

# Release Notes for FEKO Suite 7.0

May 2014

## (Changes since FEKO Suite 6.3)

FEKO Suite 7.0 sees the addition of a finite difference time domain (FDTD) solver to its comprehensive set of powerful computational methods. The FDTD solver integrates seamlessly into the FEKO suite and boasts with advanced features such as GPU capabilities to improve performance.

The new FDTD solver is used to calculate frequency domain results and allows switching between other solvers. The FDTD solver is in addition to the existing time domain simulations and Fourier transforms in POSTFEKO.

The FDTD solver is just one of the many new features and improvements available in the Suite 7.0 Release. The sections that follow will elaborate on these and other improvements.

*Note that you require a new licence file which supports FEKO Suite 7.0. This licence file is also valid for older FEKO releases, allowing the usage of multiple FEKO versions if required.*

The more prominent new features are listed below. Many smaller bug fixes and extensions are included in addition to the listed items.

## Prominent features in FEKO Suite 7.0

The main focus for the Suite 7.0 release is the new FDTD solver. Since a number of features required development across multiple FEKO components, it will be listed below, instead of repeating the feature for each component.

1. A hybrid technique is now supported which allows either PO or LE-PO to be used with the MLFMM in the same model. When using LE-PO with MLFMM, bi-directional coupling is included. This is in contrast with the LE-PO and MoM hybrid where bi-directional coupling is not supported.
2. Standard configurations (frequency domain field analysis) may be solved with the FDTD solver. The solution is performed in the time domain and converted to the frequency domain by performing a fast Fourier transform (FFT). When the FDTD solver is activated, a voxel mesh is created and the model solved by means of the FDTD solver. POSTFEKO will display all the supported results as for any other solver. The supported request types for the FDTD solver are:
  - Near field request (all coordinate systems)
  - Far field request
  - Voltages and currents for sources (automatically calculated, no request required)
  - Voltages and currents for loads (automatically calculated, no request required)

3. Scattering parameter calculations are performed in a similar way as for standard configurations.
4. A new mesher was developed to generate a voxel mesh required by the FDTD solver. The display of the new voxel mesh elements is integrated into CADFEKO and POSTFEKO.
5. The boundary conditions supported by the FDTD solver are:

**Open boundary:** The open radiating boundary is implemented as a convolutional perfectly matched layer (CPML).

**Perfect electrically conducting boundary:** The PEC boundary allows efficient simulation of infinitely large electrically conducting planes.

All boundaries can be placed on the edge of the model, at a specified position or at a distance away from the model extents. The default option is for the boundary to be placed at an automatically determined distance away from the model extents.

6. A suitable time signal is selected automatically by the FDTD solver. The signal is selected to include all frequencies of interest to ensure a successful conversion to the frequency domain. Signal parameters such as the simulation interval time may be modified.

## User interface

The GUI components have been extended to support all new features and solution techniques in the FEKO kernel. In addition to supporting the new FDTD solver, numerous other features and improvements have also been implemented. More details regarding the FDTD solver support and other features are listed in the following sections.

### 3D CAD modeller - CADFEKO

The prominent new features implemented in CADFEKO, in addition to the features listed earlier, are highlighted in the following list:

1. More than 400 extensions and bug fixes have been implemented since the previous release.
2. A new voxel mesh generator was developed to allow models to be discretised into voxel elements for the FDTD solver.
  - (a) The mesher supports non-uniform voxel meshing of geometry and mesh parts (triangles, unmeshed faces, tetrahedra and segments).
  - (b) Generated voxel meshes align to key points and boundaries of the original model to provide an accurate mesh for the given voxel edge length.
  - (c) Advanced mesh settings allow users to control the quality of the mesh. The advanced mesh settings include:

**Fraction of voxel size:** The position of gridlines are influenced by points of interest on the geometry. If these points are closely spaced, unnecessarily small voxels can result.

**Aspect ratio control:** The ratio between the longest and shortest side lengths of a voxel. Specifying the aspect ratio will add additional grid lines to decrease the side with the greatest length.

**Growth rate control:** The growth rate limits changes in size between adjacent voxels. A growth rate of unity implies no growth and will result in a uniform mesh.

- (d) Automatic mesh settings can be used to generate voxel meshes with a standard, fine or coarse mesh in addition to the ability to specify the mesh size manually. The automatic mesh sizes are calculated by taking the simulation frequency range, material properties and time signals into account.
3. The new mesh element type required a number of extensions to the display settings. Display features include:
  - Voxel face, volume and wire segment display control were developed.
  - The connectivity display control allows users to quickly identify any open boundaries and verify the correct connectivity of the mesh.
  - Support was added for cut planes through voxel elements.
  - The greyscale display option allows the view to be displayed in monochrome.
  - Legends were extended for the new elements.
4. Although multiple solution configuration support is not yet available for the FDTD solver, CADFEKO does allow multiple configurations to be defined, but only one configuration can be enabled when the FDTD solver is active.
5. Numerous new CEM validation checks were added to validate FDTD models.
6. Support is included for plane wave sources and voltage sources on wires and edges (wire and edge ports) when using the FDTD solver. Loads may be added to wire and edge ports.
7. The option to export a file containing the residuum for iterative solvers was added to CADFEKO. This option has always been available in EDITFEKO.
8. The option to export the mesh information to the \*.out file has been included in CADFEKO. This option has always been available in EDITFEKO using the EG card.

## Post-processor - POSTFEKO

The major new features implemented in POSTFEKO, in addition to the features listed earlier, are highlighted in the following list.

1. More than 150 extensions and bug fixes were implemented since the previous release.
2. Similar to the display support added to CADFEKO, the display controls for POSTFEKO have also been extended for the voxel elements.
3. The “Find elements” dialog has been extended to allow voxel elements to be found, displayed and annotated.
4. Support for instantaneous current arrows on higher order basis function (HOBF) curvilinear elements have been implemented. Due to the potential large size of the HOBF elements, multiple arrows are displayed on a single triangle.
5. The characteristic mode index can be used as the independent axis on 2D graphs displaying characteristic mode data.

6. Numerous extensions have been made to the application programming interface (API) allowing faster and more powerful scripts to be created by users. Some of the extensions listed below.

- The API was extended to allow characteristic mode results to be accessed via the scripting interface.
- Stored result entities can now be controlled from the scripting environment.
- The Matrix and ComplexMatrix objects are extended to allow sub-matrices within a larger matrix to be extracted or inserted.
- Efficient fast Fourier transform and inverse fast Fourier transform methods were added to the Matrix and ComplexMatrix objects.

### **Scripting model editor - EDITFEKO**

1. More than 40 extensions and bug fixes have been implemented since the previous release.
2. A new voltage source card (AT) has been developed that allows voltage sources to be added to FDTD models by applying a voltage source on a port defined using the PT card.
3. A new discrete load card (LT) has been developed that allows loads to be added to FDTD models by defining a load on a port.
4. A new card (BC) allows users to modify the boundary conditions used when the FDTD solver is active.

## Importing

1. Three new import file formats are available allowing printed circuit board (PCB) models to be imported (Windows only). The three formats are:

**Gerber:** The Gerber file format is a well known format used to describe PCB models.

**ODB++:** The ODB++ format consists of a directory structure containing files which describes the PCB model.

**3Di:** The 3Di format is another PCB format encountered in the industry which describes PCB models.

## Electromagnetic solution kernel

In addition to the FDTD and other notable features mentioned above, the following new features have been implemented in the FEKO kernel for Suite 7.0.

1. More than 250 extensions and bug fixes have been implemented since the previous release.
2. The FDTD solver supports GPU computing to improve performance when compatible GPUs are available.
3. It is possible to limit the number of characteristic modes calculated to the number the user requests. By default, a few additional modes are calculated to help with correlating modes for mode tracking.
4. Touchstone (\*.snp) file writing was extended so that each S-parameters solution request will be written to a separate file.
5. Non-radiating transmission lines allow the user to specify the background medium or the velocity of propagation of the transmission line. The background medium influences the propagation velocity and losses.
6. Finite antenna arrays now support waveguide ports.
7. The accuracy of the Green's function calculation were increased for distances larger than 10 lambda.
8. The receiving antenna and radiating antenna source now also support the following file formats:
  - Orbit/Satimo (\*.mfxml) measurement file.
  - CST far field scan (\*.ffs) file format.
  - CST near field scan (CST NFS) file format.
  - Sigrity near field data (\*.nfd) file format.
9. A receiving antenna (spherical modes) can now also be described as a spherical mode approximation in addition to the supported far field approximation.

# Release Notes for FEKO Suite 6.3

October 2013

## (Changes since FEKO Suite 6.2)

FEKO Suite 6.3 boasts many extensions to both the user interface and the electromagnetic solver. Highlights of the Suite 6.3 release include support for higher order basis functions (HOBf) on curvilinear surface elements for both the method of moments (MoM) and multilevel fast multipole method (MLFMM). CAD import and export filters are now part of the default FEKO installation for all licenced FEKO users. CADFEKO also includes advanced CAD healing and reconstruction tools. Significant extensions were also implemented for cable and windscreen modelling that simplify model construction and configuration. Application automation has been extended to CADFEKO and application macros have been introduced to CADFEKO and POSTFEKO allowing users to extend the applications by means of macro scripts. Characteristic modes have been extended to calculate the modal excitation coefficients as well as to perform mode tracking by correlating modes calculated at different frequencies. Speed improvements have been made to the calculation of far fields and the option to compute continuous far fields versus angle is now supported. These are just a few of the features available in the Suite 6.3 release. The sections that follow will elaborate on these and other improvements.

*Note that you will require a new licence file that supports FEKO Suite 6.3. This licence file is also valid for older FEKO releases, thus conveniently allowing the usage of multiple FEKO versions if required.*

The more prominent new features are listed below. Many smaller bug fixes and extensions have been included in addition to the listed items.

## Prominent features in FEKO Suite 6.3

1. Higher order basis functions (HOBf) for the method of moments (MoM) were included in the previous release. The support for HOBf has been extended to curvilinear surface meshes (second order curvilinear triangles with 6 vertex points). Curvilinear surface meshes allow users to utilise large HOBf elements on models that previously had to use lower order or traditional basis functions to accurately represent the model curvature. Higher order basis functions are now supported for the multilevel fast multipole method (MLFMM) further reducing the memory requirement for large models. Significant speed improvements for the HOBf matrix fill phase have been achieved which reduces the required solution time.
2. The CAD import and export filters are now available to all licensed users without any additional costs. The CAD and mesh import tools have been improved by automatically selecting the appropriate file type and import settings. The import tools provide easy access to the import log and import settings. All import settings have been revised and optimised for the various import formats.
3. CAD healing tools have been developed that allow the most common CAD errors to be corrected swiftly. The tools include the following:
  - Repair part: Heals a body by removing and repairing common geometry faults in an attempt to create a valid solid.
  - Simplify part representation: Simplifies a curve or a surface by using analytical and more robust representations of the entities.

- Repair edges: Repairs inaccuracies in the edges of a sheet or a solid body by recalculating edge and vertex geometry to a specified precision wherever possible.
- Repair and sew faces: Repairs problems in the faces of the selected part then tries to sew them into a solid or sheet part.
- Remove small features: Removes small features such as edges, faces, spikes and gashes from the input parts.

A hole-filling tool has been included that allows a face to be reconstructed from its bounding edges. This tool is often useful in cases where the face cannot be healed or is missing. A new selection tool has been developed for selecting the smallest loop of laminar edges that include the currently selected edges.

The CAD healing tools, including the hole-filling tool, only work on primitive parts and don't support parametric re-evaluation.

4. The application automation framework that was already powerful has been extended further. Application automation has been included in CADFEKO allowing users to create geometry using scripts. Only a subset of CADFEKO is accessible through the Lua scripting interface and the rest will be made available in future releases.

Application macros are available in CADFEKO and POSTFEKO allowing users to create their own tools or download scripts from the FEKO website and then have them readily available in the GUI interface. Forms or dialogs can be used to obtain user input during the execution of the script. This allows users to expand the capabilities of POSTFEKO without having to open the scripting editor each time a custom script is executed.

5. A new set of windscreen construction tools have been developed. The main new feature is a constrained surface tool that creates a windscreen work surface analogous to a CADFEKO work plane. This surface is easily specified and conforms to the shape of the windscreen. Antennas in the windscreen can then be defined in this work surface, using a regular 2D work plane which is then automatically mapped to the shape of the windscreen in 3D space. Antennas in this work surface can be specified using wires, Bézier curves and regularly spaced wires.
6. EDITFEKO has been completely rewritten and now boasts a number of new features. These include:

- A new ribbon interface similar to the other GUI components.
- A search bar allows users to quickly find the correct card.
- Window tabs (multiple files) can be re-ordered.
- Support for drag and drop of files.
- Syntax highlighting that makes editing files easier.
- Request, source and load names are included on the card panels (not just a comment at the end of the first line of the card).

7. The calculation of far fields has been accelerated by implementing a new method based on a spherical wave expansion. This allows in particular the plotting of continuous far field data that can be sampled to any resolution in POSTFEKO. The feature is attractive for the simulation of large gain antennas or RCS of large objects, where normally the far field/RCS versus angle would show a ripple requiring a fine angular resolution.

## User interface

The GUI components have been extended to support new features and solution techniques in the FEKO kernel. In addition to supporting new kernel features, other new features have also been implemented. These features are listed in the sections that follow.

### 3D CAD modeller - CADFEKO

The prominent new features that have been implemented in CADFEKO, in addition to the features listed earlier, are highlighted in the following list.

1. More than 450 smaller extensions and bug fixes.
2. Geometry and mesh parts can be excluded from the model. An excluded part can remain part of the model, but will not be meshed, taken into account during CEM validation or be included as part of the simulation.
3. Configurations can be excluded from a model. Excluded configurations will remain part of the model, but will not be solved.
4. Support for curvilinear surface mesh elements has been added to all components:
  - Curvilinear surface meshes can be generated when the solution method supports curvilinear elements.
  - Both geometry and mesh parts of surfaces can be used to generate curvilinear meshes.
  - Visualisation support was implemented for curvilinear surface meshes.
5. Numerous extensions and improvements were made to the cable modelling interface. Some of these are listed below:
  - Cables and cable components can be selected in the 3D view.
  - The snapping tool allows a snap offset to be set allowing users to quickly add cable paths at a constant distance from the model faces. It is also possible to snap to cable paths.
  - Searching for cables by specifying a subset of the names of the relevant cable harness, connector, path and cable instance is possible with the “Find cable” tool.
  - Cable conductors can be combined into more complex cable bundles.
  - Rectangle selection has been implemented for the schematic view allowing multiple items to be selected at the same time.
  - The projection of the cable network in 3D view to cable schematic view has been extended by allowing the user to select the most appropriate projection.
  - The distance between connectors displayed on the schematic view can be varied to prevent connectors from overlapping.
6. All dialogs that create entities allow the user to create a single entity or multiple entities. These dialogs now have “Create”, “Add” and “Close” buttons.
7. The ribbon in CADFEKO has a new “Home” tab, similar to POSTFEKO and EDITFEKO.
8. The performance of rendering table contents in the dialogs has been improved.
9. The command line option in CADFEKO\_BATCH to change the cable seed value has changed from `-cable_seed=SEEDVALUE` to `--cable-seed SEEDVALUE`.



## Post-processor - POSTFEKO

The major new features that have been implemented in POSTFEKO, in addition to the features listed earlier, are highlighted in the following list.

1. More than 300 smaller extensions and bug fixes.
2. Curvilinear and HOBf mesh support have been added to POSTFEKO.
  - Curvilinear surface meshes are visualised in the 3D view.
  - Currents and charges can be displayed on flat or curvilinear meshes when using higher order basis functions.
3. The application automation and Lua scripting interface in POSTFEKO has been extended. In addition to the items listed under the prominent features, the following improvements are also available.
  - Dataset improvements: The structure used for containing math results has been improved for performance and memory overhead. Datasets are now also accessible from the application automation framework. This change could cause scripts to stop working due to changes in the syntax, but they can be corrected with minor changes.
  - POSTFEKO can be launched in a non-interactive mode to execute an application automation script using `--non-interactive` as a command line argument. In this mode no dialogs are displayed and default options are selected for any dialogs that would have required a user to select an option. If the script execution fails, the application exits with an error code.
  - Two new matrix manipulation objects have been developed that allow complex and double (real) matrix operations from the scripting environment.
  - Extended automation API for the renaming of window tabs.
  - Parameters can be sent to scripts when launching POSTFEKO from a command line.
  - A batch modify function for Lua objects has been implemented.
  - A number of commonly used Lua scripting modules have been included by default with the FEKO installation. These include LuaFileSystem, LuaXml, winapi and the tools provided by PenLight. This is in addition to the luacom module that was also shipped with earlier version for COM manipulation of application on Windows.
  - Further improvements and extensions have been made to the documentation examples making it easier to develop scripts.
4. When displaying port impedances in Smith charts or when calculating insertion losses, the reference impedance specified for the port will be used instead of defaulting to  $50 \Omega$ . It is still possible to use an alternative reference impedance.
5. Standing wave ratio and mismatch loss quantities are now available for waveguide and modal excitations.

## Importing and exporting

1. External mesh import using the ABAQUS file format has been improved (by adding support for additional keywords and updating to the latest ABAQUS specification).
2. The support of both KEYOPT and KEYOP for the external ANSYS CDB mesh file format import has been extended. Numerous other improvements such as non-continuous node numbering and splitting of quadrangles into triangles have also been included.
3. The CONCEPT file import has been updated to support their latest file format (including wire radius and number of segments)
4. Exported NASTRAN mesh files support curvilinear triangles (CTRIA6 element type).

## Electromagnetic solution kernel

In addition to the prominent features mentioned above, the following new features have been implemented.

## General kernel improvements and extensions

1. More than 400 smaller extensions and bug fixes.
2. Performance has been improved by updating to the latest math libraries and compilers. (For AMD platforms it was confirmed that ACML is superior in performance to Intel MKL, keeping different binaries for each platform).
3. A check has been included to prevent optimisation runs when adaptive frequency interpolation is used.
4. Continuous frequency interpolation settings (which blocks to include etc.) in connection with characteristic mode analysis have been adjusted.
5. The treatment of cases with singular fields (e.g. near field calculation when observation points intersect with mesh surfaces) has been improved.
6. Series and parallel RLC circuits are now also supported for edge ports.
7. Closed FEM problems, i.e. completely confined by PEC and/or modal port boundaries, are now detected and the MoM solver is deactivated automatically resulting in faster solutions.
8. Large parallel MLFMM and FEM/MLFMM iterative solutions suffered from problems during the distributed, sparse LU preconditioner calculation (crashes, memory spikes, 4-Byte integer limitation, etc.). Changes to improve robustness and stability include:
  - An alternate parallel, distributed sparse library, the MUltifrontal Massively Parallel Solver (MUMPS), as default for the calculation of the sparse LU preconditioners of the MLFMM and FEM has been introduced.
  - Out-of-core sparse LU factorisation is employed when the memory requirement for an in-core factorisation is too high.
  - Sparse LU preconditioner out-of-core capability is supported for sequential runs on Intel MKL platforms (PARDISO) and for parallel, distributed runs (MUMPS).
9. A number of cable modelling extensions have been included:

- The concept of a cable harness has been introduced.
    - Grouping of cable paths that are connected via circuit elements and not necessarily connected.
    - A cable harness affects coupling calculations since LC coupling only between conductors/signals that are grouped in a bundle cross section.
    - Field coupling only between different harnesses, i.e. not between cables in a single harness.
  - Multiple signals may be connected to a single connector and pin.
  - Reading of previous solution results is supported (\*.str file), i.e. cable radiation/irradiation results can be re-used.
  - SPICE circuit files including the equivalent model for MTL harnesses can be exported, allowing postprocessing in an external circuit simulator.
10. Parallel performance and scaling of MPI-based FEKO MoM solutions have been improved for large problems and/or a large number of parallel processes by changing the process grid layout from 1D block cyclic row distribution to a 2D block cyclic distribution scheme.
  11. Calculation time for extracting spherical mode coefficients has been reduced significantly.
  12. The number of spherical modes required to capture the full radiated power can automatically be determined.
  13. The internal formulations for spherical modes have been changed to avoid numerical stability problems for higher mode indices.
  14. The ideal receiving antenna now also supports definitions using spherical modes or near field apertures in addition to the far field pattern that has been available.
  15. Domain decomposition techniques such as the numerical Green's function and the fast array solver support higher order basis functions and curvilinear triangle elements.
  16. The finite antenna array solver has been extended to support discrete loads on wires, coatings and lossy metals.
  17. The finite antenna array solver also now supports rotated elements in the array.
  18. Characteristic mode calculations have been extended to support calculating modal excitation coefficients.
  19. Characteristic modes are now tracked by correlating modes between frequency runs.
  20. Characteristic mode calculations are available for dielectric and magnetic materials and also for Green's function aperture elements.
  21. The performance of the periodic boundary condition calculation has been improved greatly.
  22. Finite conductivity of metallic faces, thin dielectric sheets, and coated PEC surfaces are now supported for UTD (reflection only, no transmission is taken into account).
  23. Coatings on the surface of dielectric bodies supported with MoM. This is not supported for MLFMM.

## Support components, installation, and licensing

1. The date and time when the "secfeko.dat" licence file was created is now available for support purposes in the secfeko -p output and also in SECFEKO\_GUI.

2. Updated the Sentinel dongle handling by disabling the check for terminal services (avoids delays at startup and works with remote desktops automatically, no longer need to set a special environment variable in this case).
3. A new setting -1 is available for the environment variable FEKO\_SECFEKO\_USE\_DONGLE to disable the usage of the dongle (i.e. functions will not be called). 0 is default and 1 was already there to force using a dongle (and then trigger fatal errors).
4. A check for synchronous times has been included when using multiple floating licence servers.
5. Similar to 32-bit, for 64-bit the Intel and AMD versions are now integrated into one single installation archive (applies to both Windows and Linux). The detection of which FEKO kernel to launch on which platform is done at run-time.
6. The Catia V5 import/export filter (only available for Windows) used to be a separate installation (a separate download). It is now integrated into the main FEKO installation.
7. A unified versioning scheme 6.3-xxx is used across all the FEKO components where 6.3 indicates the FEKO Suite and xxx is a build number of each individual component.
8. Please note that the FEKO installer now requires Windows Installer version 4.5 or newer, which is available on Windows Vista SP2 and later systems. Where required it is automatically installed by the setup executable. However when using the MSI database directly, the setup executable is not used, so please ensure that the required version has been installed on the target system. For more information, please refer to [support.microsoft.com/kb/942288](http://support.microsoft.com/kb/942288).

# Release Notes for FEKO Suite 6.2

September 2012

(Changes since FEKO Suite 6.1)

FEKO Suite 6.2 boasts many extensions to both the user interface and the electromagnetic solver. Highlights of the Suite 6.2 release include direct support for characteristic mode analysis, fast solution for large (but finite) arrays with irregular spacing, higher order basis function support and many extensions and improvements to cable modelling. CADFEKO has been extended to allow multiple solution configurations to be defined, allowing models with more than one source or load configuration to be created and solved efficiently. POSTFEKO now has support for time domain results (based on FFT/IFFT), replacing the old TIMEFEKO component. POSTFEKO also boasts a powerful scripting application programming interface that enable users to access and control all the features available in POSTFEKO. These are just a few of the features available in the Suite 6.2 release. The sections that follow elaborate on these and other improvements.

*Note that you will require a new licence file that supports Suite 6.2. This licence file is not valid for older FEKO releases. Please ask for a licence file that is compatible with an older version should you need to use an earlier version of FEKO.*

The more prominent new features are listed below. Many smaller bug fixes and additions have been included in addition to the listed items.

## Prominent features in FEKO Suite 6.2

1. Characteristic mode analysis (CMA) has been possible in FEKO for a long time, but direct support for the analysis has now been included in FEKO. This makes it very quick and easy to calculate and visualise the results in POSTFEKO. Characteristic mode analysis is the numerical calculation of a weighted set of orthogonal current-modes that are supported on conducting bodies (similar to waveguide modes). The eigencurrents are independent of any specific source or excitation and thus only depend on the shape and size of the conducting body.

CMA allows for a systematic (i.e. non brute-force) CEM design approach and provides physical insight regarding antenna operating principles. It is also possible to determine the resonating frequency of specific modes or determine optimum feeding arrangements to excite desired modes while suppressing other unwanted modes.

CMA is supported for MoM models containing only metallic structures such as metallic triangles, wires and connections but does not yet support dielectric materials or any other solution techniques (no SEP, VEP, waveguide ports, MLFMM or FEM).

2. Support for large, but finite antenna arrays has been included. It allows easier creation of finite antenna arrays by preselecting from various array layouts, such as linear, planar, circular, cylindrical or custom array layouts. Arrays can also be imported from an \*.xml file as created by Antenna Magus. The individual array elements are permitted to have arbitrary orientation as well as magnitude and phase scaling (excitations are automatically added to each element).

The solution time for the array is greatly reduced when utilising the new fast array solver known as the domain Green's function method (DGFM). For comparison with standard so-

lution techniques such as MoM and MLFMM, a feature was implemented where the same array can be solved without utilising the DGFM using the same model.

3. Higher-order basis functions (HOBf) have been implemented for MoM metallic and dielectric surfaces. Hierarchical HOBf allow triangle sizes to be increased while still accurately modelling the current distribution of the model. A coarser mesh results in fewer triangles and fewer unknowns, while allowing accurate solutions with reduced memory and run-time.

Automatic meshing in CADFEKO has also been extended to automatically mesh larger triangles where it is applicable for HOBf to be used. The display of currents in the 3D view in POSTFEKO is not yet supported for HOBf, but will be made available in future versions.

4. Support for cable simulation has been extended considerably in the last few releases and this continues in Suite 6.2. The cable extensions that have been implemented are listed below.

- Support has been added for twisted pair and twisted multiple cable types.
- Cable paths can be loaded, excited, or connected using SPICE circuits.
- Full support for S-parameter calculations in connection with cable ports added (can be active or passive).
- A new cable solution option is available that allows radiation from cables while taking irradiation into account.
- Support for cable harness, connectors and cable instances has been implemented that allow cables to be routed and combined efficiently. This representation is similar to the description of cables in a \*.kbl file.
- A new cable schematic view is available that allows sources, complex loads, resistors, capacitors, inductors, external SPICE circuits and probes to be included in the model. Different cables can also be connected to one another using the cable schematic view.
- Cable probes can be placed along a cable, giving access to the currents and voltages at any point along a cable.
- The cable bundle definition allows users to auto-bundle cables. This allows cables to be created much faster when the exact orientation of the cables in the bundle is not known or possibly not important. Auto-bundling of cables is also used when routing cables between connectors. The bundling can be randomised or re-bundled at any time to allow stochastic analysis.
- Auto-routing has been implemented that chooses (by default) the shortest route between the cable instance extremities (cable connectors). The user can choose any of the available routes, but the shortest route will be selected by default.
- The cable path definition has changed to import cable paths from NASTRAN files and not link to the external NASTRAN file. This allows the cable path to be displayed immediately in CADFEKO without requiring PREFEKO to be run to see the cable path in POSTFEKO.
- Cable paths, connectors and cable instances can be imported from complex \*.kbl files.

5. FEKO has supported multiple solutions or configurations for a long time, but support for this has now been included in CADFEKO. Multiple configuration support in CADFEKO has allowed the improvement and simplification of the CADFEKO tree while extending its functionality.

Multiple configurations allow a user to model different excitation, load or request configurations over different frequency ranges within a single model. The geometry and thus the mesh are required to remain the same for all of the configurations.

6. Time domain analysis support has been implemented in POSTFEKO, replacing the old TIME-FEKO component. Support for time domain modelling is included not using a time domain solver, but with intelligent FFT/IFFT conversions that are hidden from the user. This allows all methods such as cable coupling, PO, MLFMM, MoM, FEM and planar GF to be readily available. The input pulse waveform can be changed after the simulation with instant results. The new time domain modelling also takes advantage of adaptive frequency sampling (AFS), allowing a wide frequency range to be simulated using a very small number of frequency samples.
7. A powerful and comprehensive application programming interface (API) has been developed for POSTFEKO, allowing all aspects of POSTFEKO to be controlled using Lua scripts. As part of the API, POSTFEKO provides access to all features, simulation data and meshes that are available to be manipulated and exported.

The script editor has been extended to facilitate the powerful new POSTFEKO API. The extensions are listed below.

- Support for files that are stored on disk, rather than in the POSTFEKO session. This allows multiple users to share scripts and multiple sessions to utilise the same scripts.
- Drag and drop support has been added for Lua files.
- External Lua scripts can be run directly from the command line for automated applications.
- Breakpoint support has been added, allowing the user to pause the script at any point to inspect variables and find logic errors. This greatly improves development speed and efficiency.
- An active console has been included that allows the user to run commands and inspect the values of variables or to simply test the effect of commands before adding them to a script.
- A search and replace tool has been included as part of the script editor.
- When a script terminates with an error, the user can quickly “jump” to the point where the error occurred.
- New settings on the *Preferences* dialog allow the user to configure Lua search directories. This allows external Lua packages and common scripts to be used and re-used.

## User interface

The GUI components have been extended to support new features and solution techniques in the FEKO kernel. In addition to supporting new kernel features, other new features have also been implemented. These features are listed in the sections that follow.

## 3D CAD modeller - CADFEKO

The prominent new features that have been implemented in CADFEKO, in addition to the features listed earlier, are highlighted in the following list.

1. One of the biggest changes in CADFEKO is not readily visible when opening CADFEKO. The CADFEKO geometry modeller has been improved to be more robust, improve speed and be memory efficient while allowing more features in the future. As part of the geometry modeller improvement it is required to re-evaluate all models that were created in earlier versions of CADFEKO. Problems with the older model files, even from Suite 6.1, become visible during the re-evaluation and may need small corrections. The re-evaluation process will warn the user about any elements that become suspect. Once the model has been opened and saved in CADFEKO in Suite 6.2, then the modeller can take advantage of the new features.
2. Multiple configuration support in CADFEKO has required further extensions to the model tree. The model tree has been split into multiple sub-trees allowing the user to concentrate on either the model geometry or the model solution configuration. This reduces the amount of tree elements that are visible at a time and should greatly improve efficiency.
3. A new face snapping tool was developed that allows a user to snap to the surface of a face. It is also possible to snap to a point that is offset from the face. This tool makes routing cables in complex geometry very easy, but can be used in many other applications where it is required to create a wire or edge on or close to an existing geometry face.
4. Label selective near and far field requests have been extended and included in CADFEKO allowing the user to calculate near and far fields due to the effect of a subset of the model geometry.
5. Sources were modified so that the user may specify the port impedance that should be used for realised/effective gain calculations.
6. Stored model currents (\*.str files) are used by default, allowing very fast simulations in cases where the requests are modified without changing the rest of the model.
7. Dielectric media that use the SEP solution method are allowed to be used in a model that has a planar multilayer substrate. The dielectric region may be embedded in the multilayer substrate.
8. A planar multilayer substrate can be confined to regions making it possible to simulate a finite planar multilayer substrate very efficiently.
9. Meshing has been improved to ensure that triangles and segments do not cross planar multilayer substrate layers.
10. The near field request has been extended to allow the user to request near field potentials that are available in the kernel. The near field points on the surface of tetrahedral are exported to an XML file (\*.fse) that can be imported into SPARK3D from AuroraSAT.
11. Frequency requests have been extended to allow a discrete list of arbitrary frequencies.
12. Optimisation has been extended to allow new field polarisations for RCS as well as Ludwig III co- and cross-polarisations.



## Post-processor - POSTFEKO

The major new features that have been implemented in POSTFEKO, in addition to the features listed earlier, are highlighted in the following list.

1. 2D Graphs and charts have been extended to support the display of images. The images can be loaded from file or generated from a 3D view.
2. Polar graphs can include a representation of the model on the polar graph that indicates the orientation of the model with respect to the far field trace. When the trace is modified, then the model representation will be updated automatically.
3. Automatic reports were improved and extended. The image and report quality has been considerably improved. A new landscape orientation is also available. Titles and captions have improved integration with the reports and can be modified prior to generating the report.
4. Chart titles, legends, captions and axis titles now support Greek symbols as well as any uni-code character. Superscript, subscript, bold, italics and underline is supported for individual characters (a subset of these were supported earlier, but could not be set for individual characters).
5. The 3D view legend titles are user editable.
6. Window tabs can be re-ordered by simply dragging them around.
7. The level of extrusion used for far field displays can be manipulated for a range of far field display possibilities. Conversely, custom/imported data that is stored in a spherical coordinate system can be extruded to be displayed in the same way as far field results in the 3D view.
8. A power scale option was added in the POSTFEKO display for near fields and Poynting vector displays.
9. Power lost or dissipated is available per medium in the SAR information box.
10. RCS display in POSTFEKO has been extended to allow additional polarisations such as RHC, LHC, S, Z, Ludwig III co- and cross-polarisations.
11. Static copies of imported results can be stored as part of the POSTFEKO session (\*.pfs files).
12. Support for image exporting to the \*.emf format has been implemented. Images will also export with a transparent background when the image type supports transparency.
13. Incomplete \*.bof files can be loaded and the results displayed. Results for discrete frequency calculations are displayed as they become available. This allows simulations that terminated due to system failure to be loaded and displayed (showing the results that were computed prior to the failure).

## Importing and exporting

1. The data import tool in POSTFEKO has been extended considerably. The following changes can be highlighted:
  - A dramatic speed improvement has been made to the import process.
  - A column can be ignored during the import process allowing the import to continue as if that column was not present.

- POSTFEKO notifies the user when the external file has changed and allows the file to be imported again without requiring the settings for the import to be set again.
  - Mistakes in the import settings can be fixed and the file re-imported without having to configure the entire import again.
  - Support has been added to allow importing Touchstone (\*.snp) files.
  - Improved the support for importing internal FEKO files (\*.ffe, \*.efe, \*.hfe).
  - Import templates are automatically selected based on the file type (file extension).
2. Various file formats can now also be exported from POSTFEKO. These include:
    - Touchstone (\*.snp) files
    - Near field files (\*.efe, \*.hfe)
    - Far field files (\*.ffe)
    - Currents and charges files (\*.os, \*.ol)
  3. CADFEKO has support for Gerber file exporting.
  4. CAD import and export is now also available on 64bit Linux platforms. This excludes the CATIA format since it is not supported on Linux.
  5. The import process has been modified to be more robust as well as including more import options (option not to simplify the geometry during the import process).

## General interface changes

1. CADFEKO and POSTFEKO now boast a new search bar allowing the user to search for any term. The search result allows the user to both see where the control is used (location on the ribbon or context menu) as well as access to the tooltip; these controls can then be activated directly. This greatly improves productivity for new users or users who don't use these components on a daily basis, but also for expert users to quickly access the desired control. The search bar also allows the user to search for the term in the FEKO help.
2. 3D Mouse devices support (3D connexion) has been included for CADFEKO and POSTFEKO.
3. The run dialog has been extended, providing the user with full access to the output generated by the kernel. This information is hidden by default, leaving only the necessary information being displayed (errors, warnings and other significant notices). Notes, warnings and errors are listed separately so that they can be accessed and assessed quickly.
4. The updater shows detailed progress information (download speed and estimated time remaining) while downloading new updates and also now includes an overview of the installed components' versions.
5. The crash reporting facility has been extended further, making it more clear that user information and the example model is required in most cases to allow the developers to fix any possible problems.

# Electromagnetic solution kernel

In addition to the prominent features already mentioned, the following new features have been implemented.

## General kernel improvements and extensions

1. More than 500 smaller extensions and bug fixes.
2. Improved performance by updating to the latest math libraries and compilers.
3. MoM matrix solver performance increased by around 5% on AMD platforms.
4. Updated various MPI libraries for better parallel performance and support of the latest DAPL devices.
5. Reworked the memory management under 64-bit Windows to show better performance when allocating large arrays.
6. Reduction of the size of binary FEKO output files (\*.bof files) by using compression. Typical reduction in the order of 98.8% ... 99%. Also supporting data blocks in the \*.bof file which exceed 2 GByte in size.
7. List of labels supported at the OF card (label selective near and far field calculations).
8. List of discrete frequencies supported for the FR card (in addition to regular linear or logarithmic ranges).
9. New NC card to define configuration names (also printed to \*.out and \*.bof files).
10. Adaptive frequency runs now give the total simulation times at the end of the \*.out file.
11. Geometry checks regarding element size versus wavelength can be switched off.
12. For FEM modal ports improvements of accuracy and stability of the modal solution at waveguide ports. Now also taking symmetry into account to accelerate the solution.
13. Improved accuracy for the determination of spherical modes from coarsely sampled far field data.
14. Stability improvements for large sequential and parallel MLFMM and FEM runs.
15. More robust and accurate treatment of junctions of multiple media (MoM/SEP).
16. Improved accuracy of skin effect calculations for lossy surfaces.
17. Improved internal checks so that the MoM matrix is recomputed only when really required when loads are removed and added.
18. Improved performance by updating to the latest CUDA GPU framework, also supporting newer graphics cards.
19. Support for multiple GPUs in FEKO includes:
  - Ability to select which GPU is to be used.
  - Multiple GPUs can be used simultaneously for a single sequential FEKO run.
20. AVX (Advanced Vector Extensions) was proposed by Intel / AMD in 2008 extending the SSE (Streaming SIMD Extensions) series of SSE, SSE2, SSE3, SSSE3, SSE4, and SSE5. AVX is supported in these CPUs: Intel Sandy Bridge, Ivy Bridge and AMD Bulldozer.
21. Combination of the MoM/SEP with planar GF available which allows:

- Modelling of arbitrarily shaped dielectric bodies in connection with planar multilayer substrates (e.g. dielectric pipe buried in ground).
  - Modelling of finite size multilayer substrates enclosed inside of one MoM/SEP region.
22. A discrete frequency list can be requested using the FR card without utilising a FOR loop.
  23. Support for calculating two new field potentials in addition to the potentials that were already supported (magnetic vector potential, gradient of the scalar electric potential, electric vector potential, gradient of the scalar magnetic potential):
    - Scalar electric potential ( $\varphi$ )
    - Scalar magnetic potential ( $\Psi$ )
  24. The non-radiating network and cable circuit allows the user to specify the name of the sub-circuit that should be used, allowing multiple sub-circuits in a single file.

## Support components, installation, and licensing

1. Stopped support for SUN Solaris and HP-UX (floating licence server available on request).
2. Added support for interfacing to SPARK3D. SPARK3D is a unique simulation tool capable to determine the breakdown power level in a wide variety of passive devices. By importing the electromagnetic field from FEKO (FEM solver) and other CEM tools, SPARK3D is able to analyse vacuum breakdown (multipactor) and gas discharge.
3. New Bronze pricing category as entry level FEKO licence:
  - Only sequential version available (i.e. one CPU, not parallel and also not GUI-only)
  - Only MoM and FEM solvers included with a 2 GByte memory limit
4. Silver pricing category now also allowing 64-bit installations, but with a 2 GByte memory limit.
5. New Premium Floating Licence option which allows to separate the GUI and Kernel components (i.e. used by different users and/or on different computers).
6. Revisited the floating licence server check-out policy for GUI components in connection with parallel licences (can now check out and check in GUI on all hosts while parallel FEKO kernel is running).
7. Increased limits for FEKO LITE (e.g. 500 instead of 300 triangles).
8. Classroom licences are now supporting 1 GByte of memory instead of 512 MByte.
9. Improved support for the detection routines for dongles. New dongle drivers are used with numerous improvements and bug fixes.
10. Switched to dynamic linking for a number of third-party libraries which make the size of the binaries smaller.

# Release Notes for FEKO Suite 6.1

July 2011

## (Changes since FEKO Suite 6.0)

FEKO Suite 6.1 offers many extensions to the user interface and the electromagnetics kernel. Highlights are the redesigned CADFEKO interface, automatic report generation and scripting in POSTFEKO, major extensions to the integrated cable modelling, low frequency stabilisation, a numerical Green's function approach and the availability of the method of moments (MoM) volume equivalence principle based on tetrahedral mesh elements.

*Note that you will require a new licence file that supports Suite 6.1.* This licence file is also valid for all FEKO releases from Suite 5.4 onwards should you need to use an earlier version of FEKO.

The more prominent new features are listed below. Many smaller bug fixes and additions have been included in addition to the listed items.

### Major features in FEKO Suite 6.1

1. The CADFEKO interface has been improved to be similar to the POSTFEKO interface. The new CADFEKO interface is much easier and faster to use for both new users and existing users. Many features that were hidden in earlier versions are now easily accessible. Many usability features have also been included and the interface has been improved to increase productivity. This is accomplished whilst keeping the interface clean and simple for new users.
2. A numerical Green's function solution has been implemented allowing large MoM (method of moments) runs with predominantly static geometry to be solved rapidly, even with small changes in the geometry (for instance different antennas mounted on a vehicle). The model is decomposed into a static and a dynamic part and solved using the NGF (numerical Green's function). Changes can now be made to the dynamic part of the model and then the model can be simulated again. This time the model will be solved much faster, since the solution to the static part of the model can be reused from previous runs.
3. The volume equivalence principle (VEP) for dielectrics is now available for tetrahedral mesh elements and also available directly in CADFEKO. The VEP formulation is very stable at low frequencies and high permittivity values. VEP also shows good stability and fast convergence in iterative solutions such as the multilevel fast multipole method (MLFMM). Tetrahedral elements allow a better geometrical representation compared to the previously used cuboidal VEP elements. The cuboidal VEP solution is still available in EDITFEKO for backwards compatibility reasons.
4. A low frequency stabilisation has been included in the FEKO kernel for metallic wires and surfaces which allows the MoM matrix condition number to remain low (constant over frequency) even at very low frequencies and thus supports robust and stable solutions at such low frequencies.
5. Transmission and reflection coefficients for incident plane waves are directly available as a request in CADFEKO and EDITFEKO. The results are available in POSTFEKO for display on 2D graphs. The transmission and reflection coefficients are often used in conjunction with periodic boundary conditions (PBC), multilayer planar Green's functions, or infinite planes to calculate the properties of frequency selective surfaces (FSS) or multilayer scattering.

6. A new MoM/MTL combined cable modelling technique has been developed for cables that do not run close to a conducting surface. The combined MoM/MTL technique requires the cable to be shielded so that the cables inside the shield are weakly coupled to the external fields.
7. Realised (effective) gain taking mismatch loss into account is now directly available in POSTFEKO for all antenna models that have a single source. It is not required to change the power settings to calculate the realised gain since both gain and realised gain will be available.
8. Reporting and data interchange in POSTFEKO have been improved considerably with the following features:
  - A quick report tool has been developed that can create MS Word, MS PowerPoint and PDF (portable data format) files.
  - An advanced template report can also be created in POSTFEKO by creating the template file in MS Word and then linking the content controls in the MS Word document to the views in POSTFEKO.
  - A tool that exports all views to images has been included and greatly improves productivity when creating customised reports.
  - The quality of exported images has been improved.
  - A new image format type, EMF (Enhanced Meta File), is now available on Windows. The format is natively supported by Windows and may contain both vector and bitmap based image components.
9. A powerful scripting language (Lua) has been included in POSTFEKO allowing users to perform advanced processing on FEKO data. The file handling capabilities of Lua also provide a means to import custom file formats and to generate data objects that are supported by POSTFEKO. The data objects created using the scripting language can be displayed on 2D graphs and in 3D views.

## User interface

The GUI components have been extended to support new features and solution techniques in the FEKO kernel. In addition to supporting new kernel features, other new features have also been implemented. These features are listed in the sections that follow.

### 3D CAD modeller - CADFEKO

The CADFEKO interface is completely new and is similar to POSTFEKO. Many additional features were also added to assist with model creation. The interface has changed considerably, but with the development team's strong focus on usability it should not take long for both new and existing users to become very proficient with the improved interface.

1. Improved interface (simplification)
  - The 3D view display settings have been simplified while giving the user even more control than in earlier versions of CADFEKO.

- Auto-selection has been implemented that allows the user to cycle through the selection types (part-, face-, edge- and vertex selection) by simply clicking multiple times in the 3D view.
- Regions can be selected and edited from the 3D view.
- Geometry and mesh port creation was merged to reduce the number of port creation buttons.
- Many dialogs have been changed so that they close once the item (such as primitives) has been created.
- A distinction has been made between meshes that are used as a base geometry (such as imported meshes) and simulation meshes that are the result of the meshing process and will be used during the simulation.
- The status bar has active buttons for the most common tasks such as selection and view mode options.
- A button has been included in the ribbon to reverse geometry and mesh face normals. This feature was previously only available in a context menu.

## 2. Meshing improvements

- Improved automatic meshing that takes frequency, media properties, the size and curvature of the model and the solution method into account. Most models can now be meshed without the need to define the edge or segment length.
  - Mesh refinement options around a point and a polyline have been implemented. These are similar to the RM card in EDITFEKO.
  - Improved mesh control using anisotropic meshing. Anisotropic meshing allows the mesh to make use of elongated triangles. The number of required triangles for modelling a cylinder is greatly reduced without reducing the solution accuracy.
  - Mesh curvature refinement settings have been implemented that allows the mesh to automatically refine in areas where the model requires a finer mesh. Curvature refinement greatly improves the accuracy of the mesh representation of the model.
  - Imported meshes can be re-meshed so that finer and coarser meshes can easily be created (for simulation at different frequencies).
  - Mesh refinement rules can be created automatically by CADFEKO by using error estimates calculated from a previous simulation. This gives a visible indication to the user where the mesh needs to be refined while still giving the user control over the meshing process.
  - Local mesh size settings can now also be applied on mesh faces (not only geometry faces, edges, wires and regions). Note that all mesh features mentioned above are also applicable to imported meshes.
3. A media library of commonly used materials is now available. The user is also able to add new media definitions to the library so that known media don't need to be redefined for every new model.
  4. The layered media definition has been extended to include layered anisotropic media. This was previously only available through the EDITFEKO interface.
  5. A new NURBS primitive has been implemented making creation of complicated NURBS models possible.

6. UTD cylinders are now also supported in the CADFEKO interface. This was previously only available through the EDITFEKO interface.
7. Near field requests have been extended so that they can be defined either by specifying the number of points or the point separation.
8. A power goal optimisation has been implemented allowing the user to optimise the total power in the model.
9. A new schematic editor for connecting non-radiating networks and transmission lines has been implemented which greatly improves upon the previous version. The new schematic view also allows users to print the schematic.

## **Post-processor - POSTFEKO**

The major new features that have been implemented in POSTFEKO are highlighted in the following list.

1. The far field can be plotted according to the 3rd definition of Ludwig. The co- and cross-polarisation components are available.
2. The reference impedance has been extended to accept complex values. This allows reflection coefficients for complex impedances to be calculated.
3. Mismatch loss is now available as a plotting quantity. It is still possible to plot the power lost due to mismatch (this used to be mismatch loss in POSTFEKO).
4. The radiated power (derived from integration of the far field) is available by default for all far field requests.
5. The power that flows through the surface of a near field is available in POSTFEKO for all the coordinate systems.
6. The FEKO solution information (runtime and memory) is available in the POSTFEKO details tree.
7. 2D graph improvements
  - A new trace that is added to a graph will try to set its independent axis to the same quantity as the traces on the graph.
  - 2D graphs are able to have a multi-line header and footer.
  - Cursors on 2D graphs can jump to the global maximum/minimum or to local maxima and minima.
  - Measurements or annotations on 2D graphs have been implemented that update when the data changes. The annotations allow users to quickly see values such as beamwidth, bandwidth, side lobe levels, maxima, minima, etc. The text on the annotations can be completely customised.
8. 3D display improvements
  - Imported data (near- and far fields) can be displayed in the 3D view and on 2D graphs.
  - The request points are (by default) automatically displayed when result data is not available.
  - The display of multiple coincident named points has been improved by displaying the names of the named points in a list next to the point.



- The 3D view legend has two new options to improve data visualisation. A “scale to vector magnitude” option allows users to display the legend for all the components even when they are looking at only one or two of the components. The legend can also be allowed to round the values being displayed in the legend to improve readability.
  - A model outline display in POSTFEKO allows users to look at meshed models without requiring the triangle edges to be displayed. The resulting display allows the meshed model to look similar to the original CAD model.
9. Stored and imported data entities can now be renamed in the project browser.
  10. Storing a copy will automatically add that stored item to the current graph or view.
  11. Annotations on ISO surfaces have been implemented showing the ISO value and coordinates.
  12. Multi-select drag-and-drop in POSTFEKO has been implemented for the project browser.
  13. Many display and performance improvements have been made in POSTFEKO. The display of planar multilayer substrates has been improved while the display and performance for aperture excitations, ISO surfaces and the mesh have been improved.
  14. Advanced display settings for axes are now available that will allow the user to set the size of the axes and tick mark spacings.

## **Importing and exporting**

1. Selection based export is available for Parasolid exports allowing the user to control what part of the model is exported.
2. Support for exporting meshed CAD models to AutoCAD (\*.dxf) has been included. Note that the model needs to be meshed before it can be exported.
3. STL export is now available directly from CADFEKO.
4. POSTFEKO now supports importing S-parameter data from Touchstone files.
5. The file formats for \*.efe, \*.hfe and \*.ffe files were improved, which allows for greater support in POSTFEKO to import these files.
6. Additional support for importing angles in radians has been implemented when importing custom data files.

## **Other improvements to GUI components**

1. Performance improvements were made to both CADFEKO and POSTFEKO allowing larger models to be created and analysed.
2. CADFEKO and POSTFEKO include a default preferences dialog that allows users to customise the default settings when new models are created or displayed.
3. A new angle measurement tool has been developed that works similarly to the distance measurement tool.
4. Many keyboard shortcuts have been added to improve productivity for advanced users.

## **Electromagnetic solution kernel**

## Major kernel features

In addition to the major features already mentioned, the following new features have been implemented.

1. Support for cables has been extended and will continue to be actively developed in the upcoming releases. The changes to cables include the following:
  - Cables with arbitrary cable cross sections can be defined and solved since a 2D static FEM solver is used to calculate the RLCG parameters.
  - S-parameter computations are available for cable calculations (currently only available in EDITFEKO).
  - Series and parallel loads can be connected to terminate cables.
  - In addition to irradiation (coupling of external fields into cables) now also the case of radiation is supported (excitation of cables by voltage sources).
2. Incident plane wave excitations can be defined with local workplanes. This allows monostatic RCS calculations over an oblique cut without rotating the geometry.
3. Near and far field calculations can be requested with a local workplane.
4. The currents and error estimate request allow label ranges to be requested within a single request. In the past, multiple single label requests would have been required.
5. When using adaptive frequency interpolation then one can now select which quantities to include and which to exclude from the continuous result generation (can speed up convergence).
6. The spherical modes excitation imported from a TICRA (\*.sph) file now optionally allows an amplitude scaling factor and phase offset to be specified.
7. The spherical modes excitation has also been extended to allow the orientation of the modes to be specified using Kardan angles.
8. The FEKO ASCII file formats have been extended to allow a more complete description of the file contents (e.g. frequency) as well as user comments and empty lines (which improves readability). The following file formats were extended:
  - Near field electric (\*.efe) and magnetic (\*.hfe) files
  - Far field (\*.ffe) files
  - Current output (\*.os) files
  - Charge output (\*.ol) files

Exporting these files in Suite 6.1 will use new formats with additional headers. Both old and new formats are supported when importing these files in FEKO (i.e. backwards compatibility is ensured for existing models).

## General kernel improvements and extensions

1. More than 300 smaller extensions and bug fixes.
2. Improved performance by updating to the latest math libraries and compilers, also update the GPU CUDA framework to support newer graphics cards.

3. Support of ANSYS 12.1 CDB file format for mesh imports.
4. New parallel SuperLU preconditioner (used for MLFMM), also with 64-bit index support for large problems.
5. Thick coatings and thick dielectric sheets (where magnetic currents are used) are now also supported in connection with periodic boundary conditions (PBC). Power loss computations are also available.
6. UTD cylinders can be imported from CADFEKO via \*.cfm file.

## **Support components, installation, and licensing**

1. SECFEKO\_GUI allows the creation of request files from the menu.
2. SECFEKO\_GUI will refresh the licence data when pressing the F5 shortcut key.
3. Support was added for a new SGI Altix UV platform (Linux on Intel EM64T CPU with SGI MPT for the NUMAflex architecture.)
4. A floating licence server only installation is now supported for UNIX. This was already available for Windows.

# Release Notes for FEKO Suite 6.0

September 2010

(Changes since FEKO Suite 5.5)

FEKO Suite 6.0 introduces again many improvements and extensions. On the user-interface side, the focus of this release was on developing a new version of the POSTFEKO post-processor. The new POSTFEKO looks quite different than the previous version, but with its strong focus on usability it should be quick and easy to learn and use. A few new features were introduced into POSTFEKO as part of the initial development, but a lot more postprocessing features will follow in the next few releases!

On the electromagnetic side (i.e. computational kernel) many features around the topic of "accelerated MoM" have been added in FEKO Suite 6.0 like GPU computing (graphical processing unit), ACA compression (adaptive cross approximation), OpenMP shared memory parallelisation (in addition to the existing distributed memory parallelisation). A number of other exciting electromagnetic extensions have also been included such as efficient aperture/slot modelling using magnetic currents, error estimation, a new large element PO solver, hybridisation of FEM with MLFMM, integration of a SPICE solver (also used for cable modelling), any many more.

*Note that you will require a new licence file that supports Suite 6.0.* This licence file is also valid for all FEKO releases from Suite 5.4 onwards should you need to use an earlier version of FEKO.

The more prominent new features are listed below. Many smaller bug fixes and additions have been included in addition to the listed items.

## Major features in FEKO Suite 6.0

1. The post-processor, POSTFEKO, has been improved considerably with many new features and usability improvements.
2. The planar multilayer substrate modelling (Green's function) has been extended to allow apertures/slots (modelled with magnetic currents) in the infinite PEC planes, thus greatly reducing the number of unknowns for such problems.
3. All media definitions now allow frequency dependent materials (Debye models, Cole/Cole etc.)
4. A SPICE circuit modeller has been integrated, allowing spice circuit models to be used directly as components in the EM-model.
5. The integrated cable modelling capabilities have been extended with new cable types (e.g. ribbon, multiple conductors).
6. Error estimation can be done on models giving the user an indication where mesh refinement could be done to improve the model accuracy without refining the mesh of the entire model.
7. A new large element physical optics (LE-PO) technique has been implemented that greatly reduces the number of required triangle elements, and thus also memory and run-time.
8. The geometrical optics technique (GO) now supports plane wave excitations (also then RCS computations).
9. Ray-launching GO has been extended to support thin dielectric sheets, anisotropic media and coatings.

10. The MoM/FEM hybrid method has been accelerated (reduction in both memory and run-time) by using the MLFMM (multi-level fast multipole method) in the MoM region.
11. Adaptive cross-approximation (ACA) has been implemented that allows large MoM problems to be solved using considerably less memory and run-time (sequential version only in Suite 6.0)
12. OpenMP based shared memory parallelisation has been implemented and hybridised with the existing MPI parallelisation for improved performance and reduced resources (especially memory for MLFMM). So far this is available for the sequential and parallel MoM matrix LU decomposition phase as well as the iterative solution of MLFMM.
13. GPU technology (NVIDIA cards with CUDA support) can now also be utilised by the FEKO kernel for the MoM matrix LU decomposition phase. Other solution phases of FEKO will be ported to GPUs in the next releases. See [www.feko.info/GPU](http://www.feko.info/GPU) for more information and a list of supported NVIDIA devices.

## User interface

The GUI components have been extended to support new features and solution techniques in the FEKO kernel. In addition to supporting new kernel features, other new features have also been implemented. These features are listed in the sections that follow.

### 3D CAD modeller - CADFEKO

1. Mesh parts can now be merged into a single part. This is useful when checking the integrity of meshes.
2. Mesh connectivity has been extend to indicate free edges in the 3D view.
3. Visualisation of named points has been improved, special attention was given to the display of named points in the presence of geometry and mesh elements.
4. Named points can be copied.
5. Defined variables can be copied.
6. Multiple variables can be edited on a single dialog without requiring the model to re-evaluate after every modification.
7. Notes made in the Notes editor are saved in the \*.pre file.
8. Requesting the reading and writing of \*.mat (MoM matrix) and of \*.lud (LU decomposition matrix) files can be done from within CADFEKO.

## Post-processor - POSTFEKO

POSTFEKO is completely new, with a new interface and many additional features. The interface has changed considerably, but with the development team's strong focus on usability it should not take long to become very proficient with the improved interface. The new features have been highlighted in the following list.

1. All menu options have been placed on a ribbon, reducing clutter and making more of the features visible and readily available.
2. A new model tree (and a details tree) has been implemented, making it very easy to see what has been requested and how the model has been set up.
3. Context menus have been implemented to allow for easy access to the most useful actions.
4. Cartesian, Polar and Smith charts have been improved and it is now possible to zoom in on Polar and Smith charts.
5. Polar charts have also been extended to allow for easy rotation and mirroring.
6. The distance measurement tool has been extended to show the distance in the 3D view.
7. Ctrl+Shift can be used to quickly add annotations, or simply extract geometrical information from models in the 3D view.
8. 3D animations have been extended to allow animation over frequency and also animation of more than one result at the same time.
9. Animation export formats have also been extended and are also available on Linux.
10. POSTFEKO mathematics are now very powerful. The mathematical expressions are also updated when the results change.
11. Mesh connectivity (highlighting unconnected edges) can easily be visualised in the 3D view.
12. Symmetry planes are visualised in the 3D view.
13. Mesh colouring options have been improved and extended.
14. Smart automatic legend text displays the difference between the traces on a graph so that users should not have to type custom legend text often.
15. 2D and 3D views can be duplicated transferring all data and display options.
16. Phase unwrapping is also available for 3D view displays.
17. Colours of dielectrics defined in CADFEKO are also used in POSTFEKO.
18. Optimisation masks are now available in POSTFEKO and can be displayed on the same graph as the results.

## Importing and exporting

1. DXF import has been extended to support the start and end width attributes for polylines.
2. An upgrade of the CAD import/export library (Catia, Unigraphics, IGES, ProEngineer etc.) has been performed with improvements and support for the latest file formats.
3. The names of imported files are written to the message window for easy reference.

## Other improvements to GUI components

1. Current, voltage and power information is now readily available for loads (without that users have to manually add current requests at these locations).
2. The total percentage output is displayed in a second progress bar when running the FEKO kernel from any of the GUI components.
3. Licence errors are now also highlighted in red when running FEKO from any of the GUI components.
4. Antenna Magus can now be launched from within CADFEKO and POSTFEKO.

## Electromagnetic solution kernel

### Major kernel features

In addition to the major features already mentioned, the following list of new features have been implemented.

1. The periodic boundary condition technique has been extend to allow the user to specify the required squint angle to determine the element phases.
2. Improved accuracy is achieved by using a new adaptive weighting scheme for MoM and MLFMM triangles (convergence with coarser meshes)
3. Windscreen modelling has been extended to allow multiple distinct windscreens (i.e. different glass parameters) in the same model.
4. Windscreen modelling can be used in connection with MLFMM.
5. Faster mono-static RCS calculations (multiple incident plane waves illuminating an object) when using MLFMM.
6. Improved shielding computations have been implemented for very high shielding examples where transmission through lossy media is dominant.
7. Lossy conducting surfaces are now allowed inside the FEM region.
8. Dielectrics (FEM or MoM) are now allowed to touch infinite PEC and PMC ground planes.
9. Multiple infinite PEC planes are now supported by the planar multilayer substrate. These infinite PEC planes are allowed anywhere within the substrate.
10. Waveguide ports can be created on faces of arbitrary media and do not require the media on the two sides of the port to be the same.

### General kernel improvements and extensions

1. More than 600 smaller extensions and bug fixes.
2. The adaptive frequency interpolation algorithms have been improved for very wide bandwidth runs with better checks and notifications for convergence.
3. Improved junctions between wire segments and triangles so that thick wire segments can be connected to small triangles.

4. Significant speedup (up to factor 100 for certain examples) and reduction in memory for the planar Green's function interpolation table setup.
5. A two-way interface between FEST3D (mode matching code for waveguide structures) and FEKO has been implemented so that FEKO can import modes from FEST3D and use as excitation of waveguide structures, and FEKO can export generalised scattering matrices for further processing in FEST3D.
6. Improved performance by the latest math libraries, compilers, MPI libraries etc.
7. Sequential out-of-core MoM solutions are now supported where an in-core part exceeds 32 GByte.
8. MLFMM solutions now support near field matrices exceeding 32 GByte (double precision) and 16 GByte (single precision).
9. Great performance improvements for the FEM modal port eigenvalue solver.
10. Drastic reduction of memory and CPU-time required for ray-launching GO (around factor 4).
11. Geometry setup and check phases have been parallelised for improved parallel performance.
12. Parallel FEKO runs now also support the import and export of \*.lud files (LU decomposed MoM matrix).
13. RUNFEKO has been extended to automatically call CADFEKO\_BATCH when no \*.fek file can be found (or the \*.fek file is old) and a \*.cfx file is available.
14. A new MPI based method for remote launching on Windows has been implemented to make remote launching and the setup easier (can automatically use existing Windows authentication, no need to install any thirdparty components).
15. The possibilities to export results directly from the FEKO kernel to ASCII files has been extended to now also optionally export surface and line charge densities (new \*.ol file).

## Support components, installation, and licensing

1. Windows versions of the FEKO binaries are now signed (Verisign code signing certificate).
2. All of the necessary components for NVIDIA CUDA GPU acceleration, integrated SPICE and shared memory processing are automatically installed as part of the installation.
3. Concurrent installations (different versions) of FEKO on the same machine are supported.
4. Sentinel dongle drivers are now part of the installation and can also be upgraded automatically as part of the installation (Windows and Linux).
5. The Windows installation can now be edited to add or remove individual features without having to reinstall the entire suite.
6. For UNIX (including Linux) installation an installation log file is now created.
7. Intel Itanium IA64 is no longer supported under MS Windows. (HP-UX and Linux are still supported.)
8. Support for Microsoft Windows 2000 has been stopped.
9. The environment variable FEKO\_LICENSE\_FILE can be used to specify an alternative location and license file.
10. Sentinel dongle drivers now natively support SuSE 10, and they are now also bundled with the FEKO installations (no need to download and install separately).



# Release Notes for FEKO Suite 5.5

July 2009

## (Changes since FEKO Suite 5.4)

FEKO Suite 5.5 introduces many improvements and extensions to FEKO. The focus is on improving the user interface, windscreen antenna modelling and extending existing FEKO kernel functionality such as periodic boundary conditions. A new graphical utility, named QUEUEFEKO\_GUI, has been developed that allows creating compressed (and optionally encrypted) packages for execution on a remote cluster using a queuing system. We have also introduced an automatic update mechanism whereby users can always have the latest, up to date, FEKO components with minimal effort.

*Note that you will require a new licence file that supports Suite 5.5.* This licence file is also valid for all FEKO releases from Suite 5.4 onwards should you need to use an earlier version of FEKO.

The more prominent new features are listed below. Many smaller bug fixes and additions have been included in addition to the listed items.

## User interface

### Major features

1. The GUI components have been extended to support new features and solution techniques. These include:
  - A new windscreen antenna modelling technique (WR, WA and WD cards in EDITFEKO).
  - A new FEM eigen mode solver (MB and AB cards in EDITFEKO and FEM modal port in CADFEKO).
  - Geometrical optics now also allow the use of PEC meshed surfaces. The name “Geometrical optics for dielectrics” has been changed to “Geometrical optics - ray launching” since this solution method is not restricted to dielectrics anymore.
  - An extension for adaptive frequency sampling (continuous frequency) to allow specifying the convergence accuracy.
  - An option to export near field data to a SEMCAD \*.dat file (DA card in EDITFEKO).
  - The spherical mode source (AS card in EDITFEKO) now supports an arbitrary import orientation.
  - Far field requests using the periodic boundary condition can now calculate the far field of a finite number of unit cell elements.
  - The ideal receiving antenna (RA card in EDITFEKO) has been extended to include the option to only consider the scattered part of the field.
2. The FEKO update mechanism has been extended to automatically check for updates on a web server (FEKO website) or a local repository for bandwidth and security sensitive environments. The updater will notify the user when updates are available and allow the user to choose whether the updates should be downloaded and installed.

## Model creation

1. New geometry primitives have been introduced to aid with model creation.
  - The analytical curve primitive allows the user to create any analytical curve (not a surface) in Cartesian, spherical or cylindrical coordinates.
  - A rectangle primitive has also been introduced to speed up model creation.
  - The sphere primitive has been extended to create ellipsoids as well as spheres.
2. A new “align” tool has been introduced to easily place objects on structures - the align tool performs a rotate and a translate as a single transformation.
3. The function and use of workplanes have been improved and workplanes are now used for creating primitives instead of the “global”-“local” coordinate system of the past.
4. Saved workplanes are now managed (create, edit and remove) in the tree, similar to variables and named points.
5. Workplane placement has been simplified by placing the workplane easily on existing faces, edges and wires.
6. Primitive dialogs open with sensible default values allowing easy placement of objects and a better visual indication of how a parameter affects the primitive.
7. Snapping control has been replaced with auto-snapping by snapping to special points (face centre, edge centre, etc.) close to the mouse pointer.
8. Snapping also snaps to a clever dynamic grid that resizes to the most suitable size for the current view.
9. The transforms (mirror, translate and rotate) now also use workplanes so that these transforms can easily be applied with arbitrary orientation.
10. A number of the operators (split, sweep and spin) have been extended to use workplanes to enable operations with arbitrary orientation.
11. The polygon, polyline and fitted spline primitives can now contain degenerate points (two consecutive identical points).
12. It is now possible to delete a face from a PEC (perfect electrically conducting) solid - the region property is automatically set to free space.
13. When a geometry part is deleted the associated ports, excitations and loads will automatically be deleted.
14. It is now possible to add and remove items from a union and other boolean operators without having to copy the contents out to the root and recreating the boolean operation.
15. Rectangle and polygon select now provides an “add to current selection” mode in addition to the existing “toggle selection” functionality. Holding down <Shift> during the selection adds to the current selection.
16. Context menus (right-click menus) in CADFEKO have been extended both in the model and details tree as well as in the 3D view.

## Importing, exporting and meshing

1. Entity names are now used as labels for imported models.

2. NASTRAN meshes can be exported directly from CADFEKO (it does not use PREFEKO).
3. NEC mesh imports are now available directly from within CADFEKO.
4. A “fast mesh” shortcut has been added that meshes without requiring user input - it simply replaces the current mesh by re-meshing with the current mesh settings.

## **Solution setup**

1. When an excitation is added a new item will also appear under the “calculation” part of the tree to indicate that source data will be calculated by simply adding an excitation. It indicates that it is not required to add an S-parameter request when the input impedance or reflection coefficient is required.
2. The FEM (and thus tetrahedral meshing) is now set in the same way as all the other solution methods. It is a solution method option of a dielectric region.
3. The general non-radiating network and transmission line connections are now set up using a graphical interface.
4. Vertex ports are now allowed on the end of wires that are connected to infinite ground planes and UTD plates.
5. The “Maximum number of iterations” for the FEM can now be set in CADFEKO.
6. The use of symmetry in connection with physical optics (PO) ray-tracing has been enabled in the CADFEKO interface.
7. The transmission line in CADFEKO has the ability to automatically determine the length of the transmission line using the physical distance between wire ports.

## **Other improvements to GUI components**

1. Variables have been extended to include a comment field.
2. The notes view now opens in its own window allowing better use of multiple monitors.
3. EM-validation has been extended considerably and it also writes the results to a graphical log where warnings and errors are indicated and explained.
4. The “zoom to selection” feature has been extended to meshes.
5. It is now possible to click on entity names in the message window to select the corresponding object.
6. Progress information is indicated while loading and saving of models - this is especially useful for large models.
7. The display and colour defaults for models that don't have a stored \*.cfs file have been improved.
8. The feature to load the last loaded POSTFEKO session when POSTFEKO starts has been removed. This results in faster startup times since no sessions files are loaded automatically. It is still possible (very easy) to load the last session since it is available in the list of recently used files.
9. POSTFEKO has been extended to display axial ratio as both the minor over major axis as well as the major over minor axis.

10. Ortho-slice contours in POSTFEKO can now be placed as specified positions.
11. Ortho-slice contours in POSTFEKO can now also be coloured individually.
12. POSTFEKO 2D near field display options now allow to display the minimum or maximum of the component magnitudes.
13. A new true type font (TTF) has been added to POSTFEKO to improve the display of text on 2D graphs.
14. Extensions and modifications to existing cards have been included in EDITFEKO. EDITFEKO has also been extended to support various new cards available in the FEKO Suite 5.5 release.
15. A new GUI component, QUEUEFEKO\_GUI, has been developed that creates packages (with optional encryption) to be executed on batch queuing systems such as PBS. The new utility can create packages and extract the results after the run has completed.

## Geometry cards and pre-processing

1. New options for PREFEKO to output variables, their values and comments:
  - print-variables** Print a list of all variables (names, comments, values) to the screen.
  - print-variables-to-out** Print a list of all variables (names, comments, values) to the \*.out file.
2. The import of cable paths from NASTRAN files are more fault tolerant (e.g. wrong segment orientation detected and corrected automatically).

## Control cards and solution kernel

1. More than 350 smaller extensions and bug fixes.
2. New geometrical optics (ray launching) support for metallic triangles (PEC).
3. New technique for modelling windscreen antennas.
4. New modal ports for the FEM have been introduced that allows excitation of Microstrip lines, co-planar waveguides and waveguides with an arbitrary shape.
5. The PBC has been extended to support dielectrics and wires.
6. Improved performance by updating to the latest math libraries and compilers, e.g. now using Intel 11.0 compilers, which provide significant speed advantage for modern CPUs supporting SSE3 or SSSE3, but also on old CPUs only supporting SSE2 one can observe a performance increases up to 100% for certain FEKO solution phases.
7. For parallel FEKO runs on the same machine (e.g. multi-core), we now split the available system memory per process (e.g. no longer need to adjust FEKO\_MAXALLOC for parallel runs depending on number of processes on the host.)
8. For parallel FEKO runs avoiding problems when the file \$HOME/.mpd.conf does not exist locally on all nodes (earlier we created it automatically if missing, but only on the master node.)
9. Update of Intel MPI for parallel FEKO versions under Linux and Windows to version 3.2.1 with a number of bug fixes and improvements (performance etc.)

10. Support of Microsoft MPI for 64-bit Windows HPC 2008 and full integration into the HPC job scheduler (through the existing command line option `-use-job-scheduler` of RUNFEKO).
11. Stopped support for ScaMPI from ScaLi (SCI no longer used, and all other interconnects now covered by Intel MPI).
12. Password based authentication is no longer needed for single-node parallel runs on Windows.
13. For cluster (multi-node) parallel runs on Windows we now also support of Active Directory authentication (Windows domain required).
14. Parallel FEKO runs now support the option `"-np all"` which starts FEKO on all machines and CPUs/cores as available from the machines file.
15. Option to export 3D near field data into the SEMCAD format. Motivation is to allow SEMCAD users the modelling of complex environments with FEKO (e.g. SAR in human phantoms in a car, model car with FEKO and use interior fields then as excitation in SEMCAD).
16. Ideal receiving antenna (RA card) now also supporting to only "receive" the scattered field (i.e. we exclude the incident field contribution).
17. Supporting newer GRASP / Ticsra versions regarding spherical mode import.
18. Improved checks regarding correct application of symmetry.
19. Improved performance when using symmetry (we can now further reduce the number of unknowns).
20. Improved geometry checks regarding overlapping cuboidal volume elements.
21. Improvements for iterative solvers (MLFMM/FEM), e.g. now using a minimum number of iterations to avoid pre-mature convergence.
22. Improved performance for geometry checks involving waveguide ports (now also making use of nearest neighbour lists).
23. Grouping of MLFMM now much faster on Windows (typical example took 248 sec, now down to 1 sec).
24. Using FEM in a completely closed PEC environment now supported without having MoM basis functions on the metallic triangles (e.g. resonator, closed waveguide).
25. Updates to the SAR calculations (relaxed cube validity test for peak SAR, improved local search algorithms, adjustments to comply with IEEE P1528.1/D1.0 from January 2007, e.g. air restriction now 20%).
26. Improvements regarding the automatic modal expansion of waveguide ports (not all evanescent modes were considered).
27. Allow the usage of CFIE or MFIE (both for MoM or MLFMM) also at closed surfaces with a wire junction.
28. Arbitrary rotation ( $\theta, \phi$ ) for spherical modes is now supported.
29. Changes around S-parameters computations to avoid possible confusion:
  - For 1-port networks skip current S-parameter computation and compute S11 directly (advantage, no need to add/remove loads etc.)
  - For n-port networks (with  $n \geq 2$ ) while processing S-parameter requests, no longer write source / power / impedance data to \*.out and \*.bof files (was misleading as effect of port loads was included.)

30. Performance optimisations for waveguide port excitations by using pre-computations and other techniques. Was in particular a problem for MLFMM solutions (as certain waveguide terms required during each iteration).
31. New option to set the desired convergence accuracy for continuous frequency runs (using ADAPTFEKO):
  - High:** Will use more samples, advisable for highly resonant structures (several sharp resonances)
  - Normal:** Same as before
  - Low:** Will use fewer samples, faster, for smooth results
32. Ability to use adaptive frequency sampling (continuous frequency) also with multiple solution requests. This also allows mixed frequency (discrete and continuous) calculations in a single model.

## Optimisation

1. So far we supported either parallel FEKO runs from a sequential optimisation process, or using parallel optimisations (i.e. farming), but then each optimisation thread only used sequential FEKO runs. Now the combination of the two is supported, i.e. farming during optimisations, and then using parallel FEKO runs (e.g. Multicore hosts.)
2. For PSO (particle swarm) and GA (genetic) optimisations now a seed value can be set which influences the start values (i.e. different optimisation runs will then differ.)
3. Smaller adjustments to the solution control, e.g. now always run CADFEKO\_BATCH and PREFEKO even for models without CADFEKO geometry (solution control then still enabled).
4. Changed output of results from sensitivity analysis to make this more intuitive.

## Support components and licensing

1. Fully automatic update mechanism (not just inform users about available updates, but download and install them automatically). Works either from update repository on our WWW site, but also from a local company file server.
2. Windows installation of FEKO got certified by Veritest (partner of Microsoft) for both client (Windows XP) and server (Windows HPC) environments.
3. Ability to restrict or deny usage of floating licences to list of specified users or hosts (e.g. prevent that parallel cluster licence is checked-out on desktop PCs). New configuration file "secfekod.cfg" where users can specify INCLUDE and EXCLUDE rules for licences with lists of users and/or hosts (hostname or IP address, also wildcards).
4. Support of a new environment variable FEKO\_LICENSE\_FILE which can be set to point to an alternative location of the FEKO licence file.
5. Extended detection algorithms of number of cores per CPU to also support most recent CPUs (required for multi-core licence policy).
6. Improved usage of dongle licences on Windows remote desktops.

# Release Notes for FEKO Suite 5.4

July 2008

## (Changes since FEKO Suite 5.3)

FEKO Suite 5.4 introduces many improvements and extensions to FEKO. The focus is on providing more complete access to the features of the FEKO solver through the graphical interface components, the reduction of limitations in and between different methods (including the optimisation of the methods themselves) and the introduction of new techniques (like infinite periodic boundary conditions).

*Note that you will require a new licence file that supports Suite 5.4. This licence file is also valid for all FEKO releases from Suite 3.1.2 onwards should you need to use an earlier version of FEKO.*

The most important new features are listed below. Many smaller bug fixes and additions have been included in addition to the listed items.

### User interface

1. Alternative creation methods for certain geometry primitives in CADFEKO have been added (i.e. allows the use of different sets of parameters to define a given geometry primitive). Images in the definition dialogs have also been improved to assist in visual identification of the quantities used to define the primitive.
2. Parabolic arc and Hyperbolic arc geometry primitives have been added to CADFEKO.
3. An advanced Sweep tool has been added in CADFEKO. This complements the existing sweep tool, and allows sweeping of faces and lines along a general curved path. The object being swept may be kept parallel to its original orientation or the orientation relative to the path may be maintained during the sweep. A scaling and rotation may also be specified along the trajectory (i.e. the object being swept will be scaled and rotated around the path as it is swept).
4. The Stitch sheet parts tool provides for the connection of sheet parts in CADFEKO where the connecting edges may not exactly align. This is particularly useful when working with imported CAD geometry but may be used in various other situations. (The Stitch sheet parts tool was made available to users as part of a FEKO Suite 5.3 CADFEKO update before the Suite 5.4 release.)
5. An import module for DXF CAD geometry has been added to CADFEKO. The import module allows DXF geometry to be imported directly to CADFEKO geometry entities, and is provided to complement the existing DXF mesh import. (This import supports a large set of the DXF format, but a number of specialised entities and properties are not yet supported. CADFEKO will provide an indication of any unsupported entities or properties in the DXF file during import.)
6. CAD export filters have been added to CADFEKO for ACIS, STEP, IGES, Catia v4 and v5 (note, similar to the corresponding import modules these are licenced separately). The Catia v5 export is only available on Windows.
7. A number of features have been added to aid CAD import and identification of errors in imported mesh and geometry in CADFEKO. These include:
  - An indication of the scaling that will be applied during import.

- A robust import process that attempts to import and display even problematic geometry when at all possible.
  - Fault indicators showing problematic geometry parts or entities that may need attention after import (these indicators include a description of the fault visible in a tool-tip when hovering over the fault indicator).
8. A Zoom to selection tool has been added to assist in locating of parts or entities in the CADFEKO model.
  9. A special Transparency mode has been added to the geometry display colouring options in CADFEKO. This causes all entities, except those currently selected, to be rendered semi-transparent in the 3D view. This view mode allows easy visual identification and location of parts or entities in the 3D view.
  10. Tools have been added to help in the identification of overlapping mesh elements (both triangles and tetrahedra) in meshes created by CADFEKO or imported into CADFEKO.
  11. The tool-set provided for finding certain problems (e.g. overlapping mesh entities, unconnected geometry edges etc.) in the CADFEKO geometry/mesh have been expanded to allow searching over the whole model or only within the current selection.
  12. A tool has been added to provide suggestions regarding the global mesh size (edge and segment length) that should be used. This tool does not take specific media, topological features or solution methods into account, and is simply an indication of the free-space mesh size given the current solution frequency and model unit settings.
  13. CADFEKO provides a facility for the definition of aperture excitations (AP card equivalent). The fields in the aperture source cannot be manually specified in CADFEKO and must be based on a pre-defined ASCII text file or pre-calculated FEKO \*.efe/\*.hfe files.
  14. Spherical mode excitations (AS card equivalent) may now be set up in CADFEKO. The modes may be manually defined or based on an \*.sph file.
  15. The definition of impressed current excitations (AI/AV card equivalent) can be done in CADFEKO. Special options allow these excitations to be connected to the nearest mesh vertex during solution where exact location of the mesh vertices is unknown.
  16. Edge excitations with respect to a UTD plate or infinite ground plane can be specified in CADFEKO. (This could previously only be manually specified using an AE card in the \*.pre file.)
  17. The definition and connection of General non-radiating networks and Transmission lines can be done in CADFEKO. Network parameters (S-,Y- or Z-parameters) may be manually defined, or based on a Touchstone file.
  18. Excitations and loads can be attached to Transmission lines and General non-radiating networks in CADFEKO. Interconnections between Transmission lines and General non-radiating networks may be defined, and the Transmission lines and General non-radiating networks can also be connected to wire and edge ports on the CADFEKO geometry/mesh.
  19. CADFEKO provides a more flexible facility to specify loads and excitations in the FEM region. This makes it possible to specify a FEM excitation such that the physical relationship between the excitation and the geometry or mesh of the model is maintained through manipulation operations like scaling and translation. It is also possible to now reference ports in the FEM region as part of S-parameter calculation requests.
  20. Model symmetry can be specified in CADFEKO directly. No special geometry modifications (e.g. only creating a part of the geometry) are required.



21. Waveguide excitations can be specified in CADFEKO. Waveguide ports may be used in S-parameter calculations or excited using specific mode excitations.
22. Periodic boundary conditions can be specified (infinite periodicity in 1- or 2- dimensions). Only geometry inside the unit-cell region need be created - no geometry/mesh outside the unit cell is allowed.
23. The UTD solution method may be applied to faces that are in a more complex part. Previously UTD could only be applied to free faces. (The faces to which UTD is applied must still adhere to the requirements for a UTD face - flat with straight edges etc.)
24. Optimisation masks and constraints between optimisation parameters may be defined in CADFEKO.
25. The orientation of ports applied in CADFEKO may be reversed directly (without having to modify the mesh or geometry). The orientation is indicated in the preview of the port in the 3D view.
26. Expansion of the settings for Dielectric GO allows manual specification of the angular resolution for ray-launching.
27. EM validation has been expanded for various solution components (ports, UTD, symmetry, mesh sizes etc.)
28. Fault indicators have been added that continuously monitor and indicate certain solution parameter (non-geometry/mesh related) problems in the model. Previously these problems would have only been checked as part of the EM validate process, or would have caused specific errors during the solution set up. For example, the UTD solution method may only be applied to faces that are bounded by straight edges. If a curved face is subtracted from such a face, CADFEKO will not give an error, but the operation will be completed and a fault indicator will be shown next to the tree-representation of the face involved. The tool-tip (shown when hovering over the port in the tree) describes the fault as 'Face is not allowed to be solved with UTD since all its edges are not straight'. As soon as the fault has been rectified (the UTD solution setting removed from the face or the subtract operation reversed) the fault is resolved and the indicator is removed. CADFEKO will not allow meshing while there is a solution setup fault in the model.
29. Printing, image export and copy image to clipboard capabilities have been added to CADFEKO to aid capture of images showing the current 3D view.
30. User-definable colour themes can be set in CADFEKO. This allows customisation of a selection of colours used in CADFEKO (e.g. the background colour of the 3D view).
31. Existing POSTFEKO session files (\*.pfs) may be applied as a template to FEKO model(s) and result(s). All 3D views, plots and visualisation settings defined in the session will be shown, using the model(s) and result(s) that the session is applied to.
32. POSTFEKO provides support for visualisation of models that include periodic boundary conditions.
33. POSTFEKO provides support for visualisation of General non-radiating networks and Transmission lines that are connected to vertices, edges, segments and internal ports.
34. POSTFEKO provides support for visualisation of loads on vertices.
35. Extensions and modifications to existing cards have been included in EDITFEKO. EDITFEKO has also been extended to support the editing of the various new cards available in the FEKO Suite 5.4 release.
36. Configuration of the hosts available for farming out of optimisation steps is available in the GUI components.

37. Program icons have been improved for better look-and-feel in Windows VISTA.

## Geometry cards and pre-processing

1. The TG card has been extended to allow mirroring around a plane (x, y or z equal to a specific value).
2. NASTRAN files in alternative coordinate systems may be imported (IN card). This includes translated and rotated coordinate systems.
3. The memory management of NASTRAN file imports containing large indices and large index ranges has been optimised.
4. In previous releases, when exporting NASTRAN files, a numerical ID based on the associated number of the label string was included (as NASTRAN does not support string labels). Now an additional text file (\*.map) is written that contains a mapping between the NASTRAN element numbers and the FEKO element labels. This mechanism can be used to determine the string labels of elements in a NASTRAN file based on their numerical ID. The numbers chosen in the mapping file are based on an internal FEKO numbering.
5. When defining a cable path (CA card) the path may be imported directly from a NASTRAN file.
6. The AS card (spherical mode excitation) has been expanded to allow the specification of multiple modes in a single card, and to allow the import of spherical mode definitions directly from a TICRA \*.sph file.
7. The orientation of excitations (A1, A2, A3, AE, AN) may be reversed without modifying the mesh.
8. The waveguide excitation (AW card) allows various automatic options including geometry-independent reversal of propagation direction.
9. A new PE card for the specification of the location of the unit-cell region for calculations employing periodic boundary conditions has been added.
10. A PP card has been added to allow the specification of the phase-shift(s) in a problem using Periodic boundary conditions. Where plane-wave excitations are used, phase-shifts cannot be specified, but are calculated based on the direction of incidence.
11. A new L2 card (load on a vertex) has been added. (This is the equivalent load to the A2 card)

## Control cards and solution kernel

1. General performance has been improved by updating to the most recent versions of math libraries (MKL for Intel, ACML for AMD etc.) for the FEKO solver.
2. Infinite general periodic boundary conditions (PE card) have been implemented (1- and 2-dimensional, including skewed lattice capabilities). This method can be used for a number of applications including analysis of FSS structures (frequency selective surfaces), large array analysis etc. Currently only the MoM with metallic triangle elements and thin dielectric sheet structures in free-space, or with an infinite ground plane (BO card) are supported for periodic boundary condition calculations.
3. Using the Periodic boundary conditions provided in FEKO, it is also possible to solve 2D MoM problems (e.g. computation of the scattering properties of an infinitely long cylinder).

4. General non-radiating networks and Transmission lines may be connected to edges, vertices, segments and other General non-radiating networks and Transmission lines in the model. Transmission line ports need not be connected to geometry, but may be open or only have internal connections.
5. Internal network loads and excitations (AN card and LN card) may be applied directly to Transmission line ports. (previously only available for General non-radiating networks).
6. General non-radiating networks and Transmission lines may be connected at the same point (vertex/edge/segment) where a MoM load or excitation is applied (A1, A3, AE, A2 sources; LZ, LE, L2 loads).
7. Metallic wires and triangles in different media may be connected (i.e. interfacing metallic surfaces/wires through dielectric boundary modelled using the SEP).
8. A new weighting formulation for wire segment integrals is used in order to obtain better convergence (i.e. results are now more accurate when using a coarser mesh).
9. The calculation scheme when computing near- and far-fields in a parallel solution has been changed. This results in improved efficiency when using a small number of parallel processes.
10. General validation for symmetry has been improved.
11. The error reporting for UTD has been improved (improved messages as well as indication of the position(s) of affected item(s) etc.).
12. Waveguide excitations may be used in models that employ the MoM/PO hybrid method. (The waveguide excitation must be in the MoM region of the model.)
13. The definition for source power for waveguide ports has been modified to include the net power flow through the port resulting from all forwards- and backwards-propagating modes.
14. Even when not specifically requesting in an S-parameter calculation request (SP card), input reflection coefficient (S11) of waveguide ports can be viewed in POSTFEKO (previously this was true for other excitations like edge excitations and wire excitations).
15. An option has been added to request the automatic computation and excitation of the primary propagating mode of a waveguide of a given size. Automatic determination of the maximum number of modes to be taken into account during the solution (all propagating modes as well as all evanescent modes that decay slower than  $1/e$  over a propagation distance of one-tenth of a wavelength) may also be requested. (Manual specification of all of these options is still possible.)
16. The reversal of the propagation direction of a waveguide excitation may be specified independent to the normal direction of the face to which the port is applied. (Previously the propagation direction was based on the face normal direction - in the case of the AW card defined by the relative positioning of the points used in the port definition.)
17. An option has been added to the waveguide excitation (AW card) to exclude the port during S-parameter calculations. This then effectively acts as an absorbing load during the S-parameter computation (and not as a passive port).
18. Cable coupling (CA card) may now be used as part of a parallel solution.
19. The FEM matrix setup times have been generally optimised, improving solution time for problems including the FEM.
20. The FEM in FEKO may be run as part of a parallel solution. Memory for the various arrays (e.g. FEM matrix, MoM coupling, pre-conditioners) is split amongst the parallel processes, while at the same time the overall run-time is reduced by having all of the various solution phases of the FEM/MoM hybrid method executed in parallel.

21. For coupled FEM/MoM problems, a special case is supported when using symmetry allowing the solution of larger problems in-core (only the symmetrical MoM part is kept in memory).
22. When using the FEM/MoM hybrid method with the two regions decoupled, an out-of-core solution is now supported for the MoM region.
23. If the iterative solutions of the MLFMM and FEM do not achieve convergence within the anticipated number of iterations, the solver will automatically reduce the stopping criterion by a factor of 10 and continue with the iterative solution. Practical examples have shown that then in many cases convergence can be achieved.
24. An optional switch between the classical field computation schemes and fast near- and far-field schemes used by default in the MLFMM is now available. In certain special cases the fast schemes may not be practical as they require too much memory (e.g. computing near-fields over a very large spatial domain). Switching to the classical field computation schemes in these cases (while still using the MLFMM for the actual solution) is preferable.
25. The far-field power integral for MoM/SEP calculations has been accelerated (reduced angular sampling density; lossless media are not included and integration below an ideal ground plane is avoided).
26. For the GO method, the ray-launching procedure has been optimised both with regard to memory and run-time. This results in a dramatic reduction in memory and run-time for many typical GO problems.
27. Parallelisation of the Dielectric GO method using distributed memory.
28. A complex load can be added at a vertex on a wire in the model (L2 card). (This is the load equivalent of the A2 excitation on a vertex that was previously available.)
29. Special loads that can be used inside of a FEM region have been added. This allows for general loading as well as S-parameter computations that include ports inside of a FEM region
30. The far-field criteria has been adjusted for the radiation pattern point source and the ideal receiving antenna (AR and RA cards).
31. A recovery facility has been added to aid processing of corrupt or incomplete \*.str files (e.g. after a user-abort or system failure during a solution).
32. Support for exporting of \*.lud and \*.mat files that exceed 2 GByte has been added for Windows systems (this was previously possible on other operating systems, but was a specific limitation in Windows).
33. A new RUNFEKO option (--no-execute-prefeko) has been added. This option prevents PREFEKO from being called, even if the \*.fek file is found to be older than the \*.pre/\*.cfm files.
34. The RUNFEKO options for remote launching of OPTFEKO and TIMEFEKO have been removed (--optfeko-mode and --timefeko-mode) and are no longer supported. Specifying '--runfeko-options ...' when launching TIMEFEKO or OPTFEKO should now be used.
35. Porting to the IBM PowerPC architecture running AIX as operating system (including full parallel support with the IBM PE = parallel environment).
36. Stopped FEKO support for SGI MIPS IRIX based systems. Such machines are no longer available and all existing FEKO users that have used this option have migrated to other systems.

37. Intel MPI is now available for parallel FEKO versions under both Linux and Windows. This has the advantage that advanced network interconnection technologies (like Infiniband and Myrinet) are supported. The MPICH2 executables are still provided as part of the Suite 5.4 release for consistency reasons. Users can switch between these two options using the FEKO\_WHICH\_MPI variable if required.
38. Direct support for queuing systems is provided. Queuing system support can be accessed by using the '--use-job-scheduler' option. (This facility is only available under Windows and Linux when using Intel MPI - this is the default.) Supported queuing systems are:
  - Windows CCS (compute cluster server)
  - Torque 1.2.0 and higher
  - Altair PBS Pro 7.1 and higher
  - OpenPBS 2.3
  - Platform LSF 6.1 and higher
  - Parallelnavi NQS V2.0L10 and higher
  - Netbatch 6.x and higher
39. Support for interfacing between FEKO and CRIPTE from ESI for cable-coupling applications is provided.
40. Parallel FEKO versions for all platforms (including SUN Solaris) have been migrated from MPICH to MPICH2, which provides improved performance.
41. The Intel MPI for parallel FEKO versions under Linux has been updated to version 3.1 and various bug-fixes and improvements have been made.

## Optimisation

1. The ability to run optimisation steps concurrently on different computers/processors (farming out solutions) has been added. This may be used in conjunction with the existing parallel capabilities of FEKO, where multiple optimisation steps may run at the same time, and each optimisation step may involve a parallel/distributed solution. (Farming is not available for the Simplex method.)
2. A new optimisation goal extension that allows direct optimisation of the current in a wire segment to be optimised.
3. Support for constraints between optimisation parameters has been added (e.g.  $param1 \leq param2$ ).
4. Support for optimisation using masks has been added. This allows an optimisation goal to be defined that bases the calculation of the optimisation fitness on the relationship between two arrays of values (one array provided in the mask definition and the other computed by FEKO). The mask array need not be of the same length as the FEKO-computed array and interpolation of the mask array is used to facilitate comparison.

## Support components

1. German language support (\*.out file and screen output given in German) has been removed.

## Licensing items and other general items

1. In the licenced mode, FEKO LITE may be used on Gold and Platinum level platforms (previously FEKO LITE was only available on Silver platforms.)
2. The M&S expiry date of a license may be directly viewed in the SECFEKO GUI.
3. PCBMod and CableMod interfaces are always available (no special licence required for use).
4. When running FEKO on multi-core CPUs, previously each process was counted separately in the licensing scheme - i.e. a sequential licence supported only one single process. Now the licensing has changed from processes to CPUs, and only the number of CPUs that FEKO runs on is considered. This means that a sequential licence is sufficient to run a parallel 4-process job on a quad-core CPU. Or, alternatively, a parallel 4 licence allowed in the past to launch a 4-process parallel job, now may be used to launch a job on 4 CPUs and use all of the available cores on these CPUs.
5. The information logged to the \*.log file by a floating licence server has been improved.
6. When running the command 'secfeko -p', version information for all available floating licence servers (including multiple redundant servers) is given. Previously only the information for the first reachable server was returned.
7. For parallel licences, the CADFEKO\_BATCH component may be run on all nodes of the parallel cluster, not only those with GUI components active in the licence. This provides for remote optimisation runs within a parallel cluster.

# Release Notes for FEKO Suite 5.3

July 2007

## (Changes since FEKO Suite 5.2)

FEKO Suite 5.3 introduces many improvements and extensions to the FEKO Suite. Optimisation in FEKO has been entirely overhauled. New advanced optimisation methods are available and the optimisation options may now be defined in CADFEKO. Provision has been added to POSTFEKO for the tracking and viewing of optimisation-related results. A new solution method (geometrical optics for dielectrics) has been added that can be used for the analysis of dielectric lens antennas as well as a number of other applications. A mechanism for the inclusion of general network-parameter representations of multiport networks that may be physically connected to (and may interact with) the FEKO model has been added.

*Note that you will require a new licence file that supports Suite 5.3 in order to activate it. This licence file is also valid for all FEKO releases from Suite 3.1.2 onwards should you need to use an earlier version of FEKO.*

The most important new features are listed below. Many smaller bug fixes and additions have been included in addition to the listed items.

## User interface

1. Alternative methods for defining geometry primitives in CADFEKO, e.g. for a cylinder.
2. Import point lists from a text file for polyline, polygon and fitted-spline primitives as well as cable analysis path generation in CADFEKO.
3. Support for a model-specific list of named and saved workplanes that can be referenced during geometry creation in CADFEKO.
4. Added new mesh import option in CADFEKO for GiD mesh files.
5. If a mesh is deleted, any ports on the mesh that also have a geometry instance are automatically deleted.
6. A port annotations tool has been added to CADFEKO that displays the port labels and the names of all loads and excitations applied to each port in the 3D geometry view window.
7. The current model view (zoom, rotation and position) in CADFEKO can be transformed manually using the view transformation tool.
8. Colour the geometry and mesh viewed in CADFEKO based on the region, face or coating media.
9. Added a tool in CADFEKO that can be used to highlight the special solution methods assigned to various parts of the model.
10. The colour selection for media defined in CADFEKO is now stored along with the model in the \*.cfx file and not as part of the session in the \*.cfs file.
11. Selective importing from existing CADFEKO models (i.e. import geometry and/or mesh and/or media and/or variables and/or solution components directly from an existing external model into the current CADFEKO model).
12. Extension of the Parasolid model export that allows export of the model in any Parasolid version (version 14.0 to version 18.1).



13. Various improvements in the general CAD model import modules, particularly for assemblies.
14. Solution entities (loads, excitations, calculations) defined in CADFEKO can be included or excluded from the computation without having to delete them.
15. The free space material properties can be edited directly in CADFEKO.
16. The method for application of special solution techniques (UTD, PO and the new geometrical optics method) to a model in CADFEKO has been changed and made consistent.
17. EDITFEKO may now always be launched directly from CADFEKO. When launching EDITFEKO from CADFEKO, the user is asked if the CADFEKO solution entities should be disabled before opening the \*.pre file to avoid overlap of the CADFEKO and \*.pre file solution settings.
18. A facility to setup optimisation searches that can reference both model and solution elements inside of CADFEKO and those added/edited through EDITFEKO is available in the CADFEKO interface. New optimisation methods, including Particle Swarm and Genetic Algorithm can be used. Multiple parameters can be used. Provision is made for the definition of very flexible compound goal functions (these goals define the desired result of the optimisation process).
19. The assignment of new values to variables, model re-evaluation and re-meshing of CADFEKO models using a stand-alone command line driven tool (i.e. batch meshing).
20. An option whereby an interrupted optimisation process can be restarted from the point at which it was interrupted. The optimisation settings must be identical and all of the intermediate files that were generated up to the point where the optimisation was interrupted must still be available and not have been modified.
21. Porting of the POSTFEKO GUI component to the 64-bit x86\_64 platform (i.e. AMD64 / EM64T) for both Windows and Linux (useful where rendering of larger models or working with large result datasets is required).
22. Option that allows users to disable geometry rendering during the loading of large models in POSTFEKO. This allows the visualisation of simulation results on machines with insufficient resources for the geometry rendering.
23. Extension of online help for the POSTFEKO GUI.
24. Addition of a session-specific suppression mechanism for the POSTFEKO message indicating that there are warnings in the \*.bof file.
25. Stability improvements in the POSTFEKO polling mechanism for \*.fek, \*.bof and the newly introduced optimisation \*.pfg files.
26. Modification of the reload/serialise option allows users to indicate how updated results should be handled by POSTFEKO.
27. Extension of the UTD ray-viewing and geometry colouring options in POSTFEKO in support of the new dielectric GO method (see the kernel enhancements).
28. POSTFEKO supports the display of complex loads applied between two points in the FEM region using the new LF card.
29. Support for 'real-time' visualisation of optimisation progress (geometry and solution evolution as well as optimisation parameter and goals plotted versus iteration number) in POSTFEKO.
30. POSTFEKO support for the display of solution results (currents, voltages, S-parameters etc.) for LN and AN network port loads and excitations and support for the visualisation of the geometry-connection points of non-radiating general network ports.

31. Added online help for EDITFEKO, and links to contextual help for all EDITFEKO cards using the <F1> help key
32. Removed special support for the editing of text-based \*.opt files in EDITFEKO.

## Geometry cards and preprocessing

1. Significant speedup for the import of large meshes (e.g. NASTRAN) when the node point import option is activated.
2. Addition of special support for the definition of indexed point-arrays and expansion of the PM and PY cards to allow for point-array and variable-array based definition of polygon and polygon plate geometry primitives with no limitation on the number of points in the definition of these structures.
3. Addition of new cards to the EDITFEKO interface for the definition of geometry primitives useful in the analysis of dielectric lenses (hyperbolic plate, hyperbolic cylinder and hyperboloid section).
4. New meshing routines for dielectric lense primitives (hyperbolic plate, hyperbolic cylinder and hyperboloid section).
5. Added new cards for support of general non-radiating network usage. AN card - Network port excitation, LN card - Network port loading and NW card - General network definition.
6. New import option for GiD mesh files using the IN card.
7. Import of variables from CADFEKO via the \*.cfm file (can then be referenced directly in the \*.pre file).
8. Removed support for the \*.edg file.
9. Extended the UT card to support application of the new geometrical optics for dielectrics method.
10. Extended AF card to allow specification of an S-parameter reference impedance for the inclusion of FEM excitations in S-parameter calculations.

## Control cards and solution kernel

1. Many bug fixes and smaller enhancements.
2. Although in principle a SILVER licence of FEKO can allocate up to 2 GByte of memory, so far for many MoM or MLFMM applications on Windows (not Linux) this limit was practically at around 1.4 GByte due to DLL loading behaviour of Windows. Re-arranged the Windows DLL handling code so that one should now be able to allocate up to 1.8 GByte for FEKO runs.
3. For certain configurations improved accuracy for near field calculations in connection with the multilayer planar Green's function.
4. Fast near field calculations for the MLFMM (drastic reduction for the time spent in computing the near fields at many points for large models).
5. Improved parallel MLFMM efficiency and run-times. The improvements are in particular for the SPAI preconditioning phase, due to load balancing and improved parallel communication schemes.
6. Performance optimisations resulting in significant speedup of the matrix element computations for waveguide ports.

7. The memory allocation scheme when importing the solution from an \*.str file has been reworked such that memory for storage of the MoM matrix is no longer allocated if this is not required.
8. Inclusion of complex multiport networks based on S- Y- and Z- parameter data. These networks may be cascaded, excited (directly or indirectly) and (if required) connected to interact with the physical model.
9. Added a new method - Geometrical optics for dielectric structures (radome and lens antenna applications).
10. Availability of complex load impedances between two points in the FEM region (i.e. FEM sources can now be included in S-parameter calculations) using a new LF card.
11. Smaller updates to the peak SAR search algorithms to make them more stable and robust for special cases.
12. Adjustments to the iterative solution process for the FEM to make this faster for many general problems.
13. Waveguide port excitation available on models that include dielectric parts (MoM/SEP or FEM) or that use the CFIE (combined field integral equation) in the metallic region.
14. Extension of the UTD to allow for multiple plates (more than two) connected at a single edge.
15. Allow the use of non-radiating transmission lines at ports in connection with S-parameter calculations.
16. Using the CFIE for a metallic region is now possible even when a dielectric body is present in the model (the dielectric region may be solved using either SEP for MoM/MLFMM or the FEM).
17. Parallel FEKO versions under Linux use a newer version of Intel MPI which has a more robust and stable process launching mechanism (for specific configurations problems have been encountered in the past). The usage of the FEKO\_WHICH\_MPI environment variable is therefore now also applicable to Windows platforms.
18. The RUNFEKO command line switch '--use-mpich' is no longer supported. This should be replaced by usage of the FEKO\_WHICH\_MPI variable as mentioned above.
19. Adjustments to the \*.snp file (exported Touchstone S-parameter data) to make this more compatible with other codes.

## Support components

1. Complete re-design and re-implementation of the optimisation process and workflow to make this much more integrated with the GUI (graphical feedback of both geometry changes and results while optimisation process is running) and more user friendly in general.

## Licensing and other general items

1. Many smaller enhancements to improve the robustness of the licence mechanisms (e.g. the multiple redundant licence server handling).

2. When using a licence file which has mixed floating and node-locked licences, the requirement that the floating licence server must be known or visible (i.e. nameserver lookup required) on the client even when using a node-locked licence has been eliminated. This makes provision for the usage of a node-locked licence on a computer when network / nameserver access is not available.
3. Extension of the concept of a "preferred" licence also to node-locked licences (available so far only for floating licences). Thus if there is a node-locked licence on a host (e.g. GUI-only licence) but one also has a floating licence (e.g. full FEKO licence), then the full FEKO licence can be used if marked as "preferred" despite the matching node-locked licence. Or if for one host there are two matching node-locked licences (e.g. one purchased and one evaluation), then one can select in the FEKO licence manager which licence to use.
4. For floating licences more robust automatic check-in of checked-out licences when one floating licence is used by multiple parallel runs and one of these crashes or gets killed abnormally. In the past the parallel processes remained checked out until all parallel runs using the same floating licence were finished.
5. The addition of an option to initiate the creation of a licence request file for the current machine directly from the licence manager interface.

# Release Notes for FEKO Suite 5.2

August 2006

## (Changes since FEKO Suite 5.1)

FEKO Suite 5.2 is a major release introducing many improvements and extensions, amongst others the integration of setting solution options in CADFEKO, integrated cable coupling modelling, excitations in the FEM region, ideal receiving antennas, or also supporting single precision for the MoM (reducing the memory requirement by a factor of two).

*Note that you will require a new licence file that supports Suite 5.2 in order to activate it. This licence file is also valid for all FEKO releases from Suite 3.1.2 onwards should you need to use an earlier version of FEKO.*

The most important new features are listed below. Many smaller bug fixes and additions have been included in addition to the listed items.

### User interface

1. The entire solution setting (including medium properties, coatings / losses, the model unit, sources and loads, calculation requests, etc.) of simple models (no symmetry, one frequency loop, one set of sources, one solution) can now be set up completely from within CADFEKO. (EDITFEKO is still supported for existing and advanced models.)
2. The online manual covers the entire solution process for these simple models.
3. Sources, loads, cables, transmission lines and a number of solution requests (e.g. near fields, far fields, currents, SAR, receiving antennas) now have names. These names are set in CADFEKO or with '\*' comments behind the card in user created \*.pre files, and then used to identify these items throughout the GUI.
4. Tetrahedral and triangle meshes can now be refined (coarser or finer, not just subdivided) in CADFEKO without a need for the underlying geometry. Label boundaries are maintained, but elements can be renamed to create a single label.
5. Modifying parent components in the CADFEKO tree (re-evaluating it) will result in much fewer suspect items, i.e. properties are propagated more consistently.
6. CADFEKO now does a much more accurate checking for redundant edges (required to delete edges and join faces).
7. CADFEKO no longer runs out of memory when the geometry is built from a deep, complex tree or when there are a large number of items in the details tree.
8. CADFEKO can now archive different versions of the model as it is developed.
9. POSTFEKO and CADFEKO now give the distance between any two selected items. POSTFEKO can also show the coordinates of the bounding box of the visible items.
10. POSTFEKO can now create gray scale images.
11. The user can now configure the default background and line colours of POSTFEKO 2D plots.
12. The GUI components now work with files containing dots in the middle of the name (e.g. my.file.pre).
13. Remote parallel jobs can now be launched from the GUI components without a parallel licence on the local machine.

14. Many small fixes to POSTFEKO and CADFEKO due to customer feedback.

## Geometry cards and preprocessing

1. The external mesh import (IN card) has been extended so that also now \*.inp mesh files from ABAQUS can be imported.
2. Improvement of the autodetection routines for STL file import (IN card).
3. For the NASTRAN mesh import (IN card) so far the wide character format was supported only when reading vertex information. Now extended this wide character format to also recognise the various mesh element types CROD, CBAR, CTETRA, CTRIA3, and CQUAD4.
4. Sometimes when importing NASTRAN meshes at the IN card floating point numbers have a wrong format like “.90664-7” in the external mesh file. There the exponent ‘e’ is then missing, and at the import PREFEKO would have evaluated such expressions assuming a minus sign. Adjusted the import filter to also accept such broken NASTRAN files as input.
5. At the CB card when reading an external text file with a label mapping table, now in addition to the ANSA 11 format of this label mapping file, also ANSA 12 is now supported.
6. PREFEKO had a command line option #var=value to set certain variables for further processing. Under UNIX this # had to be escaped, but still with remote launching there were problems. PREFEKO still supports the command line option #var=value for backwards compatibility reasons, but a new format -#var=value (leading minus sign) is now also available which avoids the escaping problems and which also works with remote launching.
7. New commands !!print\_warning "...” and !!print\_error "...” are available that can be used in a \*.pre file and will then print a warning or error output. To enable multi-line error messages, the !!print\_error command will not stop processing, a subsequent !!exit should be used in this case.

## Control cards and solution kernel

1. A facility has been added in FEKO to use transmission line theory for the modelling of coupling of external fields into cables (new CA card). Several shielded coaxial cable types such as RG-58 are available, and the measured transfer impedances versus frequency are readily available in FEKO, so that users don’t have to worry about this and can directly compute currents and voltages at the cable terminals due to an external excitation (which is part of the general FEKO model). User defined cable types are also supported.
2. At the EG card there is a switch to select between single and double precision. So far this selection was applicable to the MLFMM and the FEM only. For the MoM and PO (the MoM/PO coupling terms in particular) always double precision storage was used. Now in Suite 5.2 this switch also applies to the MoM and MoM/PO coupling terms, and when using now single precision then the memory requirement is half. The new default is single precision, which will also be used when running old existing models which were not explicitly set to double precision. Double precision accuracy is required only in special cases (for instance when solving low frequency problems). The FEKO kernel has built in checks and when using single precision in such cases will advise the user to rather switch to double precision.

3. FEKO allows to read an arbitrary radiation pattern (measured data, separate computation with FEKO or another package) and use this as an ideal transmitting antenna (AR card). This feature has now been complemented by providing a similar facility also for receiving antennas. By means of the new RA card a receiving antenna can be defined by its radiation pattern, and FEKO will allow to compute the power received by this antenna under ideal load conditions (i.e. conjugate complex) taking the complex radiation pattern into account for the field computations by all the various sources (excitation, but also all the MoM basis functions etc.). Presently this feature is available in connection with MoM, PO, UTD, MLFMM and FEM, but a special Green's function (GF card) or a ground plane (BO card) are not supported in the model.
4. So far for the FEM/MoM hybrid method excitations were only allowed in the MoM region (e.g. a base station antenna in front of a human phantom). When modelling for instance dielectric patch antennas using FEM, artificial air gaps had to be created for the MoM pin feed. Now one can also directly have impressed current excitations in the FEM region (new AF card).
5. SAR computations with the multilayer planar Green's function and a plane wave as source (i.e. then basically a 1D problem) are now also supported.
6. For SAR computations the IEEE standard C95.3-2002 Annex E specifies guidelines how to deal with parts of the SAR cube not being in tissue. Improvements made in this regard when thin dielectric layers are modelled.
7. Accuracy improvements of SAR computations within thin high-contrast layers.
8. Supporting the combined field integral equation for MoM/MLFMM also in connection with a real ground plane (BO card).
9. Reworked the grouping and boxing algorithm of the MLFMM so that for big models this solution phase can now performed much faster.
10. Several stability and performance improvements to the parallel MLFMM. In particular the memory requirement per process for parallel MLFMM runs has been reduced considerably.
11. When making settings for the iterative solver or preconditioners (typically only by advanced FEM or MLFMM users) then it is now possible to set iterative solver or preconditioner separately, while keeping the FEKO default for the other.
12. For parallel FEKO runs in connection with big models improved the parallel communication to avoid problems with MPI implementations regarding the maximum message size (this could have been exceeded when exchanging the geometrical data for instance).
13. Parallel versions of FEKO for Linux on the IA32, EM64T, AMD64, and IA64 platforms are now also available in connection with Intel MPI. Intel MPI supports interconnects such as Myrinet or Infiniband, but also the traditional Ethernet (and GigabitEthernet). FEKO includes all the required run-time components to use Intel MPI, which is now also the default (but the previous MPICH or also ScaMPI are still supported and can be chosen either at install or also at run-time).
14. For the parallel MoM improved the load balancing algorithm.
15. Smaller adjustments to the way how FEKO and PCBMod from Simlab interact together to that there is a better support for the various ground plane options in PCBMod (with connections of elements from the FEKO model).
16. Performance improvements on several systems by using updated math libraries from Intel, AMD, and HP.

17. For waveguide mode excitations (AW card) in connection with a circular or coaxial waveguide it is now possible to specify a rotation angle, so that for instance two 90° rotated modes could be used as excitation.
18. The geometry checking mode of the FEKO kernel (i.e. the `--check-only` option) will now also allow to check very large models, where normally already say for a GUI-only licence the 32-MByte memory limit would be too small to even hold the geometrical data.
19. When using loops at the FR card (multiple frequencies) or for incident plane waves at the A0 card (monostatic RCS), then so far nesting such loops was not allowed. This is now possible.
20. When using A2 voltage sources at a wire segment node, the user now has better control regarding the specification of the source position and the source orientation (this can now be specified independently of the wire segment numbering).
21. When using impressed radiation patterns as sources (AR cards), then FEKO internally stores the specified radiation pattern. When having a huge number of such patterns in one model, the memory requirement could have been quite large. Therefore added a new option so that at one AR card one can use the pattern already specified at the previous AR card, then still of course at another position and with another orientation and magnitude and phase (i.e. just the shape of the pattern is the same). For certain models this results in a drastic reduction of memory.
22. For S-parameter computations (SP card) new flags are available which allow a better control regarding the way how FEKO deals with the load impedances at the ports. So far these impedances were automatically added thereby replacing possibly existing loads there, and these impedances were then kept also after the SP card processing. This is still the default now, but the user has the option to add and not replace the loads, and also to restore the original loads after the SP card processing (rather than keeping the automatically added loads). Note that the latter option (i.e. removing loads) typically results in a changed matrix, and the solution process must be repeated again (run-time impact).
23. The FEKO kernel is writing results to a binary output file for further processing in POSTFEKO, the `*.bof` file. Additionally, an ASCII readable output file `*.out` is maintained. For big runs with for instance surface current output this can be quite large. Thus now at the DA card an option introduced to switch the output of near fields, far fields, and surface currents to the `*.out` file off. One can still optionally export these quantities to separate data files (existing DA card options), and they will always for postprocessing purposes be written to the `*.bof` file. Note that if optimisations with OPTFEKO or time domain analysis with TIMEFEKO are done, then these blocks must be in the `*.out` file as these two components parse the `*.out` file.
24. When solutions are created and read again (`*.str` file at the PS card), then we had so far an automatic mode which detects if this `*.str` file exists and then the solution is read from there, if not this file was created and could then be used for subsequent runs (e.g. then there near field computation just in another plane, without recomputing the whole solution). This automatic mode has now been improved to be more fault tolerant, so if for instance a `*.str` file exists but the frequency is different, FEKO does not give an error anymore, but automatically re-computes the solution for the correct frequency deleting the old non-matching solution file. This same improved automatic mechanism also applies to reading/storing PO shadowing coefficients from/to a `*.sha` file.
25. For edge sources and loads (AE and LE cards) it is now possible to have multiple labels on either side of the source / load.
26. So far the MoM in FEKO was limited to problem sizes of 46 340 unknowns (corresponds to 32 / 16 GByte memory for double / single precision) for sequential in-core solutions, or to



that many unknowns per parallel process for parallel solutions. Updated indices from 4 to 8 Byte, so that now also larger problems can be solved.

## Support components

1. In OPTFEKO when optimising with the aim function RESONANCE then so far the optimisation goal was to make the imaginary part of the input impedance zero. Now as an extension one can also select the imaginary part of the input admittance.

## Licensing and other general items

1. Multiple redundant floating licence servers are supported. When using floating licences and the floating licence server cannot be reached (e.g. hardware failure) then in the past FEKO could not be used, or running FEKO jobs terminated. Now there is the option to setup multiple redundant floating licence servers, for instance three servers on three machines. Then using FEKO floating licences is working as long as at least a quorum of two such servers are up and running.
2. When using floating FEKO licences, then a new logging option has been added so that the floating licence server logs licence check-outs and check-ins. This option can be activated with the new command line option "-l" for the SECFEKOD floating licence server, and the log file `secfekod.log` will then be written into the `license` sub-directory of the FEKO installation.

# Release Notes for FEKO Suite 5.1

December 2005

## (Changes since FEKO Suite 5.0)

FEKO Suite 5.1 is a minor release, which includes several improvements and extensions to the previous major release Suite 5.0 from July 2005.

New functionality has also been added, the most important features being the parallelisation of the MLFMM, waveguide mode excitations, and external CAD import filters in CADFEKO.

*Note that you will require a new licence file that supports Suite 5.1 in order to activate it. This licence file is also valid for all FEKO releases from Suite 3.1.2 onwards should you need to use an earlier version of FEKO.*

The most important new features are listed below. Many more smaller bug fixes and additions have been included in addition to the listed items.

### User interface

1. Many small improvements and fixes to POSTFEKO due to customer feedback.
2. POSTFEKO now allows 2D plots of continuous data as a function of position at a user-specified interpolation frequency.
3. External CAD file import in CADFEKO (IGES, SAT, STEP, Catia, ProEngineer etc.). Note that these CAD import modules are by default switched off in the licence, if desired they must be purchased separately.
4. In CADFEKO it is now possible to import meshes (NASTRAN, PATRAN, FEMAP, STL, Concept, ANSYS CDB and AutoCAD DXF) directly.
5. In CADFEKO media names are now stored in the tree. The medium name must be specified before it can be used for a region.
6. Meshes can now also be transformed in CADFEKO.
7. In CADFEKO a new primitive is available for the creation of cylindrical or conical helices and spirals.
8. CADFEKO supports to hide selected parts, and the geometry/mesh can be displayed in a wire-frame view to allow viewing hidden items.
9. In CADFEKO mid-level items (i.e. items that constitute a part) are now also shown when selected.
10. In CADFEKO the geometry and/or mesh can be coloured according to the dielectric medium.
11. Normal vectors on surfaces can be reversed in CADFEKO. This allows removing edges between faces with opposite normals.

### Geometry cards and preprocessing

1. When renaming labels at the CB card, then based on a mapping table now a whole set of labels can be renamed at once (this feature is for instance useful when doing a NASTRAN import from ANSA, which also exports such a mapping table).

2. Meshing using NURBS surfaces is now using much less memory than before.
3. When using nested include files with a relative path like in IN ". ./filename" then so far this path was relative to the directory of the main \*.pre file. Now the file is also searched for in the directory relative to the path of the file where the IN statement is used.
4. Improved NEC file import so that now also certain NEC extensions like comments starting with the ' character or TAB separations (in addition to commas or fixed positions) are supported.
5. For the NEC file import adjusted the treatment of imported labels, in particular when in NEC the GM card is used.

## Control cards and solution kernel

1. A parallel implementation of the MLFMM is available for shared and distributed memory environments.
2. For the MLFMM a new preconditioner type SPAI (*sparse approximate inverse*) is available. Advanced users can select this at the CG card, otherwise this is chosen automatically whenever applicable (e.g. for parallel FEKO versions).
3. Many general performance and stability improvements for the sequential MLFMM.
4. A new excitation option (AW card) has been added so that for rectangular or circular waveguides or also circular coaxial cables directly a certain mode (e.g.  $TE_{10}$ ) can be specified as excitation. S-parameter computations are then also supported. Presently this waveguide feed option is available only in connection for metallic bodies (no dielectric bodies, also no PO or UTD).
5. Rework of the radiation pattern import at the AR card so to that this is now much more memory efficient when the number of angles in Theta and Phi directions is very different (e.g. 2 versus 361).
6. Porting FEKO to the SGI Altix architecture with special optimisations to use the SGI MPT library in connection with the NUMAflex interconnect technology from SGI.
7. For parallel FEKO versions under HP-UX now also SSH is supported for remotely launching parallel jobs in a cluster. For IA64 upgrade of HP MPI so that also Infiniband can be used efficiently as interconnect.
8. Tuning of FEKO for parallel HP-UX based systems and adjustments of certain parameters to give significantly better performance for the parallel solution of a system of linear equations (both in-core and out-of-core).
9. Improved convergence checks for iterative solvers in connection with MoM / FEM / MLFMM (e.g. at the end of the iterations in addition to an estimate for the residuum the true residuum is computed and compared to the convergence threshold).
10. Re-implementation of the weighting scheme within the MoM / MLFMM for wire / surface junctions so that this results in higher accuracy in particular for low frequency problems or close to sensitive resonances.
11. Better performance through updated math libraries on 32- and 64-bit Intel systems (Windows and Linux).
12. For the FEM/MoM hybrid method, advanced users can now also set the order of the basis functions at the FP card.

13. Iterative solutions can be interrupted with Ctrl-C or Ctrl-Break and this will just stop the iterations, but FEKO will continue with the solution using the best solution thus far (in order to really interrupt a FEKO job Ctrl-C or Ctrl-Break can be pressed a second time then). Under UNIX the SIGINT/SIGTERM signal can be used for this purpose.
14. The export of \*.str files with the solution (PS card) is now using a binary compressed file format which is much smaller than the ASCII export used so far. This new scheme is backwards compatible, existing \*.str files generated with older FEKO releases can still be imported.
15. For out-of-core solutions also on all UNIX systems a check regarding the available free disk space is done before starting the calculations. So far this was available on Windows only.
16. AS type sources (spherical mode expansions) can now also be applied in connection with PO (UTD was already working before).

## Licensing and other general items

1. Improved security for floating licence treatment: Shutting down or resetting the floating licence server is now only possible for users having administrative privileges (Windows) or the root user (UNIX) or the user account under which the floating licence server is running. Checking in a floating licence which is in use is also only possible either for such users, or for the user who initially checked out this floating licence, but not for other users.
2. When using floating licences in connection with parallel FEKO jobs, then now the launching of parallel FEKO jobs is also possible by using multiple user accounts or multiple different launching hosts for multiple instances of the parallel FEKO solver, as long as the total number of parallel processes available in the licence has not been exceeded.
3. FEKO licences can either be node-locked, floating, or locked to a dongle as security device. Such a dongle option was supported in the past only for the 32-bit Windows version of FEKO. This has now been extended to cover all platforms supported by FEKO under Windows and Linux, 32-bit and also full 64-bit (i.e. then AMD64, EM64T and also Itanium IA64).

# Release Notes for FEKO Suite 5.0

July 2005

## (Changes since FEKO Suite 4.2)

FEKO Suite 5.0 is a major release introducing many improvements and extensions, amongst others a new component CADFEKO, and a new post processor POSTFEKO. CADFEKO is a graphical tool for the geometry creation and meshing with a direct interface to the FEKO solver.

In the solution kernel a new solver technology FEM (finite element method) is introduced within a MoM/FEM hybrid framework, complementing the already existing hybrid methods in FEKO, with the main objective being the modelling of dielectric or magnetic objects, which can also be heterogeneous (e.g. biological objects). Other major updates include a number of extensions to the MLFMM, e.g. one can use another type of integral equation for closed bodies which gives much better convergence or one can model dielectric bodies now also with MLFMM. A remote launching facility has been added to conveniently work on a PC but start large FEKO jobs directly from the FEKO GUI on other remote machine (either sequential, but also parallel cluster etc.).

Since Suite 4.3 was an interim release with the POSTFEKO prototype made available for selected platforms only, the present release notes indicate all changes made since the previous regular FEKO release in Suite 4.2 from June 2004.

*Note that you will require a new licence file that supports Suite 5.0 in order to activate it.* This licence file is also valid for all FEKO releases from Suite 3.1.2 onwards should you need to use an earlier version of FEKO.

The most important new features are listed below. Many more smaller bug fixes and additions have been included in addition to the listed items.

## User interface

1. Complete change of the graphical pre- and post processing environment. A new component CADFEKO has been added for the graphical creation and meshing of geometrical structures. Regarding the post processing, a new post processor POSTFEKO is available, which replaces the previous components WinFEKO and GraphFEKO (GraphFEKO is only included to allow the conversion of existing WFG files). See the documentation (Getting Started Manual and Users Manual) for more details on these new pre- and post processor components.
2. All the components of the FEKO user interface are now also available under Linux for IA32 systems (can also be run as 32-bit applications on EM64T/AMD64 platforms). Note that GLIBC 2.3 or later is required.
3. In order to support changes like arbitrary strings for label or media, or node names with up to 128 characters, an alternative card format is used in EDITFEKO for the PRE file. The various input fields are no longer aligned in fixed columns, but the colon is used as separation. The old syntax is of course still fully supported (backwards compatibility), and even the column fixed and colon separated syntax can be mixed within one PRE file.
4. EDITFEKO can now poll the FEKO web-site and inform the user if new updates are available. This is done either when requested by the user or once a week. No information is sent from the user's PC to the server.

5. When using floating licences, then the FEKO License Manager will contact the floating licence server and obtain the information regarding the current licence usage and availability from there. A checkbox "local mode" has been added, so that a local licence file `secfeko.dat` can be parsed and the licence content of this local file will then be displayed, without making a remote connection to the floating licence server.

## Geometry cards and preprocessing

1. New RM card introduced to allow an adaptive mesh refinement. The re-meshing can be done either globally, or also locally with respect to a point or line or a complete cable harness as imported from CableMod (gradual change in mesh size with increasing distance). This mesh refinement can be used for both meshes created directly inside of PREFEKO, but also for meshes imported from external sources (such as NASTRAN, PATRAN, FEMAP, etc.). The mesh refinement applies to triangular patches, wire elements, and cuboidal volume elements. A refinement of tetrahedral volume elements is not yet supported.
2. By means of the RM card, also the meshing of polygonal plates as used for the UTD is supported. This greatly simplifies the creation of FEKO models where UTD and MoM/MLFMM or PO shall be compared.
3. For the import of polygonal plates from FEMAP neutral files, the number of corners is no longer limited to 25 (now an arbitrary number of corners is supported).
4. Support added for processing tetrahedral volume elements as required for the FEM. Note the meshing capabilities of PREFEKO are limited in this regard just to meshing a cuboid into tetrahedral elements (QT card). For more complex geometries the new component CADFEKO should be used, or any of the supported external mesh imports (like FEMAP, NASTRAN, PATRAN, etc.).
5. Labels and media can now have arbitrary names consisting of characters, digits, and the underscore. Thus labels and media indices are no longer restricted to integer values, but names like *Car\_Body* or *LeftLung* can be used. The new scheme is backwards compatible, integer labels/media are still supported, and are also just treated as strings. Incrementing labels (e.g. at the TG card) is still supported, and also using label ranges (e.g. at the PO card). See the user manual for more details.
6. At the CB card to change labels, the label to be changed can now be a range using globbing (i.e. the \* and ? wild cards). So for instance all labels `Wall*` can be changed to another label by just using one single CB card.
7. At the IN card added support to import CFM files (CADFEKO mesh files).
8. At the IN card for the import of DXF files, now the extrusion (i.e. a local coordinate transformation which is specified for each element) is supported.
9. At the IN card updated the NEC import so that when the NEC tags (converted to FEKO labels) are too large, the import does not abort but continues (then using FEKO label zero).
10. Significant reduction in size of the FEK files due to using compression (typical FEK file size is now 15% of the previous size when not using compression). Compression is platform independent, the same FEK file can be processed on Windows/UNIX or little/big endian or 32-bit/64-bit machines.
11. The length of names of variables has been increased from 30 characters to 128.
12. The length of the name for node names (specified at the DP card or imported) is no longer limited to 5 characters, these can be 128 characters long.

13. When reading an external data file using the FILEREAD function, then in addition to spaces now also tabs are supported in this external data file to separate individual columns.
14. Error and warning messages originating from PREFEKO now also have unique error or warning numbers for easier identification.
15. The maximum number of different labels that are supported in one model increased from 32 768 to 2 147 483 647.
16. At the TG/TP cards the selection by label can also be switched off now (i.e. these cards can be applied to any geometry present in the model, irrespective of the label).
17. Support of a colon separated format of the PRE file so that the length of the input fields is no longer limited to 5 or 10 characters, respectively (EDITFEKO will write the cards automatically in the correct format).
18. The meshing algorithms for a sphere (KU card) were adjusted so that now better quality meshes are created also for a very large sphere.
19. For cuboidal volume elements (QU/DZ/DK cards), instead of specifying the material parameters at the card directly, changed to now also make use of the medium index (then consistent with the surface equivalence principle or the FEM). Thus before the cuboids are created/imported the medium index or name must be set with an ME card, and later the material properties for each material are then set using DI cards. This is then in the control section, i.e. one can now also for instance in a loop change the material parameters. Old existing PRE files can still be processed, in a backwards compatibility mode PREFEKO creates artificial media QU\_MED\_x on the fly.
20. New geometry card FP is available to set parameters for the FEM region. So far the only option available is to switch coupling between the MoM and FEM regions off.
21. Improved the meshing of NURBS elements so that an attachment to other curved edges (e.g. cylindrical section) is more robust with respect to small rounding errors.
22. Implementation of an export facility so that FEKO can write spherical mode expansion coefficients to a SWE file (spherical wave expansion) using the file format from TICRA for their GRASP product. The spherical mode expansion is requested at the FF card, and with the DA card the user can control the creation of such an SWE file (the file extension is \*.sph).

## Control cards and solution kernel

1. Stopped supporting the Compaq TRU64 platforms.
2. For the AMD Opteron 64-bit architecture extended the FEKO support from Linux to now also include the 64-bit editions of Microsoft Windows XP or Server 2003.
3. For AMD Opteron 64-bit under Linux, so far the parallel versions were just based on MPICH (Ethernet). Now also ScaMPI support added, which then allows to run the parallel FEKO solver over protocols like Myrinet, Infiniband, or also SCI.
4. Added support for the Intel XEON EM64T platform. Full 64-bit extended memory version, optimised for this machine using the Intel compilers and highly tuned Intel math libraries. FEKO is available under Linux and also under the Microsoft Windows XP or Server 2003 64-bit editions. The LINUX version now just requires GLIBC 2.3.2 (e.g. as used for instance in RedHat AS 3.0). The version made available as pre-release with Suite 4.3 still depended on GLIBC 2.3.4. The parallel FEKO version for EM64T is like AMD64 also available based on MPICH (Ethernet), but also ScaMPI for Myrinet, Infiniband etc.

5. For IA32 Linux parallel versions support for ParaStation MPI added.
6. For parallel IA32 Windows versions switched to a new MPI implementation which avoids performance problems FEKO has had in the past (FEKO could even just hang for certain large runs after having processed a number of frequencies).
7. Significant speedup in performance for IA32 platforms using Intel CPUs by using updated library files from Intel. For AMD Athlon CPUs now also for Windows and Linux providing specifically tuned FEKO kernel executables, where the speedup for the linear algebra part in FEKO (dense matrix solution) is up to 4 times faster.
8. Added the FEM (finite element method) as another solution technique in FEKO. Fully hybridised with the MoM, where like for the MoM/PO or MoM/UTD hybrid methods the coupling of the FEM region back onto the MoM region can be considered, or this can also be switched off to reduce run-time and memory when there is a certain separation between the two regions. Note that the FEM is not yet available in parallel. See the full users manual and the examples guide for more details.
9. Extension of the MLFMM so that now dielectric bodies can be treated (both the surface and volume equivalence principle). Having metallic structures (wires, surfaces) in the same model is also supported, and also a ground plane can be present (BO card). For the surface equivalence principle, multiple dielectric regions can be used, and they can also be lossy. However, if the losses are very large, then FEKO might not be able to solve this problem within the MLFMM framework and might terminate with a suitable error message.
10. The core of the MoM (also used for the near field matrix elements in connection with the MLFMM) updated so that the matrix elements and the right-hand side excitation vector are computed according to a new scheme. This new scheme results in a much higher accuracy, which turned out to be required in certain rather critical cases (say for very low frequencies or in connection with the new CFIE formulation). As an effect of the increased accuracy, the computation time for the matrix element setup is now longer (typically about 30%), but this can be compensated for by using a slightly coarser mesh and still obtaining the same level of accuracy as with previous versions of FEKO (or even a higher accuracy).
11. Significant speedup of the far field computations in connection with the MLFMM, also now there FEKO uses the hierarchical MLFMM grouping.
12. When using the MLFMM and during the iterative solution no convergence is obtained, there might be special situations where one would like to see the results using the non-converged solution, but without waiting for the iterations to reach the maximum number of iterations. For a number of platforms there is now the facility that pressing Ctrl-C or Ctrl-Break (or for non-interactive batch jobs sending the SIGINT or SIGBREAK or SIGTERM signals) during the iteration, FEKO will not stop immediately, but will continue the current iteration step and then proceed with the solution. A note will be printed in this case, and to really terminate FEKO one must send the termination signal a second time (then FEKO will terminate instantly).
13. At the AC card when importing sources from CableMod (a cable harness) or from PCBMod (signal traces on a PCB), then now an arbitrary rotation and translation is supported.
14. For the AR card when importing a measured or computed radiation pattern as source in FEKO, the bilinear interpolation on the complex field strength values was replaced by a more suitable scheme resulting in a much higher accuracy, in particular when the sampling density versus angle is low.
15. A new CF card has been added, where on a per label basis for the MoM or the MLFMM the type of integral equation EFIE (electric field integral equation) versus MFIE (magnetic



...) versus CFIE (combined ...) can be set. By default the EFIE is used in FEKO since this is the most general formulation (applicable to closed and open bodies). But to improve convergence in particular in connection with the MLFMM, for closed bodies when using the CF card, one can switch to the CFIE, which is better conditioned and results in faster convergence. Note that the CFIE region must be closed and the normal vector must point outwards. One can mix different integral equations also within one model (say apply the CFIE for a closed PEC body, and mix with the EFIE for wires or open surfaces).

16. Extension of the SA card to allow the computation of spatial peak average SAR values at a user specified point, or also in connection with the planar multilayer or the spherical Green's function.
17. The spatial peak SAR search can be quite time consuming, and thus this phase of the SAR computation has been implemented in parallel for parallel versions of FEKO.
18. For the MLFMM at the ILU preconditioner also a level-of-fill of zero can be used. Block Jacobi preconditioning is also supported (useful in connection with the CFIE for instance, or the volume equivalence principle for dielectric bodies). The automatic selection of the preconditioner (if no CG card is used as recommended) is now taking this also into account.
19. For the MoM/PO hybrid method the PO shadowing coefficients can now be exported to or imported from a \*.sha file. This can be used to significantly speedup ray-tracing when the same geometry is used repetitively.
20. For very large models (say PO or MLFMM with one million triangular patches or more) the phases of the geometry preprocessing and the geometry checks could have taken rather long. Implemented a completely new algorithm here which reduces the scaling drastically (for one example the run-time is down from 2 hours to 40 seconds). A similar faster algorithm is used for the MLFMM not only during the geometry setup and checking, but also within the MLFMM formulation itself during the grouping and boxing phase.
21. When using geometric symmetry then the MoM matrix elements must be symmetric, i.e. also loads must be applied symmetrically. This was documented so far in the users manual and FEKO was also giving a warning if unsymmetric labels were found due to using geometric symmetry and having any type of loads or losses (Skin effect etc.). Depending on the specific model setup, when getting this warning, the solution would then have been wrong (unsymmetric matrix) or still correct. Sometimes users were ignoring this warning or not aware of the consequences. Thus now FEKO has a rigorous check for such a case. Either a fatal error is given in cases where geometric symmetry cannot be used, or the FEKO computation continues (and then results will be correct).
22. When using the planar multilayer Green's function to model earth (i.e. just two layers and no ground planes), then the near field calculation at a distance of larger than 10 wavelengths could have shown rather significant errors. The formulation has been improved so that now also terms of the surface waves are taken into account in this case.
23. Extension of the SK card so that users can specify an arbitrary complex surface impedance. This impedance boundary condition is then applied within the MoM or MLFMM frameworks. Note, however, that there are certain limits on the impedance range for such an impedance boundary condition to work. If in doubt, it is suggested to do a validation (e.g. compare the impedance boundary condition for the specific values and frequency etc. to a rigorous model using the MoM or FEM in FEKO).
24. CO card extension so that thin dielectric coatings of metallic surfaces can also be used in connection with MoM or MLFMM (so far this was supported only in connection with the PO). Note that the coating must be electrically thin, otherwise approximations used are not applicable.

25. Smaller updates to the SAR extraction routines (SA card) to make this more stable under extreme conditions (e.g. very low mass density). It is now also possible to extract spatial average SAR values (averaged over 1 or 10 g tissue) at a user specified location.

## Support components

1. The launcher RUNFEKO now supports also launching sequential or parallel FEKO jobs on remote hosts, including the automatic transfer of all the required files. This is also working cross-platform, e.g. from a Windows PC using a GUI-only licence of FEKO a remote job can be started on a UNIX workstation. This remote launching applies not only to the FEKO kernel as such, but also OPTFEKO or TIMEFEKO runs can be launched remotely. For parallel runs the nodes where to actually run can be different to the remote host. So for instance from a Windows PC one can remotely launch a parallel run on a cluster control node, which in turn will start the parallel run on the cluster nodes. This feature is also fully supported from within the FEKO GUI. See the FEKO documentation for how to setup and use this remote launching facility.
2. Launching parallel jobs from within OPTFEKO and TIMEFEKO has changed, the command line options `-np x` and `--machines-file m` are no longer supported as options for OPTFEKO and TIMEFEKO as such. Rather now an option `--runfeko-options` has been introduced after which any options can be passed to RUNFEKO (including the options `-np x` and `--machines-file m` for parallel runs, but also the option `--remote` for instance for remote runs on another machine).
3. Improved the accuracy of TIMEFEKO for very low frequency components (basically the DC offset of the response).
4. In ADAPTFEKO improved the stability and accuracy for continuous frequency runs with a very large bandwidth (one could have had convergence to a wrong solution in the past).
5. Sentinel dongles can now also be used for 32-bit FEKO versions running within a 64-bit edition of Microsoft Windows on EM64T or AMD64 platforms.

# Release Notes for FEKO Suite 4.3

October 2004

## (Changes since FEKO Suite 4.2)

FEKO Suite 4.3 is an interim release only with the main purpose of making a prototype version of the anticipated new postprocessing technology POSTFEKO available, and to port FEKO to the new Intel XEON EM64T technology (64-bit extension).

For further details on POSTFEKO, the user is referred to the *POSTFEKO Transition Guide* which in Section 2 gives an overview on the new features of POSTFEKO as compared to the existing WinFEKO / GraphFEKO postprocessing options. As emphasised in Section 1 of this Guide, this version of POSTFEKO is only made available now as a prototype in an early stage of the development, to encourage user feedback on this new user interface.

This Suite 4.3 release is also not made available for all the platforms which are supported by FEKO. Except for the new EM64T platform, the distribution is in principle limited to those platforms where POSTFEKO is available: Microsoft Windows and Linux on 32-bit Intel or compatible PCs. For other platforms, the file formats of Suite 4.2 are fully compatible to the Suite 4.3 release, and thus also POSTFEKO can be used in connection with result files that were obtained for instance on a HP-UX workstation.

Due to the limited availability of the Suite 4.3 executables to specific platforms only, detailed release notes with a list of all changes for all platforms will be made available with the next full release for all platforms.

Only one new major feature shall be highlighted here, this is an automatic adaptive re-meshing and mesh refinement option. Both local and global mesh refinement is supported. A new RM card has been added, see the User Manual for more details and usage examples.

*Note that you will require a new licence file that supports Suite 4.3 in order to activate it. This licence file is also valid for all FEKO releases from Suite 3.1.2 onwards should you need to use an earlier version of FEKO.*

# Release Notes for FEKO Suite 4.2

June 2004

## (Changes since FEKO Suite 4.1)

FEKO Suite 4.2 is an update release that contains many improvements and extensions and introduces amongst others the new MLFMM solver technology as well as the concept of floating licences.

*Note that you will require a new licence file that supports Suite 4.2 in order to activate it.* This licence file is also valid for all FEKO releases from Suite 3.1.2 onwards should you need to use an earlier version of FEKO.

The most important new features are listed below. Many more smaller bug fixes and additions have been included in addition to the listed items.

### Geometry cards and preprocessing

1. At the IN card a new import filter for ANSYS \*.cdb files has been added. Such meshed geometry files can be exported from ANSYS Classic, AI Environment, and Workbench.
2. Smaller adjustments to the FEMAP import filter to fully support the FEMAP version 8.3 file format.
3. For the node names as defined at DP cards, a strict usage of only the characters 'a'-'z', 'A'-'Z', '0'-'9' and the underscore '\_' is enforced.
4. Significant speedup of PREFEKO for the creation of large \*.fek files.
5. Update of the PH card to be able to also mesh plates with holes where the internal angle of the hole is larger than 180°.
6. When using the KK card to create a circular or elliptical cone, then now the bottom and top angles can be specified separately, and also the specification of start angles is possible.

### Control cards and solution kernel

1. Availability of the multilevel fast multipole method (MLFMM) for the analysis of metallic structures in FEKO with a rigorous implementation (accuracy in the same order as the traditional method of moments), but with a large reduction of memory requirement and run-time. This new solution option can be activated with the FM card (see also the provided example file `example_41`). The old multipole methods FMM and FSSMM have been removed, any input file using these will now default to the new much more sophisticated technique.

The new MLFMM allows metallic surfaces and wires as well as connections between these. A real ground (BO card) is also supported. Critical solution options (such as for the preconditioning and the iterative solution phases) are chosen automatically. At this stage the MLFMM is available only for sequential FEKO executions, not in parallel.

2. Support of the new 64-bit platforms Intel Itanium-2 for Windows and Linux (HP-UX was already supported in FEKO Suite 4.1) and 64-bit AMD Opteron under Linux. Parallel 64-bit versions of FEKO are also available for Linux on Itanium / Opteron (not 64-bit Windows).

3. New excitation option (AS card) to use impressed spherical modes, both inward or outward propagating. The superposition of modes with complex coefficients allows the synthesis of an arbitrary radiating field (often such spherical coefficients are readily available from measurements, for instance from spherical near field measurements).
4. When computing the far field, with a new option at the FF card a decomposition of the far field into spherical modes can be activated and the mode coefficients will be determined.
5. Automatic specific absorption rate (SAR) extraction for the MoM surface equivalence formulation, where whole body average SAR or SAR over 1 g or 10 g cubical tissue can be computed (new SA card).
6. The special execution mode LFFEKO (low frequency FEKO) has been removed since this was too limited regarding possible applications, and also the usage was not very intuitive. A direct replacement is not available yet, but FEKO is in general quite stable also for low frequency computations down to the kHz range. FEKO also monitors the condition number and will print a warning if stability problems are encountered due to a low frequency.
7. The usage of #maxalloc or #maxallocm is no longer recommended. Under Windows and Linux the FEKO kernel is now able to automatically detect the installed memory and will switch to an out-of-core solution before the operating systems starts to swap. On other platforms (e.g. SGI or SUN or HP-UX workstations), this is accomplished by setting the memory at install or update time (follow the installation instructions).
8. Under Microsoft Windows FEKO is now using its own heap management routines, which are optimised for the FEKO usage and can largely cope with memory fragmentation issues, such that on a given computer typically now larger problems can be solved in-core, before having to switch to an out-of-core algorithm.
9. For accuracy reasons, the FEKO kernel performs arithmetic using double precision. At the EG card a new flag has been added which allows to switch to single precision storage for arrays to reduce the memory requirement. Currently this switch applies only to the MLFMM. For the MoM, PO, and other solution techniques it has no effect in this FEKO version.
10. Due to specific optimisations, a significant speedup (up to 35%) has been obtained on Intel Pentium and XEON CPUs running under Windows or Linux for the phase of the LU-decomposition of the MoM matrix.
11. Several improvements to the UTD routines in FEKO, for instance regarding to being more tolerant with respect to geometrical errors when importing CAD files.
12. S-parameter computations were limited to 25 ports so far. This limitation has been removed, there can be an arbitrary number of ports now.
13. Proper support of arbitrary AE type sources (edge currents) in connection with S-parameter computations.
14. Setting the execution priority is now also supported for SUN Solaris workstations.
15. Several improvements for the planar multilayer Green's function, like optimisations in the interpolation scheme with respect to accuracy and run-time.
16. For the coupling of FEKO with CableMod or PCBMod from Simlab, now by default a NASTRAN file of the FEKO geometry is also exported, which is referenced in the created \*.isd file and thus readily available to CableMod or PCBMod, respectively.
17. Update of the STL export option in the FEKO kernel to properly adhere to the STL standard.
18. NASTRAN export is now using a wide column format for improved accuracy (more digits).
19. Accuracy improvements for the Touchstone \*.snp export by using more digits.

20. When impedances are computed, then now not only the imaginary part is printed, but also the inductance / capacitance are readily available in the \*.out file.
21. For 32-bit Linux platforms using a parallel FEKO version support of the Myrinet and Infini-band interconnect technologies in addition to SCI through ScaMPI (FastEthernet and Gigabit Ethernet are supported by the standard parallel version of FEKO).
22. For out-of-core solutions on Windows now monitoring the available hard disk space to avoid error conditions due to attempting to write to a full hard disk only many hours after having started a run.
23. Performance and stability improvements for large parallel runs on 64-bit systems using more than 2 GByte main memory per process.
24. When doing large MoM runs using the same model but different excitations, then it is now possible to export the LU-decomposition of the MoM matrix to a \*.lud file and store this. For a subsequent run using the same geometry and at the same frequency, but with a different excitation (e.g. different spherical mode representation of an antenna or a different incidence angle of a plane wave), this file can then again be imported and results in a very fast solution (PS card option).

## Support components

1. For OPTFEKO, when multiple blocks were involved (e.g. the impedance at multiple frequencies or a far field pattern optimisation for multiple cut planes), then so far the average of the aim function for each block has been used during the optimisation process (which is the minimisation of the aim function). Now in addition to this averaging also the MINIMAX principle is supported, which means that only the maximum of all the aim functions for each block is considered, and this is then minimised.
2. In OPTFEKO more than one aim function can now be specified, and the different aim functions can be combined with arbitrary weighting factors.
3. The OPTFEKO aim functions RADIATION\_PATTERN and GAIN have been extended so that one can now also optimise for the LHC / RHC / S / Z polarisation field components or gain / directivity.
4. For the continuous frequency interpolation algorithm with adaptive sampling as implemented in ADAPTFEKO, now switching to a new internal representation which typically requires fewer discrete sampling points than the previous method and exhibits improved stability.

## User interface

1. Support of floating licences (not only for the user interface, but for all components of the FEKO Suite, including the kernel, also on parallel systems).
2. A new utility SECFEKO\_GUI has been added which allows to manage both node-locked and floating licences. Possible tasks include the interaction with the floating licence server, but also just displaying the licence usage with information regarding expiration date etc. For platforms where the GUI is not available (such a HP-UX, SUN or SGI), these tasks can be accomplished by a command line utility SECFEKO.

3. Improved editing capabilities in EDITFEKO for \*.opt files of OPTFEKO with a completely re-designed panel. All extensions are now supported (such as multiple aim functions), but also more intuitive to use.
4. Editing support for include files with a \*.inc file extension in EDITFEKO.
5. In EDITFEKO in addition to supporting all kernel extensions (like the new SA or FM cards and added or changed options at the other cards), many smaller extensions like the ability to move the splitter bar between card panel and editor, or easier configuration of parallel process startup options.
6. GraphFEKO now allows adding phase on a Smith chart to model the rotation due to transferring the reference.
7. Fixed a bug which allowed GraphFEKO to close without warning if graphs were unsaved.
8. Updated GraphFEKO to read \*.out files also for special combinations of cards where it failed in the past.
9. WinFEKO now use less memory for large models.
10. Improved SAR display in WinFEKO. (New SA card not yet supported.)

# Release Notes for FEKO Suite 4.1

July 2003

## (Changes since FEKO Suite 4.0)

FEKO Suite 4.1 is an update release that contains many improvements and extensions and introduces the new multi-platform EDITFEKO.

*Note that you will require a new licence file that supports Suite 4.1 in order to activate it. This licence file is also valid for all FEKO releases from Suite 3.1.2 onwards should you need to use an earlier version of FEKO.*

The most important new features are listed below. Many more smaller bug fixes and additions have been included in addition to the listed items.

### Geometry cards and preprocessing

1. PREFEKO can now also import vertex points (the vertices of polylines as well as the start and end points of wires) from AutoCAD \*.dxf files. In addition, it can now import and mesh (into triangle elements) unmeshed closed polyline surfaces. This allows importing geometry from a CAD package, such as AutoCAD, which does not include its own mesher.
2. PREFEKO now also supports labels when importing points from a FEMAP neutral file. This also allows label-selective points import.
3. The NASTRAN import filter now also supports comma separated files.
4. PREFEKO supports a new command line option `--ignore-errors` which makes errors non-fatal, i.e. PREFEKO continues even though it encountered errors. While this can result in more errors as a consequence of the first one, it may sometimes be useful to see all geometry modelling errors at once rather than one by one.
5. The ZY card now allows oblique cylinders.
6. Fixed a number of bugs which involved nested FOR loops containing IF statements and/or IN cards importing \*.pre files.
7. PREFEKO supports defining variables from the command line, for example

```
prefeko filename #variable=value
```

which is an attractive feature to run models from scripts or batch files and change certain parameters (note that on UNIX the hash sign needs to be escaped by a backslash).

8. A new PREFEKO command `!!print_to_out` (similar to `!!print`) will print information to the \*.out file. This allows the writing of comments or additional information (such as command line specified variables) to the \*.out file.
9. The first line in the \*.pre file may no longer be the filename. It may be a comment or any other command.
10. The built in functions in PREFEKO now includes the Bessel and modified Bessel functions of integer order  $J_n(x)$ ,  $Y_n(x)$ ,  $I_n(x)$  and  $K_n(x)$ . (They are called BESJ, BESY, BESI and BESK respectively.)



- When using variables like #a we now also support arrays like #a[0] or #a[3\*#i+5]. The index of an array must be an integer value, which can also be negative. The arrays need not be allocated, but each entry must be defined before it may be used.

## Control cards and solution kernel

- Due to numerous optimisations and fine tuning of code, there has been a significant speedup of the FEKO kernel on 32-bit Intel Pentium 4 and XEON CPUs running under Linux. The table below lists representative CPU-times for a 2.4 GHz Pentium 4 machine:

Filename	FEKO Suite 4.0 (kernel 45.155)	FEKO Suite 4.1 (kernel 46.238)	Speedup
example_08	31.618 sec	12.716 sec	2.49 times
example_12	14.497 sec	7.534 sec	1.92 times
example_14	13.886 sec	9.241 sec	1.50 times
example_18	130.359 sec	63.053 sec	2.07 times
example_21	103.269 sec	48.368 sec	2.14 times
example_29	42.142 sec	22.282 sec	1.89 times
example_30a	60.046 sec	26.650 sec	2.25 times
example_34	95.845 sec	44.294 sec	2.16 times
example_35a	51.754 sec	24.179 sec	2.14 times
example_35c	130.912 sec	63.487 sec	2.06 times
example_37	27.739 sec	12.360 sec	2.24 times
example_38a	184.836 sec	80.809 sec	2.29 times
example_38b	34.855 sec	15.773 sec	2.21 times

- Both sequential and parallel FEKO versions are now available for the 64-bit Intel Itanium architecture. Supported operating systems are HP-UX and Linux. A Windows port is in progress and can be expected for the next release.
- For SUN Solaris running on UltraSparc III CPUs a 64-bit version is now available (sequential and parallel).
- FEKO has also been ported successfully to the CRAY SV1 architecture.
- Sequential FEKO versions for Windows or Linux PCs (Intel or compatible) can use multiple CPUs on one board (if available) for the phase of the LU-decomposition of the matrix only (i.e. still different to a parallel version where all phases are in parallel, and where also distributed systems are supported). Should this be desired, the environment variable OMP\_NUM\_THREADS must be set to the number of CPUs. On the other hand, if this variable is set for another application, but FEKO must run as a single threaded application only, then set the environment variable MKL\_SERIALYES.
- The C shell is now supported under UNIX for the installation and the other scripts (a new initialisation file initfeko.csh is created which needs to be executed at login).
- Parallel versions on UNIX cluster now also support the secure ssh communication as an alternative to rsh for the parallel installation (remote copying etc.) and for launching parallel processes remotely.
- Both parallel and sequential versions of FEKO now support a new command line option --priority x to allow running it with a lower priority in order to do other jobs in the foreground. The priority can also be increased, but this requires administrative or root privileges.

9. The PO can now be applied to thin dielectric sheets as well as coated conductors.
10. The sequential MoM formulation now supports larger than 40 GByte out-of-core solutions on all platforms (on certain platforms one got errors when trying to access certain sectors).
11. Improved checks of the geometry, thus more errors in the input file (like overlapping elements) can be detected.
12. Numerous improvements to the UTD ray-tracing routines for double diffraction.
13. When using the exact Skin effect formulation for wires then the evaluation of Bessel functions became instable when the wire radius is very thick as compared to the penetration depth. In such cases FEKO now switches to an asymptotic expression.
14. In connection with the Green's function for planar multilayered media, now improved accuracy for far field computations very close to the critical angle, and also more accurate solutions for very thick layers (several thousands of wavelengths thick, i.e. for optical studies).
15. Though not recommended (for efficiency and speed reasons), FEKO solutions including out-of-core solutions are now working on mapped network drives under Windows. This did work in most cases already before, but certain system configurations resulted in errors (often not reproducible).
16. For parallel versions improvements regarding both stability and speed in the underlying communication protocol by using the latest MPI libraries for the various platforms.
17. More robust error treatment for parallel versions due to a FEKO native parallel error handler.
18. L4 card now allows a switch to remove all L4 loads.

## Support components

1. OPTFEKO now supports an option `--resume` to resume an optimisation process that has been stopped, provided that the `*.sta` and `*.bat` files are still available. (For example, if the previous optimisation has been stopped by pressing `<Ctrl><C>` or due to a power failure.) For Windows/DOS this option must follow right after the filename.
2. The `NEARFIELD_VALUES` aim function in OPTFEKO has been extended such that one can also optimise the fields directly (i.e. switch the normalisation off). The number of near field points has also been increased from 1000 to 2000.
3. The aim function `RADIATION_PATTERN` has been extended such that one can also optimise for gain/directivity in dB, and such that in addition to minimising the deviation from a specific aim pattern, one can now also specify a band with min/max values.
4. A new aim function `RESONANCE` allows optimising an antenna / circuit / resonator to resonance (i.e. imaginary part of the input impedance should be zero).
5. Both OPTFEKO and TIMEFEKO now support of the option `-np x` to use the parallel version of FEKO during optimisation or time domain analysis.
6. The adaptive frequency interpolation technique now gives a percent progress indication at the end of each completed subinterval. Certain parameters for this technique have also been adjusted to reduce the number of required frequency sample points for very wide band results.

## User interface

1. New multi-platform version of EDITFEKO available.
2. EDITFEKO can now also launch OPTFEKO and TIMEFEKO with a simplified dialog to control the command line options for all the other components.
3. WinFEKO now uses scrollable panels such that one can use a smaller window or lower resolution.
4. The UTD ray data has been divided into separate categories for near and far fields allowing separate selection in WinFEKO.
5. Numerous small bugs in the parsing of the output file have been fixed, for example very small values (written as, for example, 1.23456-789) are now parsed correctly. It is also now quicker for large files.
6. WinFEKO and GraphFEKO now also extract the mass density of the media from the \*.out file when calculating SAR.
7. The colour selection for labels has been improved such that a much larger number of labels will have unique colours. In particular the mapping of colours to labels can now be assigned arbitrarily by the user (in the legend just double click on a colour box and a window will appear where the colour can be re-assigned).
8. Animation in WinFEKO has been improved to be less sensitive to other windows covering the render area during the preparation of the animation.
9. Many fixes regarding printing, animation and cut-planes in WinFEKO.
10. GraphFEKO now supports two new arithmetic functions (a) to take the inverse or the of the values of the specified series and (b) to take 10 to the power of the series value. In addition it can create a zero series (from which one can determine an arbitrary constant value by specifying an offset) and a linear series (where the left axis is set equal to the bottom axis — this can be scaled to any slope).
11. When using adaptive frequency interpolation and specifying a minimum frequency stepping, one might end up with a solution that has not converged in a certain frequency interval. This is now indicated in GraphFEKO.
12. FEMAP no longer requires a default file which needs to be updated with each new version of FEMAP.

# Release Notes for FEKO Suite 4.0

December 2002

## (Changes since FEKO Suite 3.2)

FEKO Suite 4.0 is an update release that contains many improvements and extensions and a beta version of the new multi-platform EDITFEKO on UNIX platforms. This version also supports FEKO LITE instead of the old demo version. (Limits are slightly higher for FEKO LITE than what they were for the demo mode.)

*Note that you will require a new licence file that supports Suite 4.0 in order to activate it. This licence file is also valid for FEKO Suite 3.1.2 and later in case you need to use an earlier version of FEKO.*

The most important new features are listed below. Many small bug fixes and additions as well as performance improvements have been included in addition to the listed items.

### Geometry cards and preprocessing

1. The NASTRAN import filter (see the IN card) has been extended to allow importing 16 character wide grid points. In addition variables are supported for the label selecting fields at the IN card.
2. The PM card has been extended to allow specifying up to 26 internal mesh points to allow connecting with other structures.
3. Fixed bugs with respect to the number of nodes in processing PM and PY cards.
4. The PH card now supports angles larger than 90° around the hole.
5. Fixed bugs leading to a floating point exception or an infinite loop in treatment of polygonal plates.

### Control cards and solution kernel

1. The planar Green's function now also supports the AR card. In addition, it uses an asymptotic technique to calculate the near fields at large distances.
2. It is now also possible to export the four potentials  $\vec{A}$ ,  $\vec{F}$ ,  $\nabla\varphi$  and  $\nabla\psi$  directly.
3. The AP card now supports apertures calculated using negative angles.
4. The PO ray tracing is much more efficient and various small bugs have been fixed. Multiple reflections are now fully supported. (Visibility between certain regions can be specified with the VS card.) Electrically thick dielectric/magnetic coatings of conducting surfaces are also allowed.
5. Non-radiating transmission lines now support losses.
6. For Windows the FEKO kernel has been compiled to make use of the Pentium IV instruction set if this is available. This will yield speed improvements of up to 50% on these machines.
7. The FEKO-CableMod interface now supports adaptive frequency sampling.
8. The FMM (fast multipole method) has been significantly improved, there is now a MLFMM variant (multilevel).

## Support components

1. Improved error checking for all components.
2. In addition to the penalty function which limits the range of the optimisation variables, OPTFEKO can now enforce that the parameters never move outside the specified limits.
3. When optimising an average reflection coefficient, it is possible to specify a minimum reflection coefficient such that OPTFEKO will not continuously improve certain reflection coefficients further and further while others are still much larger than the desired value.

## User interface

1. WinFEKO and GraphFEKO now process UNIX \*.out files without converting them first which allows processing data from large out files that previously was not possible.
2. Paths containing spaces should now be fully supported.
3. WinFEKO and GraphFEKO now correctly extract the conductivity from the \*.out file when calculating SAR.
4. New line arithmetics tools in GraphFEKO support converting between real and imaginary parts and magnitude and phase.
5. WinFEKO allows a simple way to configure and start the parallel version of FEKO on Windows.