Real Ground Option Used in Boat-at-Sea Scenario

A real-life operating environment of various antennas can include presence of infinite soil or water below the antenna. In some cases, the soil or water do not influence significantly the performance of the antenna and can be excluded from the simulation i.e. the antenna can be simulated as it is in the free space. On the other hand, in some cases the infinite surface below the antenna has to be included into the simulation.

This application note addresses a case where the influence of the ground cannot be neglected. The application of WIPL-D *Real Ground* option to perform the calculations and examine the modification of radiation pattern in the presence of the real ground is described. It will be shown that **WIPL-D Software**, **a full wave 3D electromagnetic Method-of-Moments based software,** can be effectively used for such simulations.

For the purpose of a demonstration we will consider a boat with a radiating monopole immersed in the see water. The results of interest are S-parameter and radiation pattern. We will also illustrate how *Unused Entities* option can be effectively applied to exclude insignificant details from the simulations. Finally, a comment regarding the application of PEC and WIPL-D option *Real Ground* used for taking into account influence of the see water surface will be presented. Special attention will be given to the changes observed in radiation pattern.

WIPL-D Models

A CAD file of the boat was imported to WIPL-D Pro CAD software. A radiating monopole on the roof of the boat's cabin has been modeled as presented in Figure 1.

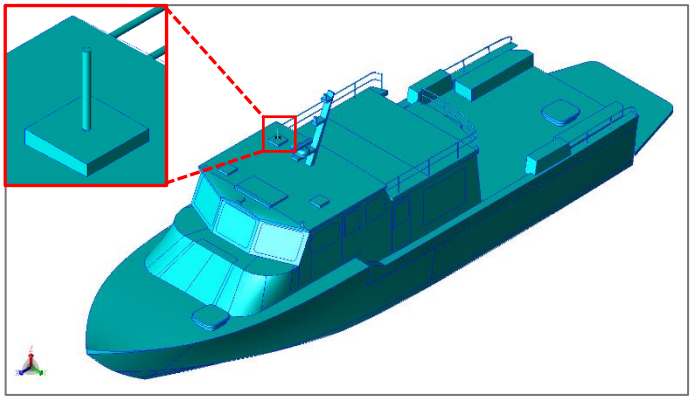

Figure 1. Model of the boat imported to WIPL-D Pro CAD with radiating monopole.

The model of the boat was meshed i.e. converted to WIPL-D Pro native format (Figure 2). The next step was excluding insignificant parts of the boat from the simulation. It was done by entering WIPL-D Pro and applying *Unused Entities* option to the meshed boat model. The entities which will be excluded from the simulation are shown in yellow, as presented in Figure 3.

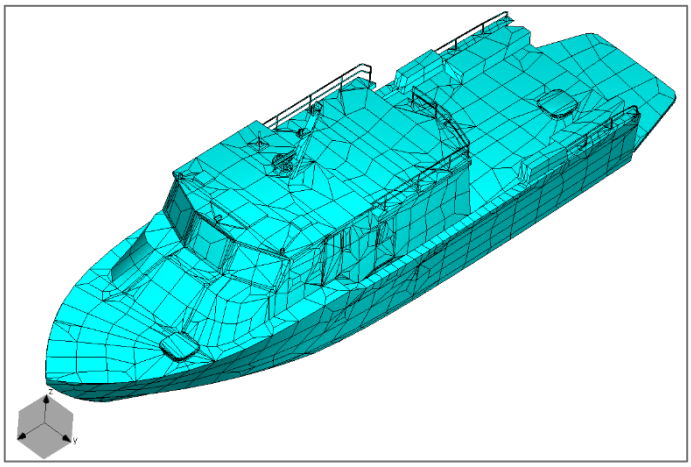

Figure 2. Meshed model of the boat - WIPL-D Pro.

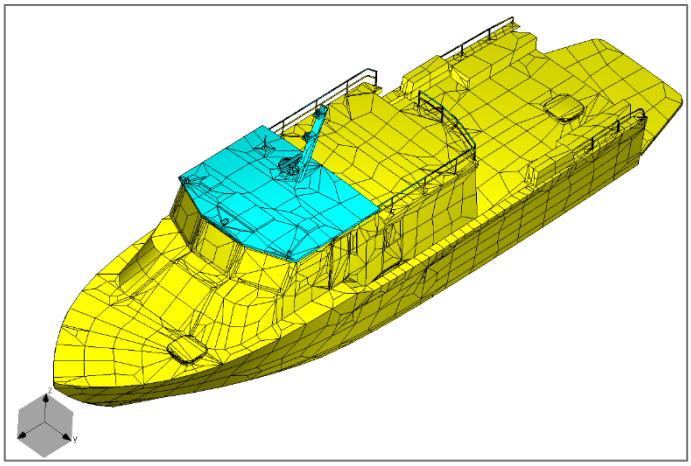

Figure 3. *Unused Entities* option applied to the boat - WIPL-D Pro.

In order to investigate situation with the boat immersed into sea water, three projects are created.

The first project models the boat at sea water with *Real Ground* option activated. Although named *Real Ground*, this option actually considers the influence of the infinite surface described with appropriate dielectric parameters to radiation pattern. This means that the option can also be used where dielectric properties are the one corresponding to the see water. In our case, the dielectric properties of the see water are taken as follows: relative dielectric constant equals 70, and the conductivity equals 3.

The second project models the boat at sea - above infinite PEC plane. This means that instead of using the *Real Ground* option, we defined a simply infinite PEC plane located below the boat.

Finally, the third project considers the boat above infinite PEC plane with *Unused Entities* option applied. In the other words, some entities have been excluded from the simulation.

Simulations and Results

The three projects described were simulated from 0.1 GHz to 0.2 GHz in 21 frequency points. Radiation pattern was calculated at each frequency point in 721 directions. The radiation pattern was calculated at phi=90 degrees angle. In WIPL-D coordinate system, theta=90 degrees angle points toward z=+Inf axis.

Computer hardware used for simulations is presented in Table 1. Number of unknowns and simulation times per frequency for all three projects are presented in Table 2. Each simulation time presented mainly consists of matrix fill time and matrix solution time. Matrix solution was performed using GPU card. CAD operations and meshing are not encompassed with presented simulation time.

Table 1. Computer used in the simulations.

Hardware	Description
CPU	Intel® Core™ i7-7700 CPU @ 3.60 GHz 3.60 GHz
RAM	64 GB
GPU	Nvidia GeForce GTX 1080

Table 2. Number of unknowns and simulation times for three simulated scenarios.

Project	Number of Unknowns	Simulation Time per Frequency [sec]
Boat-at-Sea (Real Ground Option)	21,512	56.2
Boat-at-Sea (PEC)	21,646	86.3
Boat-at-Sea (PEC with *Unused Entities*)	4,084	12.2

Calculated S-parameters and radiation pattern are presented in Figure 4 and Figure 5. Comparing the curves presented in Figure 4, it can be concluded that the presence of the conductive sea water does not influence the return loss of the antenna. Furthermore, the results are not affected significantly if the option *Unused Entities* is used as explained. This means that for the particular case using *Unused Entities* option does not produces significant differences in current distribution over the antenna elements comparing to the full model. Analyzing radiation patterns presented in Figure 5, one can conclude that the method of modeling sea water affects to some extent calculated values of the radiation pattern. The results are mostly affected for the directions around angles of 0° and 180° which are close to the water.

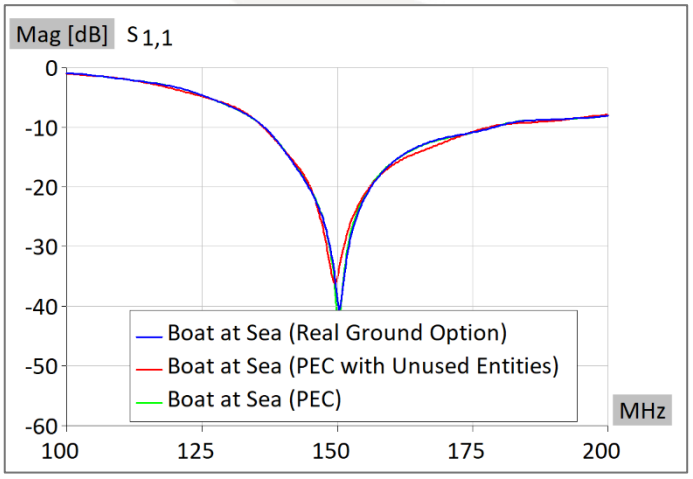

Figure 4. S-parameter calculated for three scenarios of the boat-at-sea.

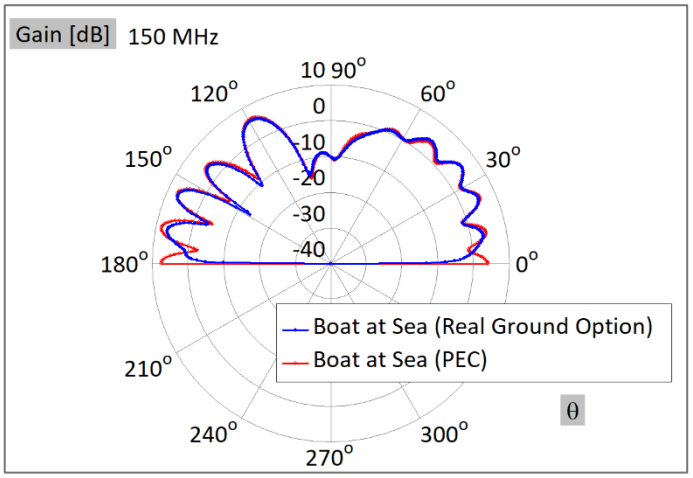

Figure 5. Radiation patterns and influence of the infinite PEC plane and real ground option.

Conclusion

The application note describes simulation of a real life antenna placement operating environment. All projects consider a monopole mounted on a boat emersed in a sea water. In the first project, the influence of sea water to radiation pattern was modeled by applying *Real Ground* option and using dielectric properties of the sea water. In the second project, the sea water is modeled as infinite PEC plane. Finally, in the third project option *Unused Enitites* are applied with PEC approximation. The obtained results are in line with the expectations.

It has been found that the conductive sea water does not influence the return loss of the antenna and *Unused Entities* option does not produces significant differences in current distribution over the antenna elements. The PEC approximation of the conductive see water affects the radiation pattern results for the directions around θ angles of 0° and 180°

All the simulations are performed using standard, cost effective workstation.