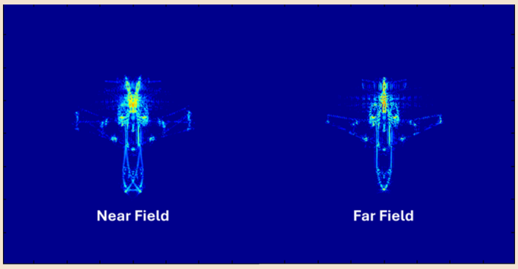
SC13-Transformations for Radar Cross-Section (RCS) and Imaging from Monostatic Near-Field Measurements



Abstract

True far-field (FF) radar cross-section (RCS) measurements of full-scale targets are often impractical to perform because of the large distances and/or large compact range reflectors required to produce a plane wave illumination of the target. This fact has led to a requirement for techniques that can infer FF RCS from limited (specifically, monostatic-only) measurements in the near-field (NF) of the target. This short course will present an in-depth derivation of a family of mature, self-consistent, and accurate monostatic RCS near field-to-far field transformations (NFFFTs) based on models that are used in synthetic aperture radar imaging. These image-based techniques have been successfully applied in practice to a wide range of targets and measurement configurations.

Recommended prerequisites

A basic understanding of RCS measurement techniques.
A cursory familiarity with near field antenna measurements and transformations.
An understanding of Fourier transforms and other basic signal processing methods.

Learning objectives

An in-depth understanding of the mathematical formulation and implementation of image-based RCS NFFFTs.
An appreciation of the NFFFT limitations and their impact on the FF RCS predictions.
Knowledge of the near-field measurement rules-of-thumb for achieving accurate NFFFT results.

Course outline

1. Introduction, Background, and Definitions
2. Image-Based NFFFT Motivation
    - Rigorous near field antenna and RCS transformations
    - The bistatic dilemma
    - Image-based NFFFT introduction
3. Image-Based NFFFT Formulations
    - Radar imaging model
    - 2D scanning geometries
    - 1D scanning geometries
    - Minimum scanning region (MSR) concept
4. 1D Scanning Implementations and Example Results
    - Discrete implementation considerations
    - Reference target data and performance metrics
    - Walk-throughs and performance demonstrations
5. 1D NFFFT Enhancements
    - Antenna pattern compensation
    - Correction for off-waterline collections
6. Recent Advances Toward "Modern" NFFFTs

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Ivan J. LaHaie received his BS degree from Michigan State University in 1976 and his MS and Ph. D. degrees from the University of Michigan in 1977 and 1981, respectively, all in electrical engineering. He joined the Environmental Research Institute of Michigan (ERIM) in 1980 and worked there for 30 years during its various incarnations as ERIM International, Veridian Systems, and General Dynamics Advanced Information Systems. He joined Integrity Applications Incorporated (later Centauri and KBR) in 2010 as a Senior Principal Scientist until his retirement in 2021. Dr. LaHaie is an internationally-recognized authority in the development of techniques for RCS measurement error mitigation, near field-to-far field RCS transformations, and RCS uncertainty analysis.

Dr. LaHaie is an IEEE life fellow and an AMTA fellow. In 1991, he received the IEEE Aerospace and Electronic Systems Society Radar Systems Panel Award, given annually to the nation's leading radar engineer under 40 years of age, for his contributions to synthetic aperture systems and electromagnetic modeling. He received the AMTA Distinguished Achievement award in 2004 for his pioneering work in the development of automated radar signature imaging technology, RCS measurement technology and standards, the design and evaluation of electromagnetic interference and error source mitigation techniques, and for his contributions to the field of radar signature target support interaction modeling.

Bibliography

1. *LaHaie, I.J. (2003), Overview of an Image-Based Technique for Predicting Far Field Radar Cross-Section From Near Field Measurements, IEEE Antennas and Propagation Magazine, Vol. 45, No. 6, pp. 159-169.*
2. *LaHaie, I.J. and S.A. Rice (2003), Antenna Pattern Correction for Near Field-to-Far Field RCS Transformation of 1-D Linear SAR Measurements, Proc. of the 25th Annual Meeting of the Antenna Measurement Techniques Association (AMTA '03), Irvine, CA, pp. 240-245. Also published in IEEE Ant. Prop. Mag., Vol. 46, No. 4, August 2004, pp. 177-182.*
3. *LaHaie, I.J., C.M. Coleman, and S.A. Rice (2005), An Improved Version of the Circular Near Field-to-Far Field Transformation (CNFFFT), Proc. of the 27th Annual Meeting of the Antenna Measurement Techniques Association (AMTA '05), Newport, RI, pp. 196-201.*
4. *Coleman, C.M., I.J. LaHaie, and S.A. Rice (2005), Antenna Pattern Correction for the Circular Near Field-to-Far Field Transformation (CNFFFT), Proc. of the 27th Annual Meeting of the Antenna Measurement Techniques Association (AMTA '05), Newport, RI, pp. 202-207.*
5. *LaHaie, I.J. (2009), Generalization of Circular and Linear Image-Based NFFFTs to Off Waterline Collections, Proc. of the 31st Annual Meeting of the Antenna Measurement Techniques Association (AMTA '09), Salt Lake City, UT, pp. 316-322.*
6. *LaHaie, I.J. and B.E. Fischer (2013), Transformations for Radar Cross-Section and Imaging from Monostatic Near-Field Measurements, short course materials from the 35th Annual Meeting of the Antenna Measurement Techniques Association, Columbus, OH. Also presented at the 2014 IEEE AESS Radar Conference, Cincinnati, OH.*
7. *LaHaie, I.J. and G.D. Dester (2019), Application of L1 Minimization to Image-Based Near Field-to-Far Field RCS Transformations, Proc. of the 13th European Conference on Antennas and Propagation (EuCAP 2019), Krakow, Poland.*

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