Application Sheet

FEKO

Comprehensive Electromagnetic Solutions

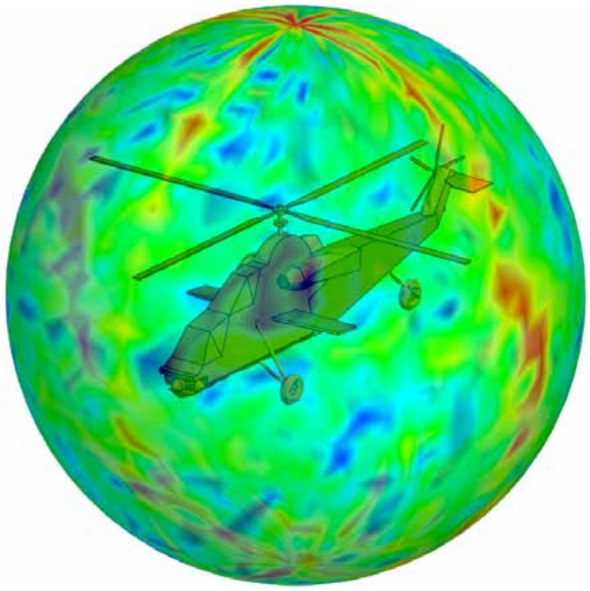
Scattering and Radar Cross Section

Introduction

The scattering properties of an object is the spatial distribution of scattered energy when the object is exposed to incident electromagnetic fields. Incident fields can be reflected, scattered into multiple directions or absorbed by the object, depending on the object's shape, size and material properties. Two scenarios exist where the scattering properties of structures are important:

1. Designing systems that detect objects with non-cooperative technology, for example collision detection and avoidance systems.
2. Designing objects with the intent to increase or inhibit the ability of transmitters to detect it by non-cooperative means, for example stealth aircraft.

Radar cross section (RCS) is a measure that describes an object's scattering properties. It is defined as the quotient of scattered power density to incident power density for a particular object where the incident and scattered directions may vary without restriction. As FEKO can distinguish incident from reflected electromagnetic (EM) field components, it is well suited to scattering and RCS computations.



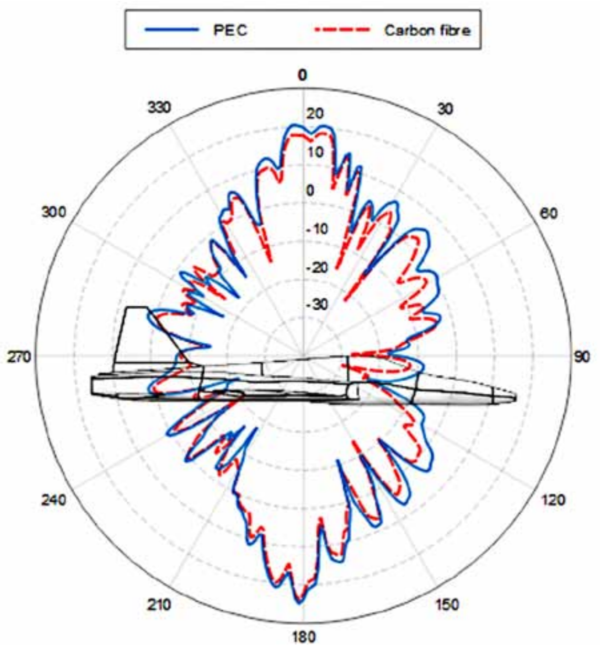
The RCS intensity view of an attack helicopter

Solution Methods

The variety of numerical methods in FEKO make it possible to optimise models for investigating the required level of detail. Full-wave methods, for instance the multilevel fast multipole method (MLFMM), or asymptotic high frequency methods, such as physical optics (PO), large element physical optics (LE-PO) and ray launching geometrical optics (RL-GO), may be used to model field scattering from an object. These methods all cater for special materials (for example anisotropic carbon fibre) to be used to model the object under investigation.

The multilevel fast multipole method (MLFMM) is an efficient method for full-wave scattering analysis. It employs smart initialisation of its iterative solver to speed up convergence for monostatic RCS computation over a range of angles.

When objects become electrically large, the computational cost of the MLFMM becomes prohibitive. In such cases, physical optics (PO) or ray launching geometrical optics (RL-GO) can be used. In cases where multiple reflections are not significant, LE-PO provides an extremely efficient solution.



The comparison of RCS for an aircraft with perfect electric conductor (PEC) versus carbon fibre body panels

Standard Presentation of RCS Data

Well-known, standard representations can be used to display RCS data in POSTFEKO. These images are useful for gaining physical insight, developing operational theories and refining technology from both radar and detectability perspectives. Examples of standard visualisations include:

- 3D representations of RCS, which help develop physical insight into the scattering properties of an object.
- 2D Cartesian or polar plots for review of detailed RCS levels and comparison with the RCS of other objects.

Advanced Presentation of RCS Data

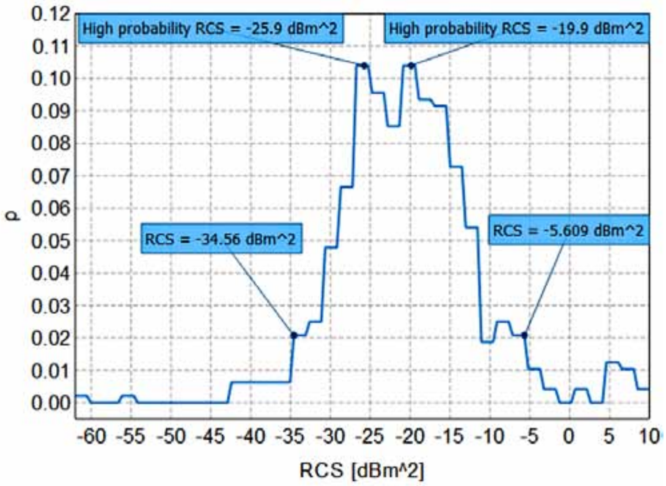
Radar engineers often seek more advanced representations of RCS data, including:

- Probability density functions - where the likely RCS of a target is investigated when the angle of incidence is unknown.
- Intensity plots: RCS magnitude versus sweeps of both azimuth and elevation angles of incidence. It immediately becomes evident which perspective of the target has the largest RCS.
- Inverse synthetic aperture radar (ISAR): A post-processed representation of RCS that forms images to help with the identification of targets by identifying where the scattering originates on the object.

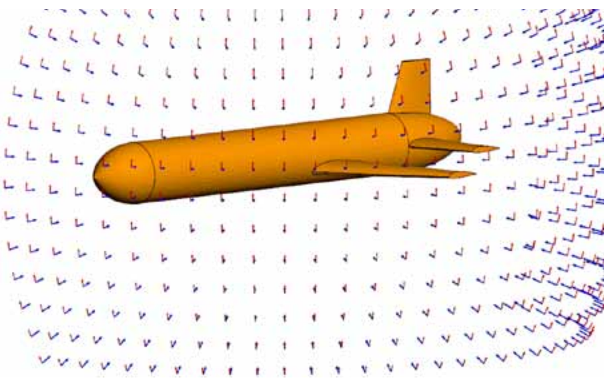
POSTFEKO's powerful user interface and Lua scripting environment make it possible to generate all of these advanced scattering views. For example, in the case of ISAR, a small band of frequencies and angles of incidence may be defined for the computation of RCS with any of the relevant FEKO solvers, resulting in a large block of raw RCS data. The data may then be post-processed with Lua to form the ISAR image, which can be overlaid onto the actual target to investigate the correlation of the ISAR image with the true geometry of the object. These images may then be used to design and train detection algorithms for target recognition radar systems, without having to spend large amounts of money on expensive prototyping or complex measuring and testing equipment.

Conclusions

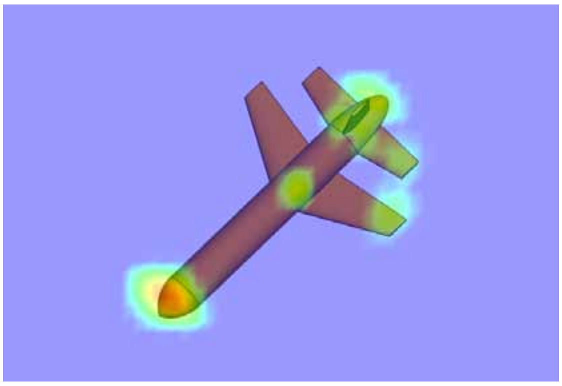
CADFEKO is a powerful CAD tool for the creation of appropriate models. The FEKO solver offers various mathematical methods for solving scattering problems. POSTFEKO has the ability to render scattering properties and RCS in both simple and advanced representations, making FEKO an industry leading tool for scattering and RCS modelling and analyses.



The RCS probability density function (PDF) rendered with POSTFEKO and Lua scripting



The angles of incidence for a plane wave source excitation during a detectability study



The ISAR representation of a mock-up of a cruise missile

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