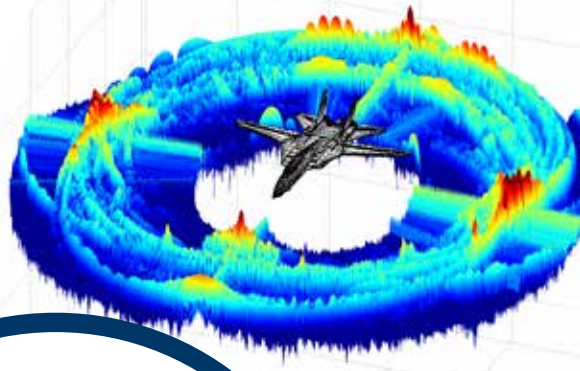
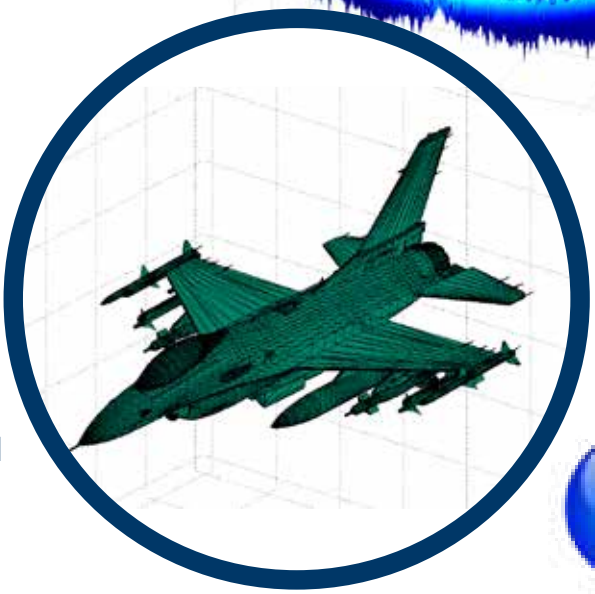
SigmaHat Software for radar and electronic warfare applications





SigmaHat is an efficient computational electromagnetic (CEM) software tool used for the calculation and analysis of the radar cross section (RCS) and other electromagnetic (EM) scattering features of targets of interest in radar and electronic warfare (EW) engineering. It is based on asymptotic (high frequency) electromagnetic (EM) calculation techniques and can be used to calculate the RCS of electrically large complex three-dimensional (3D) objects such as aircraft, land vehicles and ships. SigmaHat is efficient and accurate and has been used for various applications – It has been validated with other commercially-available CEM tools, as well as radar measurements.

The software provides a cost-effective way of augmenting RCS measurements, which are often costly and incomplete, by filling in gaps or extrapolating with high fidelity simulated RCS data. SigmaHat is used with hardware in the loop and scenario simulator tools to calculate the RCS of targets being simulated. It also serves as an excellent training tool for radar and EW engineers who need to develop their understanding of RCS and other EM scattering principles. Such knowledge is crucial for system and algorithm design, as well as during testing and evaluation.

Main uses

SigmaHat has several applications in the field of radar and EW engineering, including:

- Calculation of the RCS of objects such as aircraft, land vehicles and ships;
- Calculation and analysis of EM scattering features of target objects for use in the development and evaluation of radar systems and techniques;
- Supplement RCS measurements of target objects, which can be limited in aspect angles and frequency coverage, by additional RCS calculations.;
- Simulation of the RCS of objects in complex scenes, for instance a ship on the sea surface;
- Simulate high resolution range (HRR) profiles, inverse synthetic aperture radar (ISAR) images and/or micro-Doppler, e.g., Jet Engine Modulation (JEM), signatures of radar targets. These results are extremely useful during the development of non-cooperative target recognition (NCTR),
- Train engineers in terms of target scattering mechanisms and RCS features; and
- Generate high fidelity RCS scattering models of targets for engagement analysis in the Sensor and Electronic Warfare Engagement (SEWES) environment and hardware in the loop (HIL) systems such as the Engima system.

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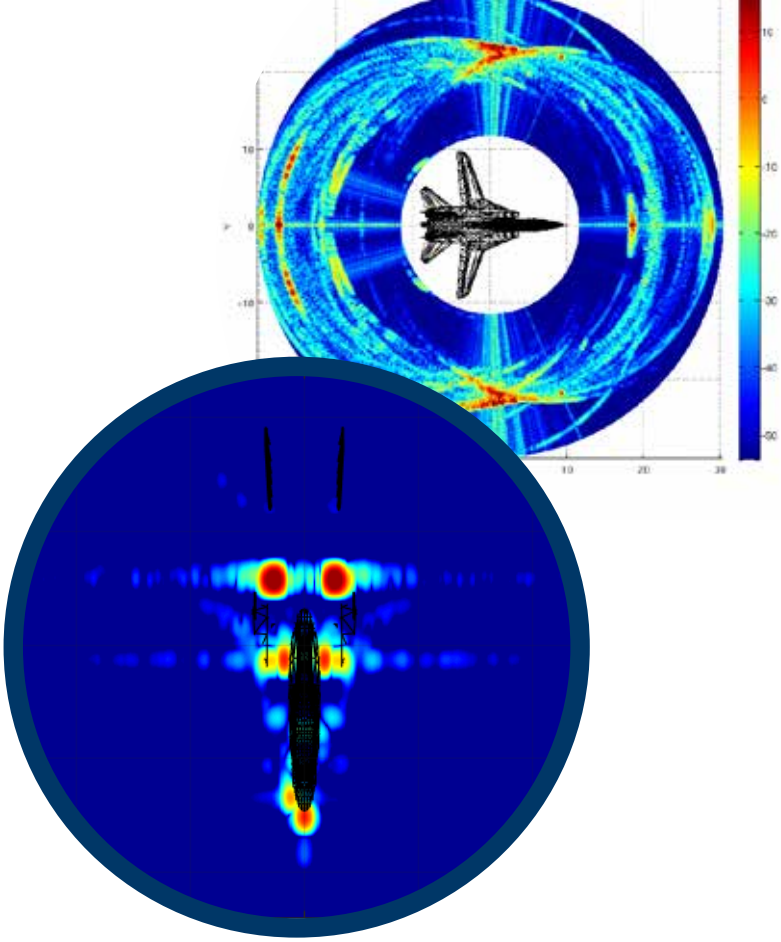
Main features

SigmaHat has the following main features:

- Easy-to-use Graphical User Interface;
- Import and basic manipulation of CAD models of complex 3D objects;
- Calculation of the RCS of targets at multiple aspect angles and frequencies;
- Supports multi-core processing;
- Batch processing modes for linear RCS simulations, HRR profile and ISAR image generation and so forth;
- Innovative calculation techniques, which can be optimised for accuracy or improved run-times;
- Generation of various target scattering outputs, such as:
  - Real Beam Image (RBI),
  - HRR profile, and
  - ISAR image.
- Generation of high-fidelity RCS scattering models of target objects for use in the SEWES environment for RCS resynthesis;
- Generation of high-fidelity RCS scattering models of complex targets for use with the Engima system for ISAR image resynthesis; and
- Animation of parts of a target;
- Complex environment simulations such as ship on a sea surface.
- Simulation of complex targets with absorbing material regions.



How it works

SigmaHat provides the following CAD **input model** features:

- Easy import CAD models;
- Support various CAD file types such as, NASA structural analysis (NASTRAN), object (OBJ) and standard triangle language (STL) files;
- Basic geometry manipulation (e.g., translate, rotate and scale);
- Support for object animation (e.g., rotating helicopter blades and dynamic sea surface);
- Support for target-in-environment simulations (e.g., ship on sea surface).

SigmaHat provides the following **calculation method** features:

- First bounce scattering calculation using the asymptotic Physical Optics (PO) method;
- Multi-bounce scattering calculation using ray-tracing calculations together with the Geometric Optics (GO) and PO methods. This is also known as the shooting and bouncing ray method;
- Accurate geometric blockage evaluation using ray tracing calculations;
- Efficient calculation of scattering response at multiple discrete frequencies;
- Edge diffraction scattering calculation using

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the Incremental Length Diffraction Coefficient method;

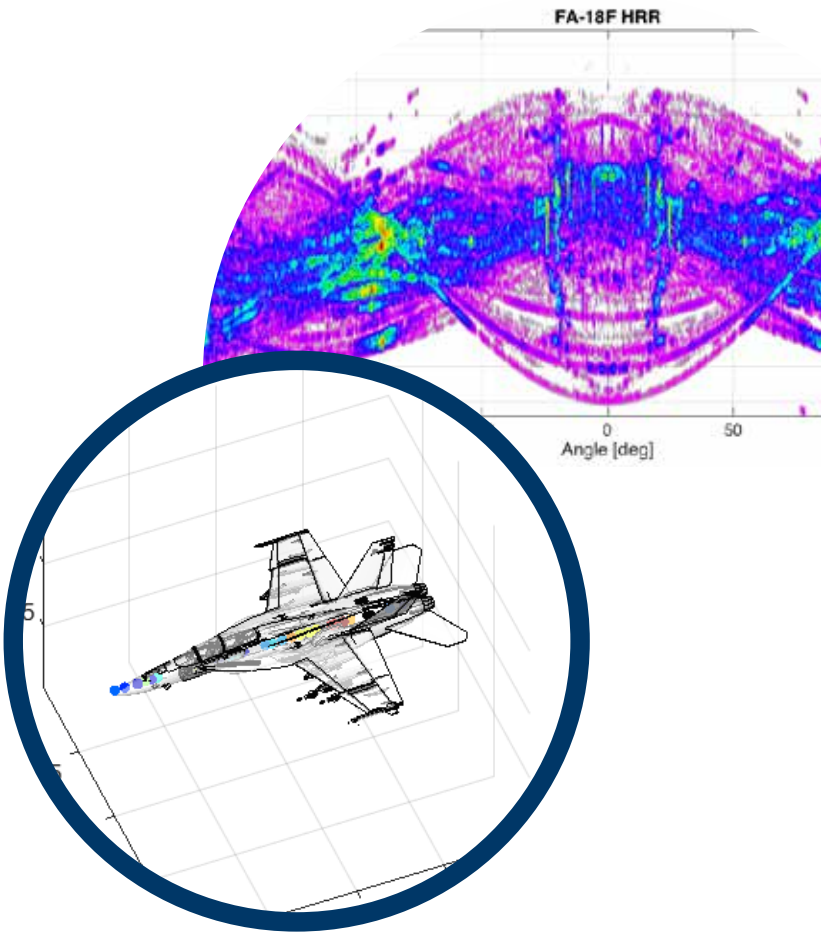
- Automatic edge finding algorithm;
- Principle polarisation (H and V);
  - Co-polarised field responses (HH and VV);
  - Cross-polarised field responses (HV and VH);
- Nearfield calculation method (using curved wavefront);
- Bistatic scattering calculation method;
- Solver parameters can be optimised for faster calculation or a more accurate solution;
- 1D- and 3D scattering centre extraction algorithm.

SigmaHat can provide the following **outputs**:

- RCS data per frequency and per aspect angle;
- Complex (amplitude and phase) scattered field;
- Real beam image (RBI) for visualisation of scattering contributions;
- HRR profiles;
- ISAR images;
- Output data is stored in Matlab file format;
- Table of target scattering centres for use in the SEWES and HIL-Enigma environment; and
- 2D and 3D scattering centre extraction and association for the use in HIL-Engima systems.

SigmaHat provides the following calculation **performance** features:

- Calculation performance is increased through parallel processing. This includes the use of multiple central processing unit (CPU) cores, as well as multiple processing nodes (batch processing) in a cluster configuration;
- A high-performance ray tracing engine is used to reduce calculation times;
- Loop optimisations reduce calculation run-times; and



- Adaptive sampling can be used to balance solver accuracy and calculation speed.

SigmaHat provides several **easy customisation features** (when used in the Matlab environment):

- Basic geometry class can be extended to provide advanced CAD model features such as rotating structures (e.g., helicopter blades), environment (e.g., animated sea swell height map) and so forth;.
- Default types of batch simulation can be extended (e.g., turntable, spherical, igloo etc.);
- SigmaHat's post-processing toolset can be used to import result data into Matlab for analysis

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