chamber (NAL-MAC)

Radome

- Integrated antenna-radome analysis capability
- Includes paints analysis and specifies fabrication tolerances
- Narrow-band/ broadband radome designs
- Monolithic/ sandwich (including honeycomb) designs
- Variable thickness radome (VTR) design
- Hybrid-VTR design for missile radomes
- Multi-sector optimisation radome design
- Ground-based and airborne radomes (for aircraft, missiles, etc.)
- High-temperature, high performance radomes
- Stealth radomes
- Radome EM performance enhancement
Broadbanding techniques
Tuning and correcting radome performance
- In-house EM material characterisation for candidate radome materials
- Radome measurements at NAL-MAC



High temperature radome



Saras aircraft nose cone radome

Computational Techniques

- High-frequency techniques
GTD, UTD, PO, PTD
- 3-D Ray tracing
- Geodesic constant method (GCM)
- EM analysis of curvatures structures
All quadric and ogival surfaces
- Metamaterial design for aerospace applications
- Method of moments (MoM)

Airborne Antenna Analysis

- For aircraft, missiles, and SLV's
- Radiation pattern prediction
- Antenna siting applications
- Antenna performance optimisation
- Antenna pattern characterisation at NAL-MAC

Experimental Microwave Facility (EMF)

- EM characterisation of materials
- VSWR of antennas and radomes
- Scattering parameter measurements

EM Characterisation of Materials

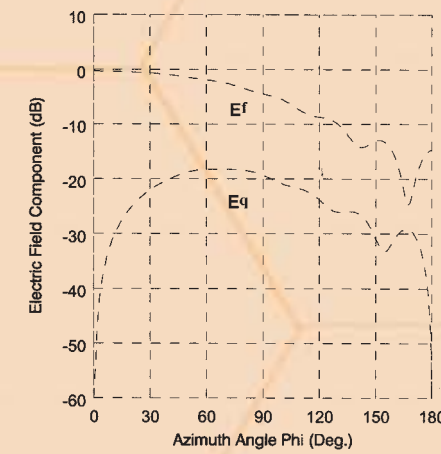
- Dielectric measurement system (DMS)
Based on VNA HP85107B
State-of-the-art accuracy and repeatability
- Permeability measurement system (PMS)
Magnetic material measurements for RAM
- High temperature material characterisation



Broadband radome for TU 142 aircraft



Sandwich radome for Maritime Patrol Radar



UTD computations for canonical shapes



Antenna siting analysis for Saras aircraft



VSWR measurements for antenna and radome



EM characterisation of materials

Microwave Anechoic Chamber (NAL-MAC)

- Certified to 60 dB down performance
- Completely shielded chamber (10.5m x 7.3m x 3.1 m)
- Computer controlled pedestal with azimuth rotation
- Computer controlled azimuth-elevation antenna positioner
- Metal plate lens and dielectric lens for compact range
- Antenna pattern characterisation
- Full scale radome test
- RCS studies



NAL-MAC certificate handing over to NAL Director



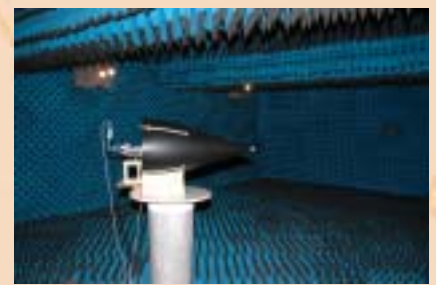
Antenna radiation pattern measurements



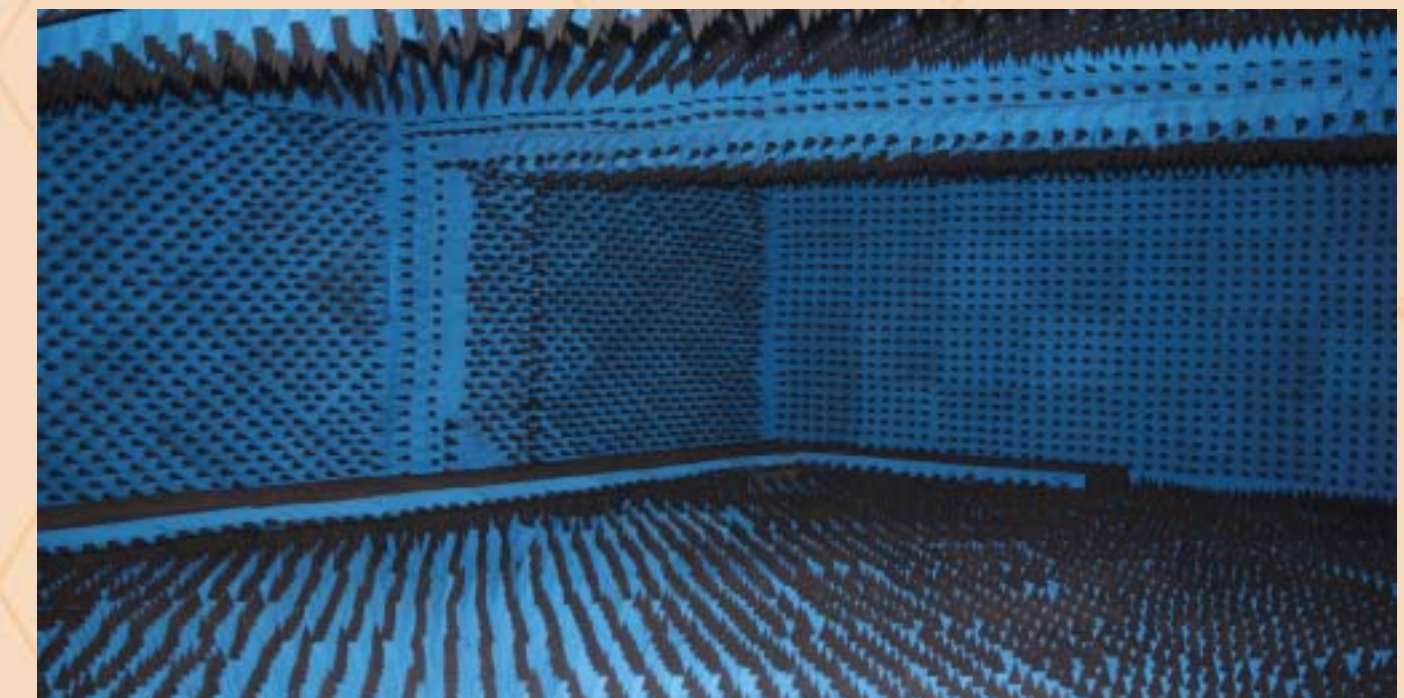
Metal plate lens designed and developed in-house



State-of-the-art power meter for NAL-MAC



Full-scale radome measurements



NAL Microwave Anechoic Chamber (NAL-MAC)