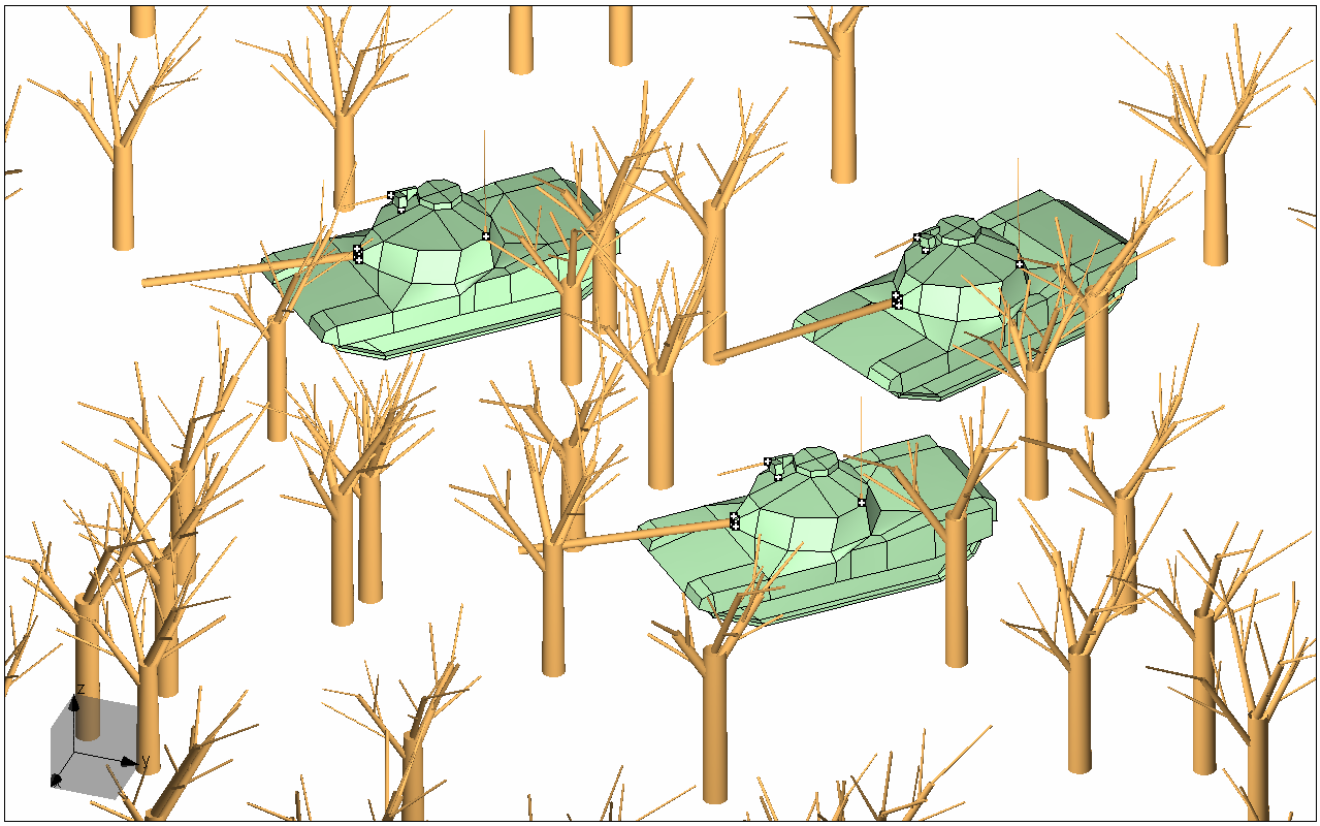
Modeling of Trees, Foliage, and Complex Sceneries

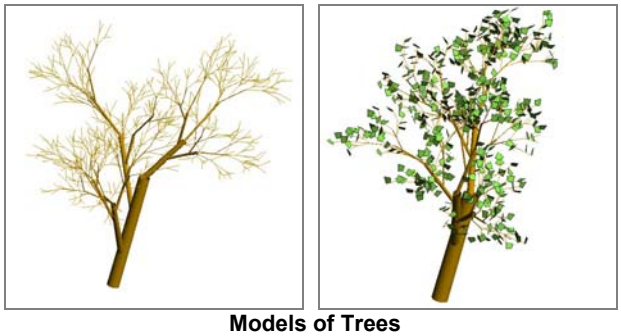
Scattering of **EM waves** from **trees** and **foliage** as well as the propagation of EM waves in the presence of forests plays an **important role** in many civil and military applications. For example, in the usage of Foliage Penetrating Radar (FOPEN) for detecting potential targets in the forest.
If all the trees are modeled as dielectric rods and plates, the CPU time needed for rigorous MoM simulation is unacceptable for the real-life problems. However, the approximate but still accurate modeling is possible using the WIPL-D Pro EM solver.

Efficient MoM Modeling of Trees and Foliage

Computationally efficient modeling of trees and foliage can be done with metallic wires (for branches) and metallic plates (for leaves) with distributed loadings over them. The error is negligible for all branches that have the radii $a \le \frac{\lambda}{8}$, where a is the radii and λ is the wavelength at the operating frequency. The branches that do not satisfy this condition have to be modeled rigorously as the dielectric rods. With this approach the **number of unknowns** needed for the simulation is **reduced** approximately **100 times**! Only ~100 unknowns are needed for the modeling of a single tree, using presented approach.



Model of Tanks in Forest – Complex Scenery



Models of Trees

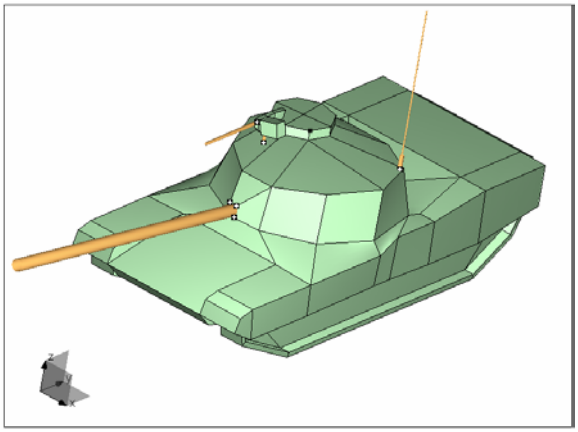
Detail of leaves and branches

The model of a tree with only metallic wires and plates is valid up to approximately 150 MHz (considering that the tree trunk has diameter less than about 2 ft / 60 cm). Over that frequency, the tree trunk has to be modeled as the dielectric rod.

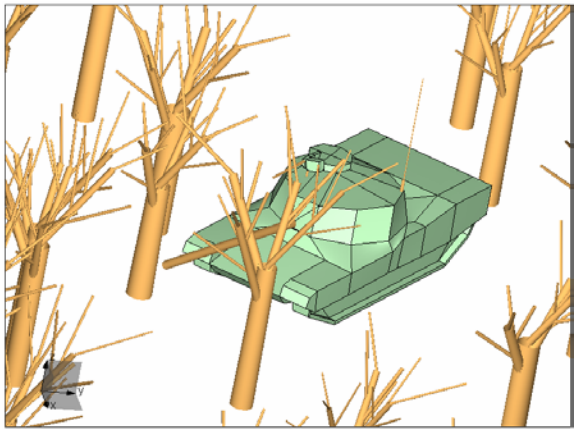
On a Core i7 workstation, the simulation of the whole forest with **100 randomly placed trees** and additional objects inside **takes about 10 minutes**.

The presented approach opens the possibility for a **rapid full 3D EM simulation of complex sceneries** involving trees, foliage, and potential targets inside forests.

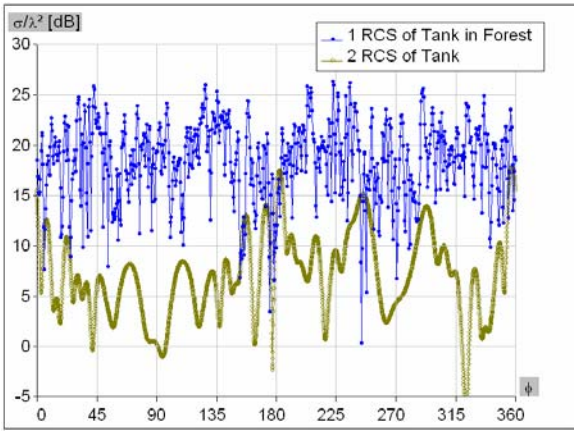
Applying this approach on the parallel computers and clusters allows **simulations of the whole landscapes and complex sceneries**.



Model of Tank



Model of Tank In Forest



RCS of Tank (yellow) and Tank in Forest (blue)

Case Study

Project: Calculating Radar cross-section (RCS) of a tank alone and the same tank in the forest at 100 MHz. The forest has 50 trees, and the tank is positioned in the middle of it. The total number of unknowns for the project is 5143 (1600 for the tank and 3543 for the forest). The number of monostatic directions is 721.

Comments: The simulation of the scenery took **45 seconds** on a Intel (R) Core (TM) i7 950 @ 3.07 GHz with 8 GB of RAM.