

THE ANTENNA RESEARCH LABORATORY AN OVERVIEW OF PAST AND CURRENT PROJECTS

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The state-of-the-art of measurement facilities of ARL coupled with a record of more than ten years of externally funded research in the areas of antennas, microwaves and electromagnetics at Villanova, has created an educational and research environment that is unique in Delaware Valley and conducive in bringing government and industry together for collaboration on joint projects. The ARL's measurement facility includes a 29' x 28' x 27' compact-range anechoic chamber capable of fully automated antenna pattern, gain and RCS measurements from 2 to 40 GHz. Over the last ten years, the research at ARL has been sponsored by numerous grants from both industry and federal agencies, including grants from National Science Foundation, Office of Naval Research, DARPA, Naval Air Warfare Center, Motorola, Lockheed Martin, Boeing, Mitre, Comcast and American Electronics Laboratory. These grants have included three primary areas of research at ARL: microwave and millimeter-wave low-profile printed antennas, computational electromagnetics, and antenna design automation using evolutionary computational techniques. We have also recently, in collaboration with the University of Pennsylvania, embarked on research on the emerging areas of metamaterials and their antenna and microwave applications. Our other collaborators over the last five years have been the Naval Sea Systems Command, NSWCCD-Philadelphia, Middle Atlantic Research Consortium (MARC), Drexel University and Lafayette College.

Some of the general areas of present research activities at ARL include:

Low Profile and Printed Antennas

- Development of novel techniques for multi-band and/or multi polarization microstrip antennas and arrays for such applications as GPS, regional mobile-sat array, feed arrays for offset reflectors, Other Common transmit & receive antennas
- Development of novel bandwidth enhancement methods for printed antennas.
- Development of novel gain enhancement methods for multi-layered millimeter-waves printed antennas.
- Design of multi-band selective surface (FSS) polarizers for satellite applications.
- Investigation of fractals and other space-filling curves, such as Piano and Hilbert curves, for applications that require a planar antenna structure with a very small footprint but resonant at a very low frequency.

Numerical Electromagnetics

- Development of efficient Method of Moment (MOM) based codes for modeling of printed antennas of arbitrary shapes in a multi-layered uniaxial magneto-dielectric medium.
- Development of Finite-Difference Time-Domain (FDTD) based codes for modeling of multi-layered conformal antennas on curved structures.
- Characterizations of metamaterials and numerical analysis of antennas over various high-impedance surfaces made of such materials.
- Use of MOM-based tools in electromagnetic modeling of antennas on aircraft. For example, in a close collaboration with NSWCCD, we are presently in the midst of numerical modeling of the Boeing's V22 aircraft and comparison with measured results using a scale model of V22.

Development of Efficient Antenna Optimization and Design Automation Tools

At high frequencies, consideration of the effects of mutual coupling, surface-waves and conductor/dielectric losses becomes of paramount importance in synthesis and design of multifunction and high gain printed elements and arrays, as well as in design of other high performance antenna structures subject to various design constraints. Over the last five years we have developed efficient electromagnetic optimization and synthesis tools based on evolutionary computational techniques for design and synthesis of complex antenna structures. In particular we have developed problem-specific algorithms based on Evolutionary Programming and integrated them with the MOM based electromagnetic models for shape optimization of novel antenna configuration capable of various multifunction operations.