Mobile Phone Simulations with Human Head and Hand Models

The transient solver of CST MICROWAVE STUDIO® (CST MWS) with its PBA and TST techniques is widely known to deliver very accurate and fast results for various types of antennas including electrically small antennas such as those found in mobile phones. Once the design of a mobile phone is concluded (assuming it in free space), the performance of the phone needs to be tested in more realistic surroundings such as near the head and when placed in the hand. This is important since the field distribution and radiation pattern will be influenced by the head and hand. Finally, for certification, the Specific Absorbtion Rate (SAR) also needs to be proven to fullfill inernational standards such as the IEEE C95.3 standard.

The following study uses a complete CAD model of a Sony Ericsson mobile phone which was imported in CST MWS as a step-file. In addition, the SAM phantom head and a phantom hand are imported, as shown in Figure 1.

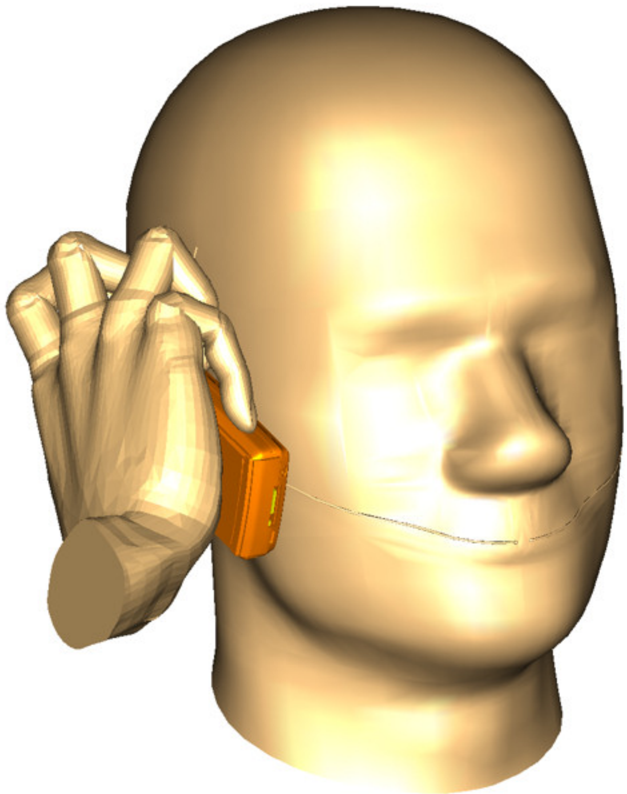

Figure 1: Mobile phone with SAM-head and hand phantoms.

For the dicretization a global number of 15 lines per wavelength was chosen. The detailed parts of the antenna are automatically refined by the CST MWS expert settings. The final number of mesh-cells sums up to be around 11 Million cells. This mesh leads to a total simulation time of 129 min on a 64 bit PC with a 2.0 GHz processor for a broadband analysis up to 2.5 GHz. A view of the mesh is shown in Figure 2.

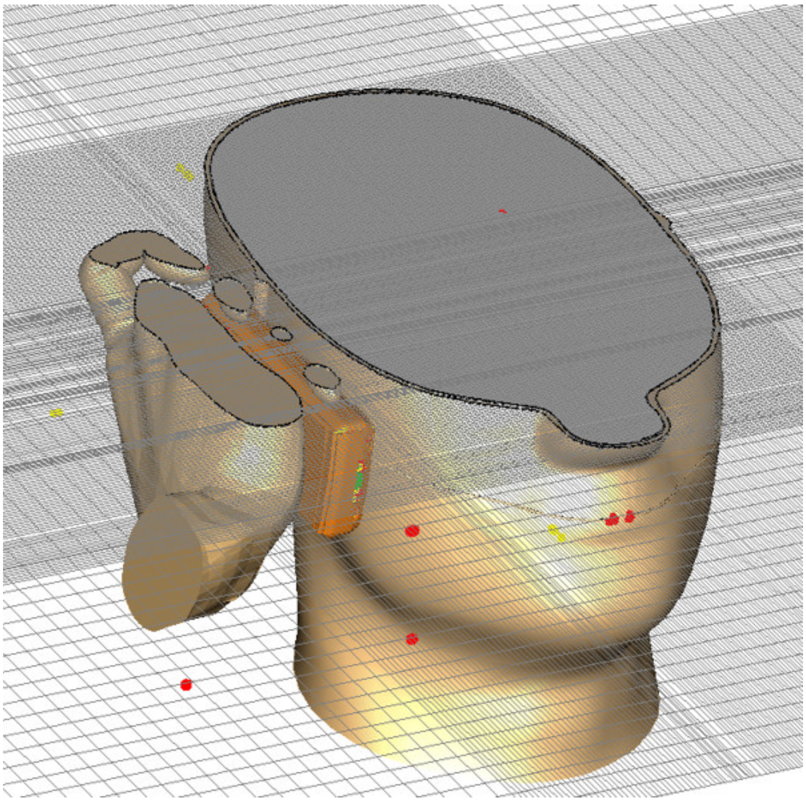

Figure 2: Mesh view.

Due to the high dielectric permittivity of 40 in the brain tissue the mesh needs to be much finer in the head region compared to the surrounding vacuum. In classical time domain solvers these fine mesh-lines need to be extended to the boundary of the computational domain (as e.g. in Fig. 2). However, the subgridding scheme in CST MWS allows different levels of mesh to be used for different solids in the model. Using the subgridding reduces the number of mesh-cells to just 4.5 million (see Fig.3).

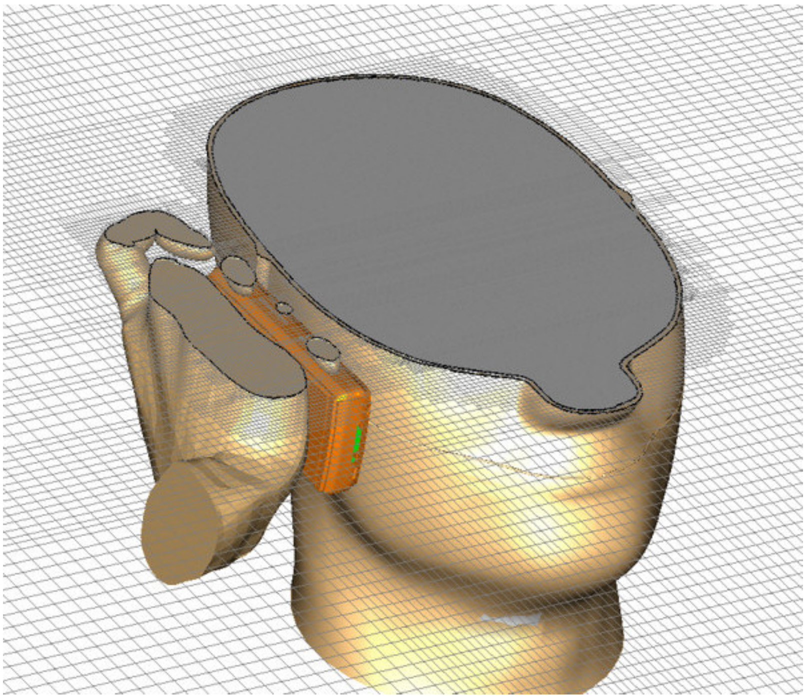

Figure 3: View of a mesh using subgridding.

The resulting field distribution at 1.8 GHz is shown in Figure 4. It can clearly be seen how the wavelength inside the head is shortened compared to vacuum due to the high dielectric values. The radiated field is basically guided around the head.

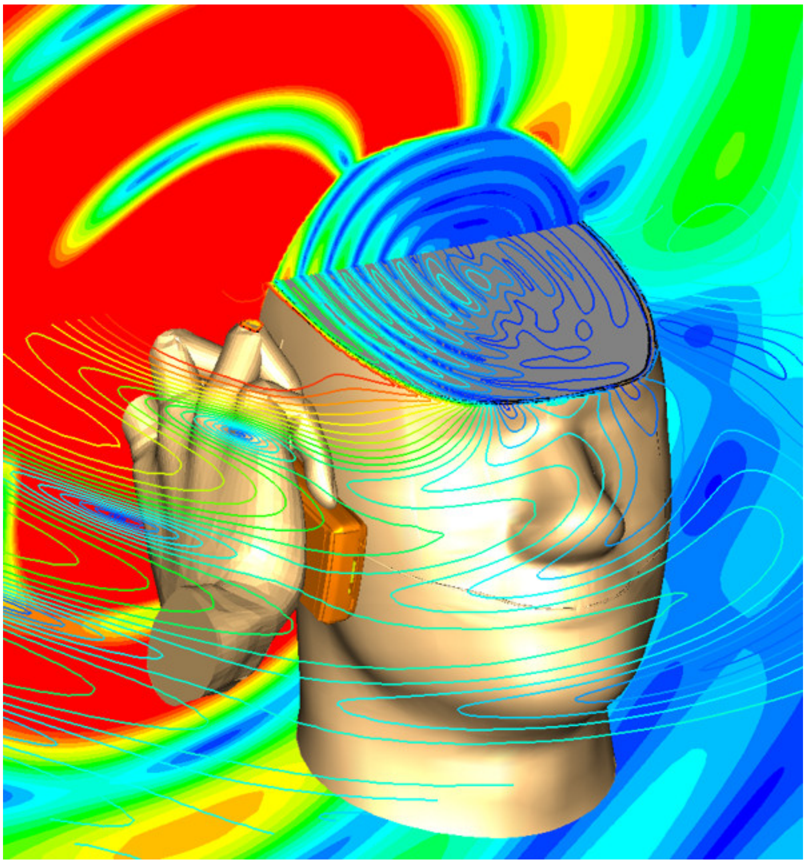

Figure 4: E-field distribution at the GSM band at at 1.8 GHz.

The farfield plot (Figure 5) shows clearly that the main radiation direction is located between the hand and the head.

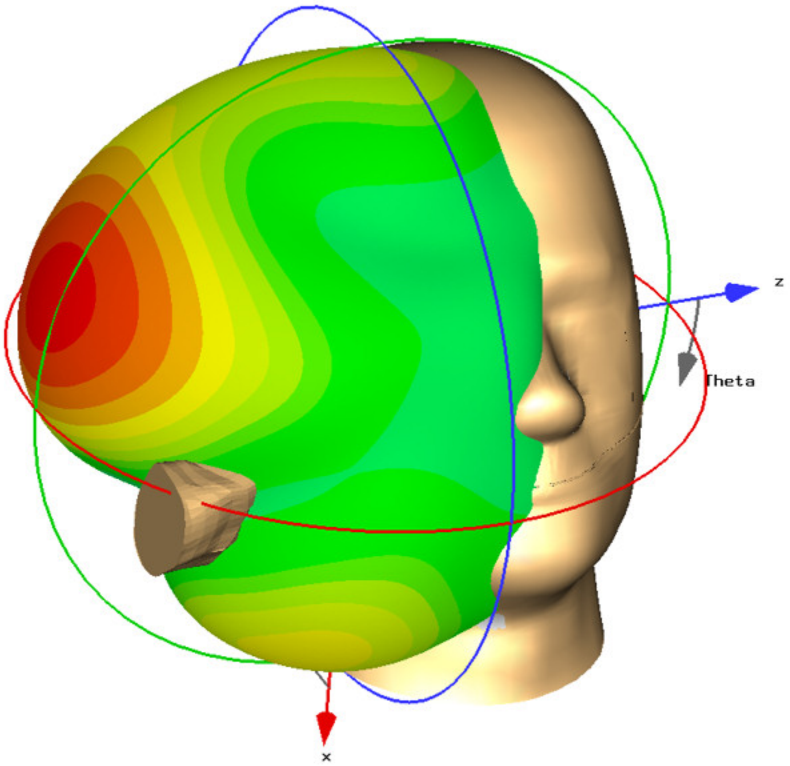

Figure 5: Farfield pattern at 1.8 GHz.

A requirement for the certification is to be compliant to the SAR standard IEEE C95.3. Currently the SAR value needs to be measured, but already in the design stage it is very useful to check this value through simulation. In the near future pure simulation may be sufficient for certification. Figure 6 displays the distribution of the SAR value averaged over 1g tissue mass.

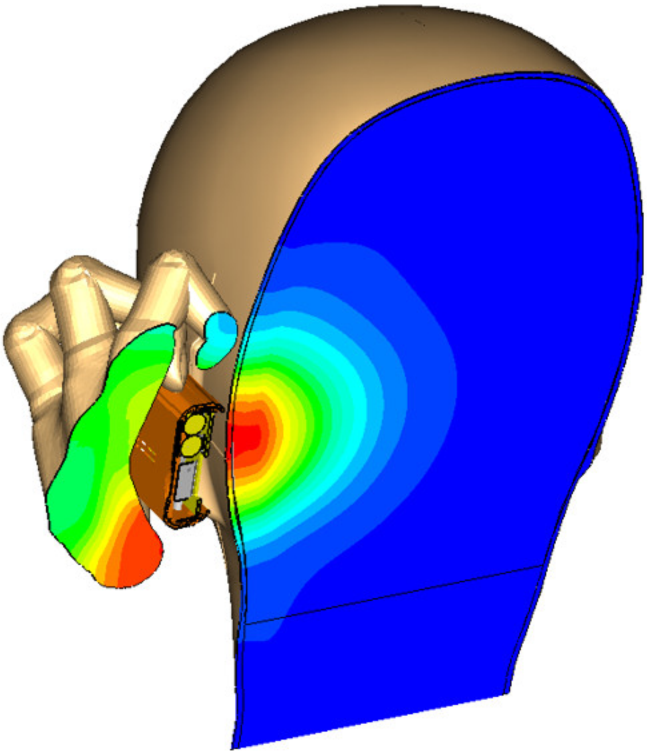

Figure 6: SAR distribution averaged over 1g following the IEEE C95.3 standard.

This article has shown how a single simulation tool, namely the CST MWS transient solver, can be used to not only design and optimise the antenna of a mobile phone in isolation but also check its performance in the presence of a human head and hand. The very high efficiency of the transient solver is clearly shown in terms of simulation time. Despite having more then 11 Million mesh-cells the simulation required just over two hours. In just one simulation the broadband return-loss, the field distribution, the radiation pattern and the SAR-values for various frequencies can be determined.