Application Sheet

FEKO

Comprehensive Electromagnetic Solutions

Radiation Hazard / Human Exposure Modelling

Introduction

Protection against the dangers of excessively high levels of radiation is an important part of any system design process that involves radio frequency (RF) transmitters. The dangers of overexposure for humans are foremost in the mind of the general public, but engineers also deal with dangers relating to the accidental ignition of highly combustible liquids (for example fuels) or ordnance in military environments. Various standards or guidelines are enforced around the world to ensure safe levels of radiation in any particular environment. Examples of these include:

- ICNIRP, which is widely applied to communication networks and devices.
- IEEE 1528, which details the qualification of radiation sources against the levels of radiation that is absorbed by a human head.

These standards typically use one of two criteria in the evaluation of radiation levels:

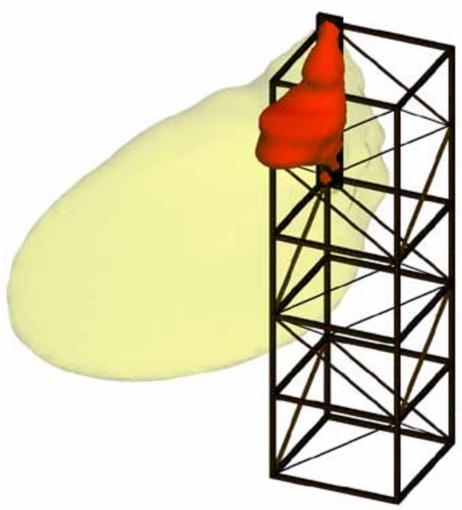
- Magnitude of field levels around the source of radiation or at the observation point. These values can be noted as spot values or plotted as iso-surfaces depicting surfaces where a specified maximum field level can be measured.
- Energy absorbed by a human body near the source of radiation. The specific absorption rate (SAR) is reported in Watt per kilogram of body mass, either as a spatial peak value (averaged over either a 1 g or a 10 g tissue cube) or as a whole-body average.

FEKO's hybridisation of various simulation methods makes it an ideal tool to use while investigating radiation hazards or the risks of human exposure to radiation, since:

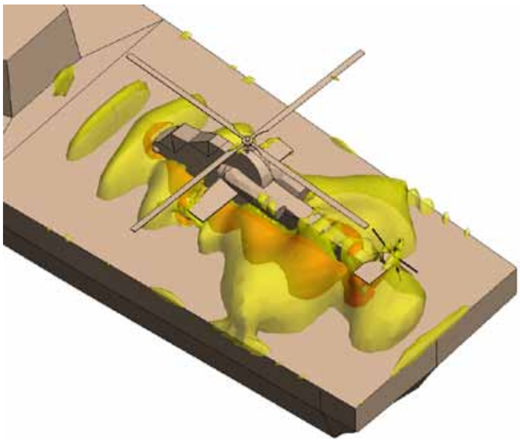
- The multilevel fast multipole method (MLFMM) is well suited to the computation of near field blocks around electrically large structures. For example, a global system for mobiles (GSM) transmitter which can be visualised with iso-surfaces to depict hazard zone boundaries.
- The method of moments (MoM) and MLFMM hybridisation with the finite element method (FEM) is ideally suited to the computation of SAR levels in humans near sources of radiation.

Reference Levels Case

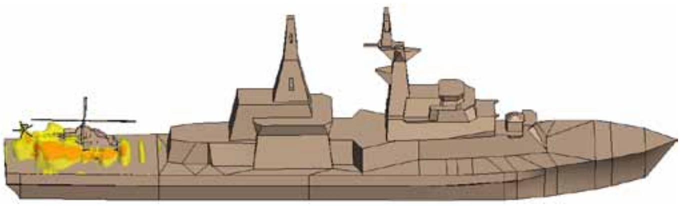
Field level based guidelines are often referred to as reference levels. Iso-surfaces are a very common way to depict boundaries of exclusion. Within this boundary the applicable reference level is exceeded. Examples on this page show ICNIRP exclusion zones around a mobile phone base station antenna and HERO zones (exclusion zones for ordnance safety) on a military ship. The ICNIRP case demonstrates the occupational exclusion zone (red) which is the boundary that RF trained personnel should not enter, while the yellow zone depicts the public exclusion zone that the general public should not have access to. In the same manner, the HERO zones depicted on the ship indicate the most



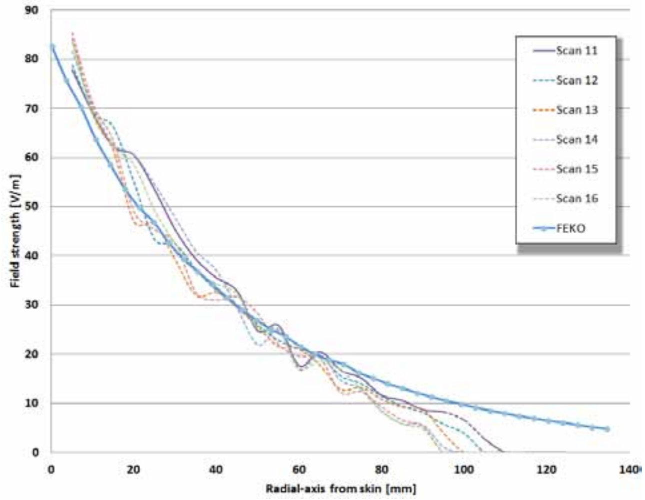
ICNIRP public (yellow) and occupational (red) exclusion zones around a GSM base station antenna



HERO limits for helicopter with active communication antenna on a ship's deck, shown from above



HERO limits for helicopter with active communication antenna on a ship's deck, shown from the side stringent ordnance safety standard (red) and the less stringent standard (yellow).



Field strength verification in partnership with industry

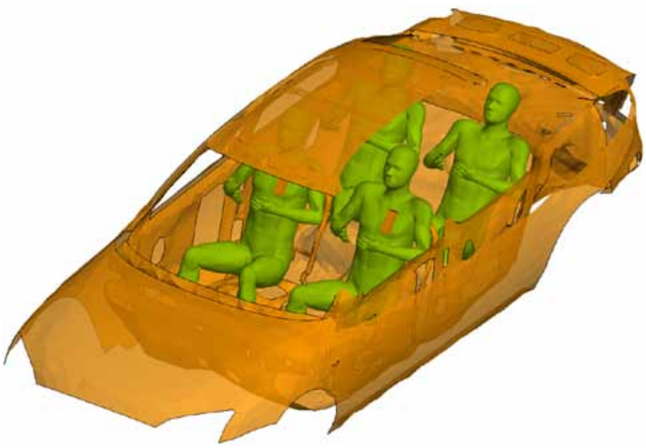
Absolute Restrictions Case

SAR levels are the most important consideration when evaluating human radiation hazard based on the ICNIRP guidelines. FEKO was benchmarked for use in such scenarios in conjunction with an industry partner in the United Kingdom. The graph depicts a FEKO simulation compared to the measurement of field strength inside an instrumented phantom, filled with liquid that accurately represents human tissue at the relevant frequency. The excellent comparison between measurements and FEKO simulation provided confidence that FEKO's FEM is excellently suited to the simulation of in situ human problems and therefore the computation of SAR. FEKO's algorithms follow both CENELEC and IEEE standards, rigorously conforming to industry best practices for SAR computation in an effort to provide even more confidence in simulation outputs.

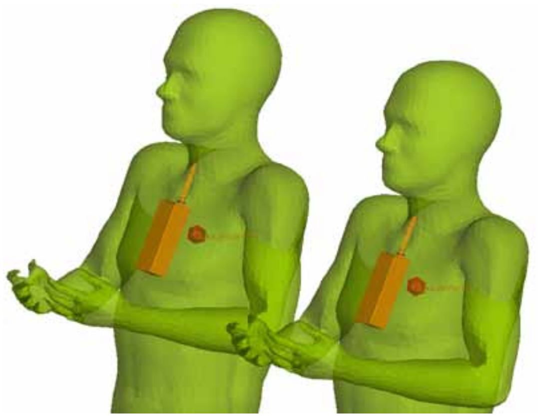
FEKO was subsequently used to compute both whole-body average and peak local exposure SAR values for a wide range of scenarios. The scenario shown here required the simulation of four phantoms, wearing personal radios, while seated in a vehicle. The large metallic body of the vehicle along with the dielectric body phantoms is a challenging simulation problem, but one that is easily solved with the MLFMM-FEM hybrid formulation in FEKO. The MLFMM solves large metallic objects while the FEM solves for fields inside complex dielectric bodies, for example the phantoms in this case study.

The same MLFMM-FEM technology may be applied where standards are used that estimate field levels inside of humans, for example ARPANSA. Electric and magnetic fields may be computed easily with FEKO for a range of frequencies and then appropriately scaled and summed for a final answer, as described by the applicable standard.

Phantom with radio close to body



SAR computation for phantoms wearing personal radios in a vehicle



Local peak SAR directly behind radio

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