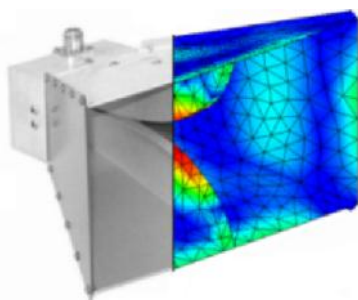




Introduction to the FEKO Suite

FEKO is a suite of tools that is used for electromagnetic field analysis of 3D structures. FEKO simulations are based on the Method of Moments (MoM) solution to Maxwell's equations and features several extensions to the MoM for the solution of complex problems, including large structures and complex dielectrics or human tissue. Various output parameters can be computed and displayed in a number of formats to make FEKO a leading electromagnetic simulation software suite.

<i>Solution Methods</i>	<i>Applications</i>	<i>Special Features</i>
• Method of Moments (MoM), extended to a wide range of applications e.g. dielectric volumes, planar multi-layered structures, dielectric and magnetic coatings, thin dielectric sheets, ground plane reflections, periodic boundary conditions. • Multilevel Fast Multipole Method (MLFMM) • Finite Element Method (FEM) • Physical Optics (PO) • Geometrical Optics (GO) • Uniform Theory of Diffraction (UTD)	• 3D Antenna design • Antenna placement on large platforms • Microstrip antennas (Planar and conformal) • Microstrip circuits • 3D RF components (Waveguide) • EMC analysis (Including complex cable harnesses) • Dielectric bodies (SAR) • Scattering analysis (RCS)	• True hybridisation (MoM with FEM, PO, GO and UTD) • Adaptive Cross-Approximation • Parallel processing • Optimisation • Adaptive frequency sampling • Domain decomposition • Time domain analysis • Low frequency analysis • GPU acceleration • Out-of-core solution • Wide range of hardware supported



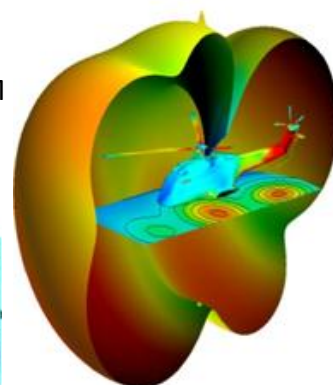
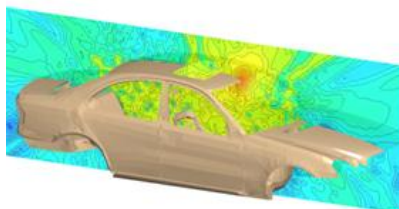
Applications

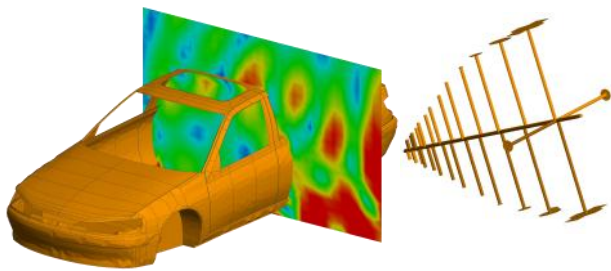
Antenna Analysis

Wire antennas, horn and aperture antennas, reflector antennas, microstrip antennas, phased array antennas, helical antennas. Many special formulations enable the analysis of practical antenna problems.

Antenna Placement

The MoM/FEM, MoM/PO, MOM/GO, MoM/UTD hybridisations and the MLFMM enable the analysis of antennas mounted on electrically large platforms where the interaction with the nearby structures influences the antenna characteristics, e.g. UHF antennas on aircraft or ships, GSM antennas on motor vehicle, etc.



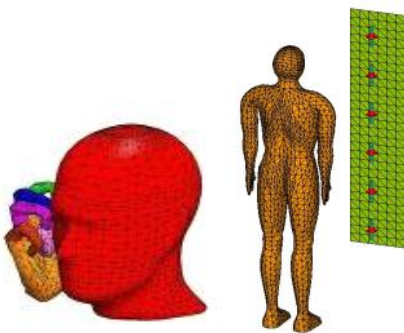
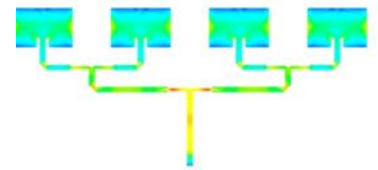


EMC and cable problems

FEKO is used extensively for EMC analysis, especially in the automotive industry. It is useful for computing cable-to-cable and cable-to-device coupling and for the investigation of cable radiation effects. FEKO can solve both radiation and irradiation problems, through standard multi-conductor transmission line (MTL) theory or the combined MoM/MTL solution method.

Planar microstrip antennas and circuits

A full 3D MoM formulation is available for the analysis of microstrip antennas with arbitrarily oriented metallic wires and surfaces in multi-layered dielectric media. Interpolation tables are used for faster simulation times.

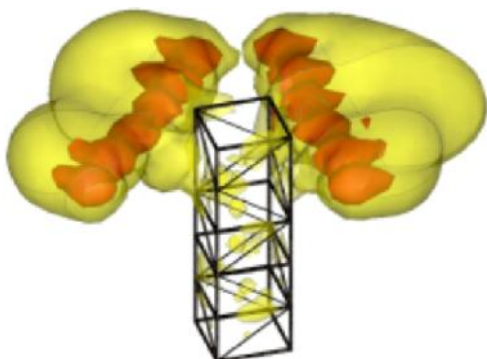
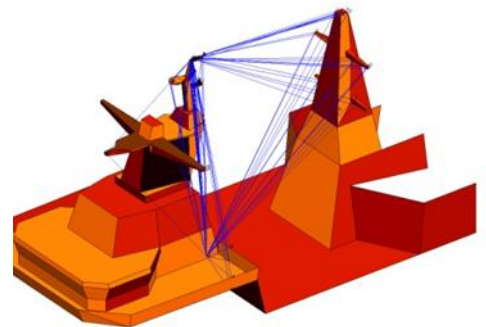


Dielectric bodies (e.g. SAR computation)

Field values can be calculated inside multiple dielectric regions, each with different dielectric parameters. These fields may be used for computation of the Specific Absorption Rate (SAR) in these regions. This functionality has found wide application in the analysis and design of mobile phones and has also been applied extensively in studies regarding the compliance of cellular base stations to international radiation exposure guidelines.

UTD ray tracing for RF antennas

The visualization of UTD rays can be very informative in identifying high frequency scattering and reflection points. Typical application of this technology is in the investigation of inter-antenna isolation, radiation pattern distortion, etc. Typical examples of this application include RF antennas on ship superstructures or mobile phone base stations in complex building environments.

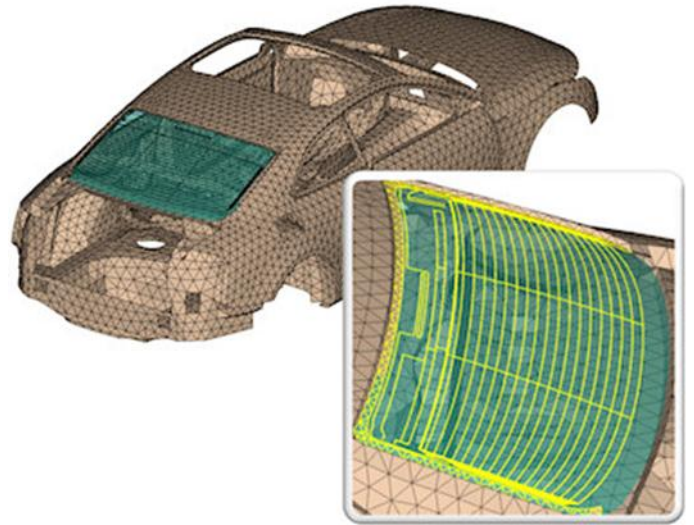


Radiation exposure safety studies

The MoM or MLFMM may be used to compute near-field values around complex building and antenna structures where people work. Isosurface plots are then instrumental in determining where the safety boundaries conforming to international radiation safety guidelines are located. Such information is typically used to place signage and barriers at the site, ensuring safety of the public and personnel in proximity to the transmitters.

Analysis of windscreen antennas

Windscreen antennas may be modelled with a MoM-based solution method that was designed specifically for this class of problem. Multiple layers of windscreen glass can be taken into account, without meshing the glass. Antenna elements may consist of either wire or metallic elements which are located inside a layer or on the boundary between adjacent layers. Multiple windscreens may be taken into account and coupling with external geometry, e.g. a car body, is accurately modelled.



GRAPHICAL USER INTERFACE (GUI)

The FEKO GUI consists of CADFEKO and POSTFEKO and is available for Windows and Linux.

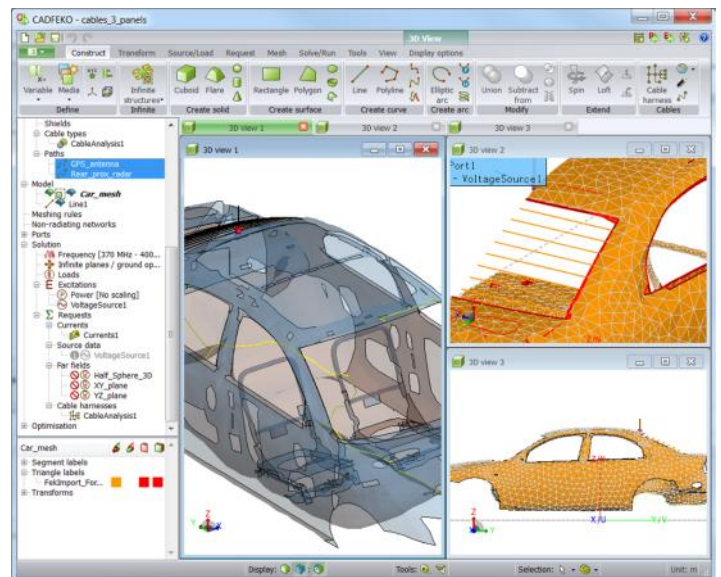
CADFEKO

Functionality:

- Interactive geometry specification.
- Automated or custom meshing.
- Excitation and port definition.
- Solution control.
- Optimisation setup.
- Output requirement specification.

Features:

- Create canonical structures (cylinders, polygons, spheres, cones, etc.) with the click of a button.
- Perform boolean operations on geometry objects (e.g. split, union, intersect and subtract).
- Define various types of curves and surfaces, including analytical curves, splines and NURBS surfaces.
- Create geometry by spinning, sweeping and lofting lines and curves.
- Translate, rotate, scale and mirror objects.
- Project points, curves and surfaces onto surfaces or solids.
- Enter parameters in terms of variables and/or mathematical expressions which may be modified to change the geometry.
- Surface meshes (triangles) and volume meshes (tetrahedra) may be created with user specifiable mesh density for any specific region of the geometry.
- Import and export filters for complex geometry or mesh models in industry standard CAD formats (such as AutoCAD, Parasolid, ACIS, Unigraphics, Pro/ENGINEER and CATIA for geometry and NASTRAN, STL, ABAQUS and Concept for meshes.)



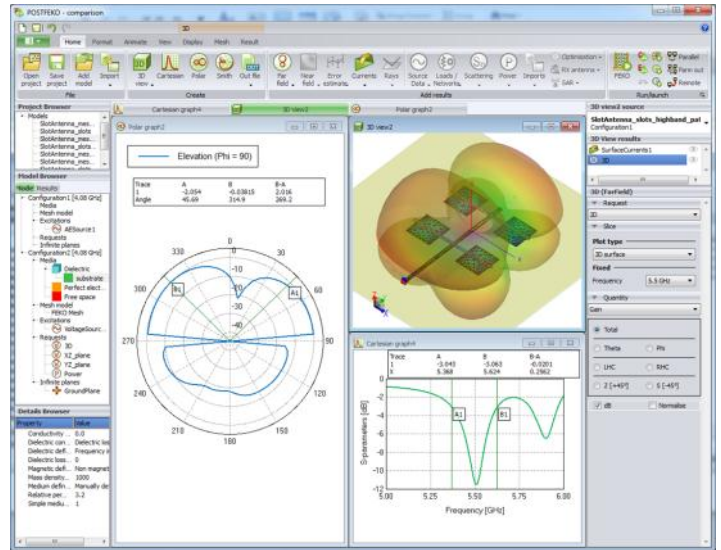
POSTFEKO

Functionality:

- Model validation.
- Post-processing and visualisation of results.

Features:

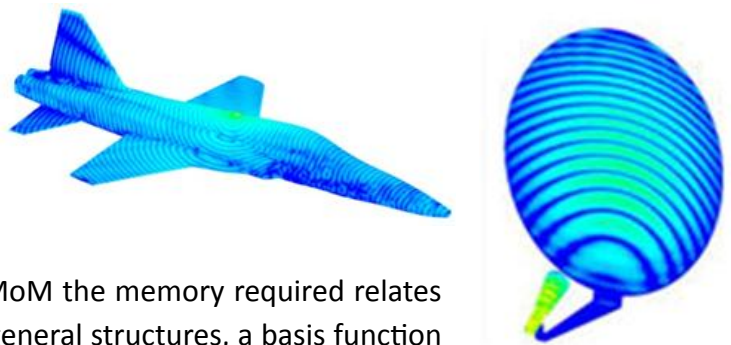
- Support for multiple 2D and 3D views with multiple geometry (*.fek) and result (*.bof) files in a single session.
- Support for multiple results of the same type, e.g. displaying more than one near-field ortho-slice in the same 3D view.
- Multiple and arbitrarily oriented cut-planes are supported.
- Advanced Specific Absorption Rate (SAR) display options.
- UTD ray colours indicate their relative amplitudes.
- Electrical surface currents and electrical charge density display options.
- 2D graph measurements and annotations for values such as local and global maxima and minima, beamwidth, bandwidth and side lobe levels.
- Scripting based advanced post-processing.
- Report generation in MS Powerpoint, MS Word and PDF formats.

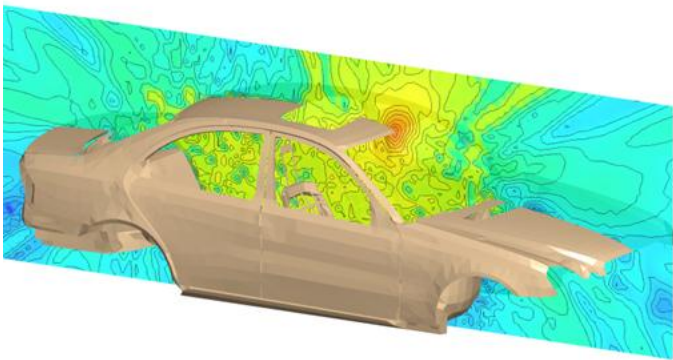


Solution of Electrically Large Problems

Full-wave techniques (MoM, FEM etc.) generally suffer from poor scalability. This limits the electrical size of the problems that can be solved on typical computers. When using field based solution techniques (FEM, FDTD), the discretisation of the field introduces a very small error as a wave propagates through the mesh. For very large meshes, these errors could add up, resulting in reduced accuracy in results. The error can be reduced by using a finer discretisation, but this increases the resource requirements.

The MoM does not require field discretisation, which means that the propagation distance does not degrade the accuracy of the results. With the MoM the memory required relates to the number of basis functions squared (N^2). For general structures, a basis function density of about 100 basis functions per λ^2 is recommended. For 1 GByte RAM, and using no symmetry, this translates to a surface area of approximately $82\lambda^2$ that can be solved in-core. Larger problems can be solved using an efficient out-of-core solver in FEKO, but this solution is slower than an in-core solution.

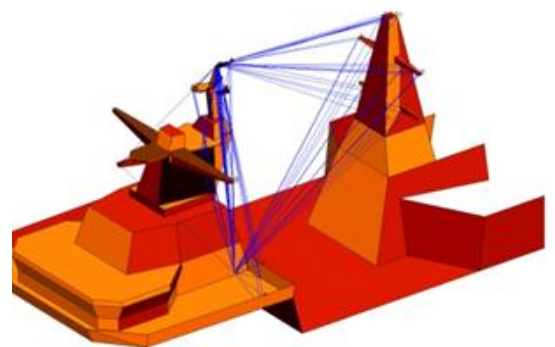




The memory requirements for MoM is proportional to N^2 , whereas that of the MLFMM is $N \cdot \log(N)$ (for metallic surfaces $N \approx 100 \cdot (A/\lambda^2)$ with A the surface area). For large N this is a huge difference!

Although the MLFMM enables the analysis of electrically large problems, this accurate full-wave method is not sufficient for the solution of electrically huge structures (e.g. aircraft or ship at 10 GHz and above).

Asymptotic high frequency techniques (PO, GO and the UTD) offer a solution to the scalability hurdles in such problems. In the PO formulation the currents on the metallic surfaces are simply calculated from the incident field. The GO works by launching rays from each MoM element and placing Huygens sources on surfaces, while with the UTD only the closed form reflection and diffraction (edge and corner) coefficients are used in the solution. The size of the object, therefore, does not influence the memory requirement. The coefficients (terms) and the number of interactions do however influence the run-time. The UTD formulation requires that the smallest dimension of the UTD objects be at least in the order of a wavelength.



Whereas the triangles (for PO and GO) are well suited to represent complex geometry, the use of flat polygonal plates restrict the application of the UTD to geometries which can be modelled sufficiently with such plates (e.g. a ship).

In FEKO, the generally applicable MoM has been hybridised with the Physical Optics (PO), Geometrical Optics (GO) and the Uniform Theory of Diffraction (UTD). This hybridisation enables the solution of large problems on small computers. The hybridisation allows for full wave analysis where required, and approximations to be used when applicable.

Asymptotic predictions of memory usage for the MoM with and without MLFMM			
N	MoM	MLFMM	Application
100,000	150 GB	1 GB	Military aircraft at 690 MHz Reflector antenna with aperture size 19λ .
200,000	600 GB	2 GB	Military aircraft at 960 MHz Reflector antenna with aperture size 27λ .
400,000	2.4 TB	4.5 GB	Military aircraft at 1.37 GHz. Reflector antenna with aperture size 38λ .
1 000,000	15 TB	12 GB	Military aircraft at 2.2 GHz Reflector antenna with aperture size 60λ .