Harmonic Radar Cross-Section Modeling with Non-linear Method of Moments

Streamlining production of simulated training data for target discrimination algorithms for electrically large platforms

To streamline production of simulated training data for target discrimination algorithms, we are providing an efficient and high-fidelity modeling capability for non-linear radar response of electrically large platforms, such as hypersonic missiles, that is unavailable in the current commercial and government space.

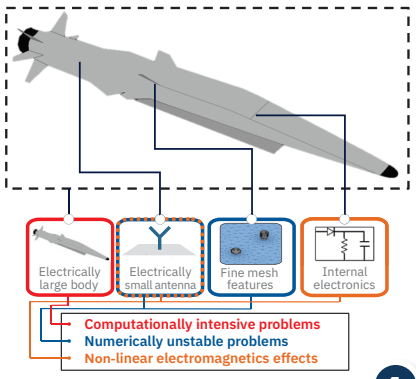
Threats addressed in this IRAD include discrimination of hypersonic missiles vs. decoys and detection of hostile UAV and nefarious devices.

Procedure

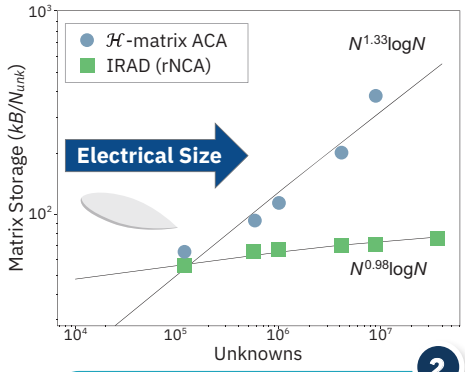
We develop theory and formulation for method of moments with harmonic balance (MoM-HB). Commercial large language models were employed to assist in method formulation.

Observations

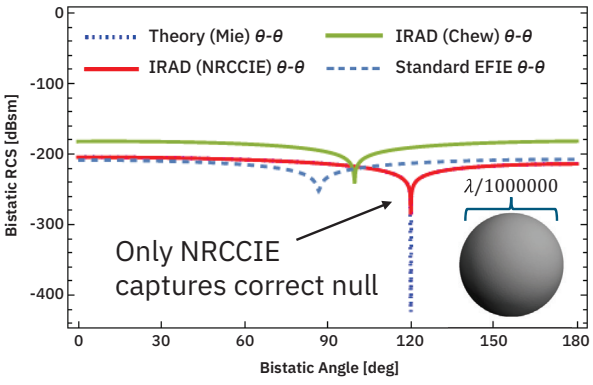
Our methods development IRAD has been successful addressing multiple facets of radar cross section modeling:



1 Non-linear effects due to internal circuitry: a complementary component of target signature analysis



2 The success of the nested cross approximation method in dramatically reducing resource requirements for electrically large problems



3 The success of novel integral equations formulations for describing very fine or electrically small features that lead to numerical instabilities in conventional approaches

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Key Features

- Capturing non-linear effects illuminates hidden internal details of target circuitry
- Hierarchical matrix algebra coupled with harmonic balance enables analysis for large platforms and high frequencies
- Efficient modeling capability enables rapid generation of training data for target discrimination algorithms

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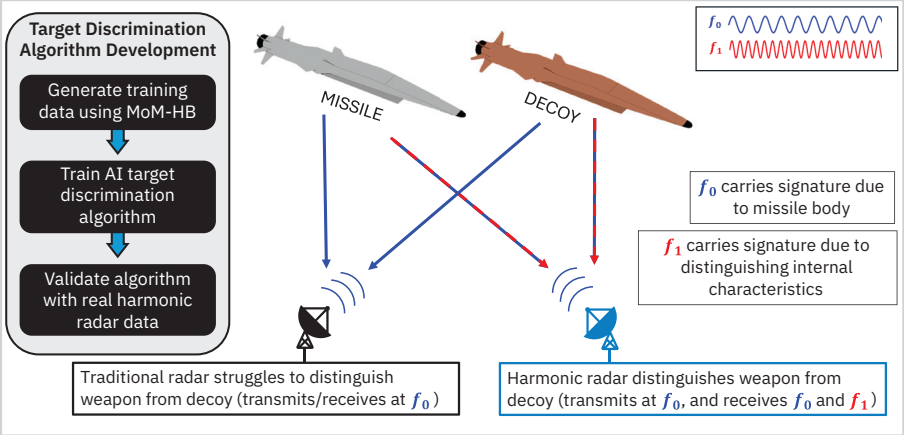

Target discrimination with harmonic radar

Building on the great success of our previous computational EM methods development IRADs and CRADs, we began integrating method of moments with harmonic balance (MoM-HB). An efficient MoM-HB approach will provide the ability to model harmonic response from internal electronics in missiles or other platforms. Efficient computation of harmonic radar signatures for electrically large vehicles with multi-scale components can provide a wealth of training data for AI target discrimination algorithms.

Next Steps

- Develop a prototype code implementation of MoM-HB using our *Stars MoM* tool
- Integrate with additional cutting-edge methods developed on IRAD: nested cross approximation for larger problems and novel integral equations for numerical stability

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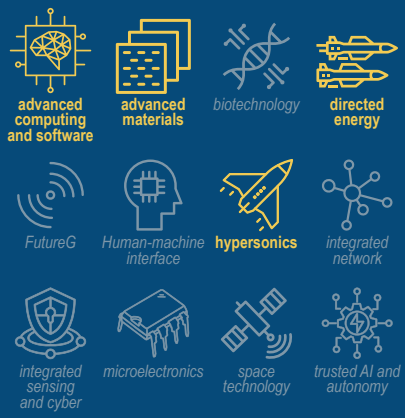
Critical Tech Areas



DoD Priorities

1. Southwest Border Activities
2. Combating Transnational Criminal Organizations in the Western Hemisphere
3. Audit
4. Nuclear Modernization (including NC3)
5. Collaborative Combat Aircraft (CCAs)
6. Virginia-class Submarines
7. Executable Surface Ships
8. Homeland Missile Defense
9. One-Way Attack/Autonomous Systems
10. Counter-small UAS Initiatives
11. Priority Critical Cybersecurity
12. Munitions
13. Core Readiness, including full DRT funding
14. Munitions and Energetics Organic Industrial Bases
15. Executable INDOPACOM MILCON
16. Combatant Command support agency funding for INDOPACOM, NORTHCOM, SPACECOM, STRATCOM, CYBERCOM, and TRANSCOM
17. Medical Private-Sector Care