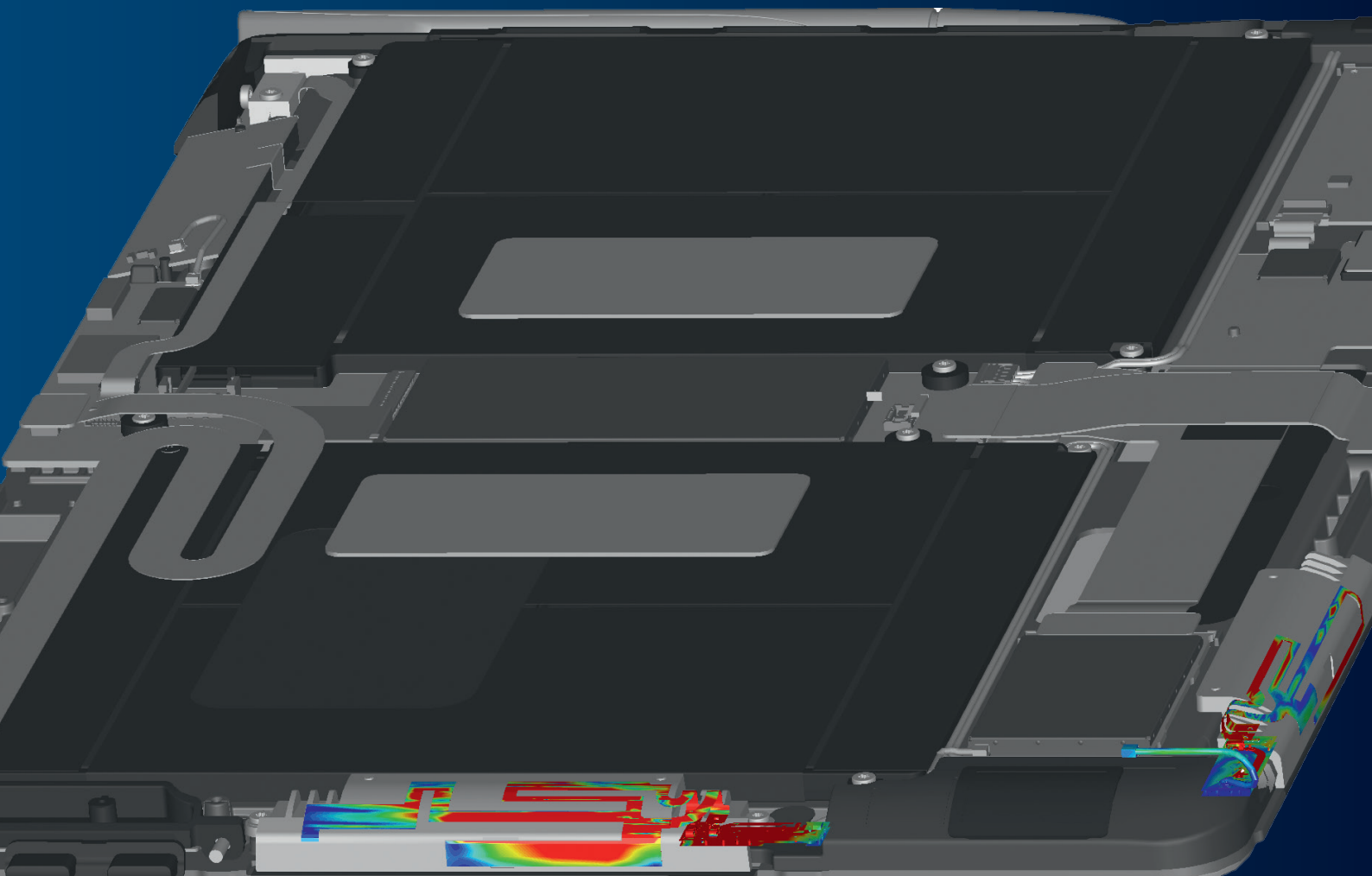


CONVERGENTIA CASE STUDY

CST Studio Suite Simulations replace Prototype
Builds for Convergencia



THE IDEA: COMPACT HIGH-PERFORMANCE ANTENNAS FOR PORTABLE ELECTRONICS

Convergentia is the world's first "virtual build factory", and specializes in providing virtual prototyping services to customers in a wide range of industries, including the consumer electronics market.

Portable devices such as smartphones and tablets nowadays contain many wireless systems, including cellular, Wi-Fi and GPS. Each system requires a functional antenna, since poor antenna performance may lead to a bad user experience in the form of low data throughput or poor coverage, and can cause calls to be dropped and car navigation to fail. On the other hand, devices must look appealing and their size must be minimized. The thinness of the devices and the presence of metallic structures have caused challenges to antenna design. Without 3D simulations, there is a high risk of having poor antenna performance or clumsy industrial design. The alternative for antenna verification is to use multiple prototyping rounds, which are expensive and have a long lead time. However, there are things that cannot be effectively studied with prototypes, for example grounding structures and impedance matching networks.

For 3D simulation to be useful, the simulated results need to correlate with the measured data. A good agreement between the two is necessary to build confidence in the simulated data. Convergentia found that when discrepancies between the two arose, these were mainly due to the lack of similarity of the simulation model and the prototype, since it's not practical or even possible to 1-to-1 model all the complicated structures such as display, touch sensor or speaker. Material properties can also be unknown at the frequencies of interest. Therefore, it was up to antenna designer's competence to judge how to model the parts that cannot be used directly from the mechanical 3D model. Convergentia's engineers have many years of experience of modeling and designing electronic systems and sought a simulation tool that would let them make the most of their skills. For this reason, they turned to the powerful solvers of CST Studio Suite®.

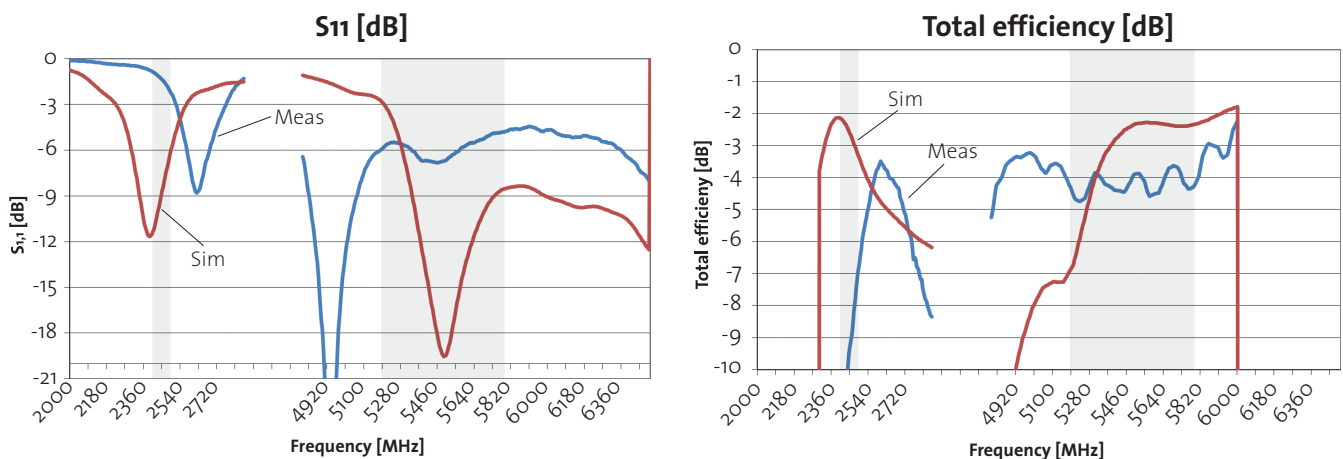


Figure 2: Uncertainties in material properties and component values leads to variation between the virtual prototype and the measured data (here for the Wi-Fi antenna). This means that accuracy is paramount in material characterization.

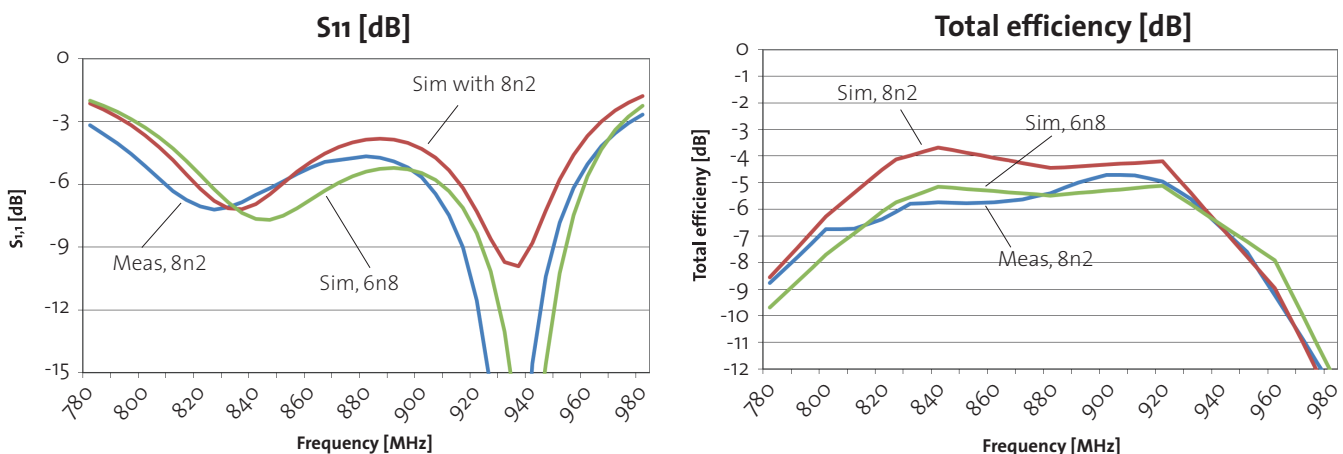


Figure 3: Simulated and measured S_{11} (top) and radiation efficiency (bottom) of the primary cellular antenna for two different matching circuit configurations. Tuning component values and material properties against measurement allows much better agreement to be achieved.

THE CHALLENGE: ACCURATELY MODELING PCB LAYOUT AND GROUNDING STRUCTURES

Most modern integrated antennas include either lumped components or RF switches for impedance matching, although due to the vast amount of frequency bands within LTE, chipset suppliers have started to include integrated antenna matching tuners in their circuitry. In the early phase of the R&D process, tuning elements can be designed with circuit simulators, but for a working prototype, layout simulations are a must. This is especially important at higher frequencies ($f > 1.7$ GHz), when layout parasitic effects can become dominating.

Traditionally, antenna tuning is done with network analyzers by optimizing the return loss of the antenna. Without a matching network, a good impedance matching usually also ensures good radiation properties. The efficiency of the antenna can be checked in an anechoic chamber. This design process cannot be used for antennas with a matching network, because good impedance matching may consider more the losses in the network than good radiation of the antenna. With combined antenna and layout simulations, engineers can avoid additional PCB design rounds and skip the tedious and slow antenna tuning process.

Antennas require a proper ground plane in order to function correctly. This can be difficult to realize in small devices with several separate metal parts. Creating a good ground plane on a device means that the metal parts should be connected together so that maximal antenna performance is achieved. If grounding structure is not properly designed, it may result in insufficient bandwidth or there may be unintentionally created RF traps, which increase the antenna loss by several decibels. These kind of lossy resonances are well-known to antenna designers and are very difficult to track and correct in prototypes. It may take weeks to find the cause of these problems, and a new prototyping round would be needed in order to fix the problem. Simulation made it possible for designs to be examined without the cost of constructing a prototype, and field visualization allows resonant components to be identified by eye.

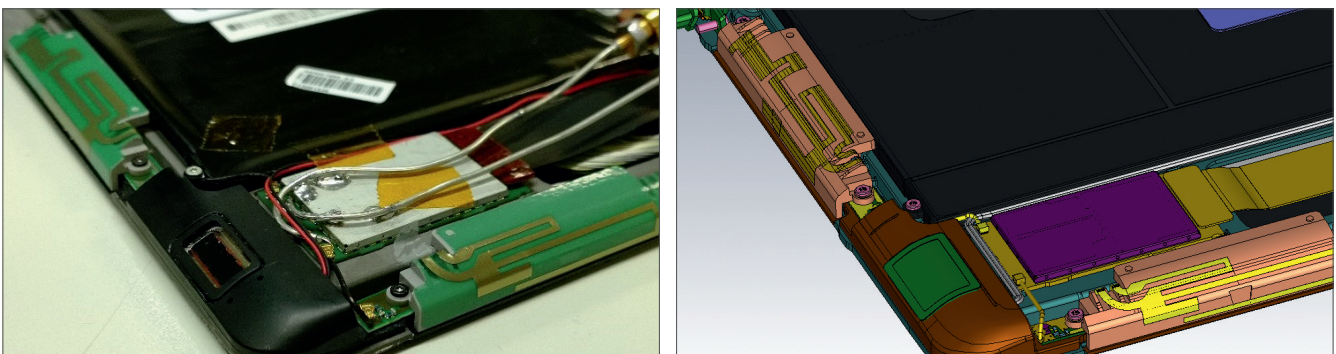


Figure 4: A physical prototype of a tablet with several antennas (left) and the equivalent simulation model (right).

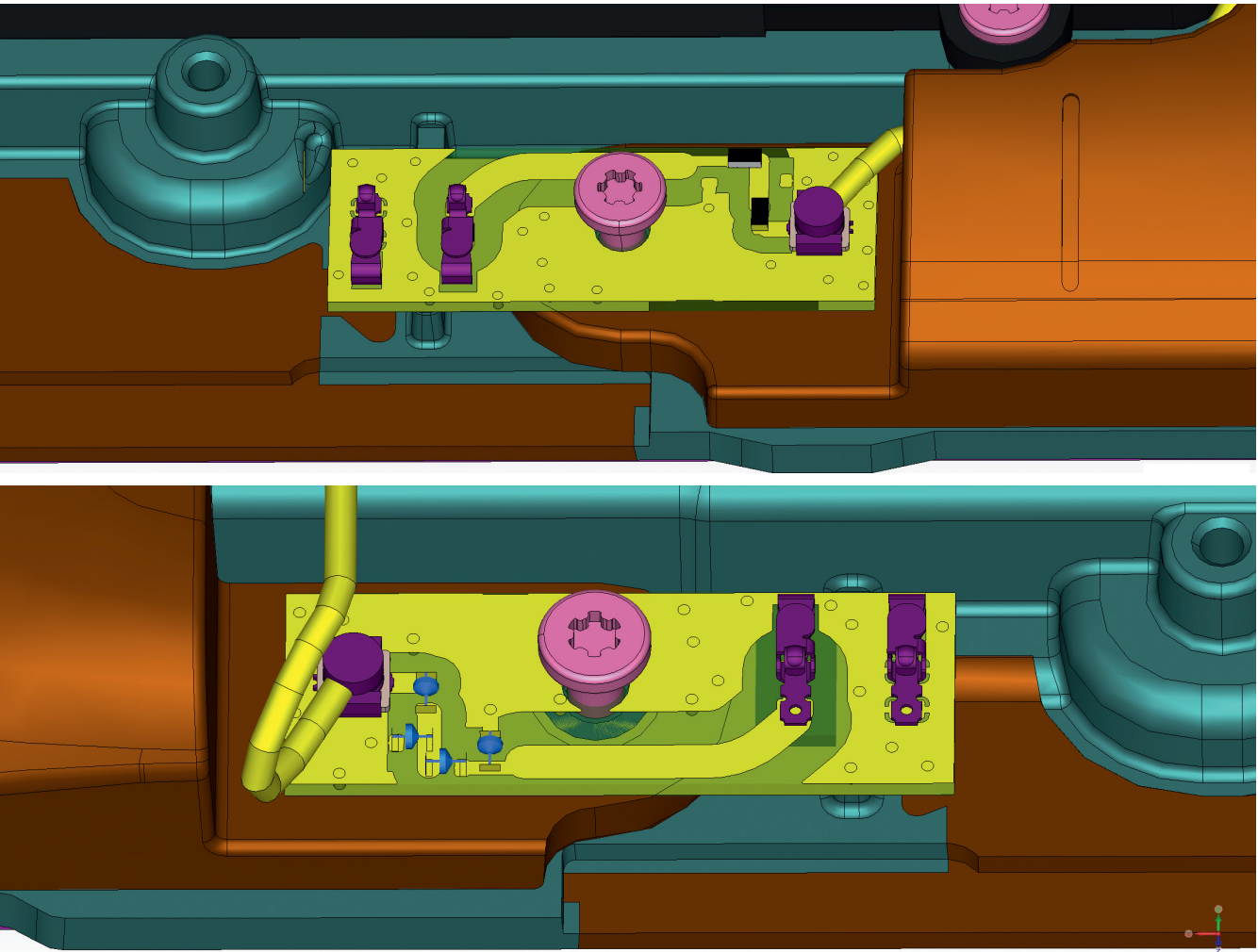


Figure 5: (Top) The unmatched cellular antenna. (Bottom) The layout of the cellular antenna matching circuit, with four components.

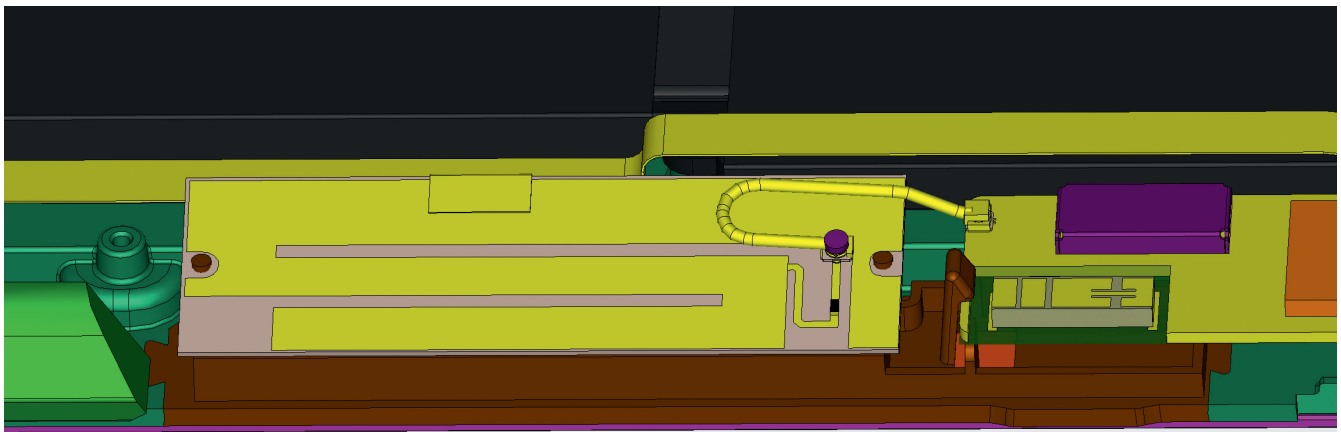


Figure 6: The GPS and Wi-Fi antennas.

THE RESULT: ACCURATE VIRTUAL PROTOTYPES OF REAL SYSTEMS.

Figure 4 shows a tablet prototype constructed by Convergentia with primary and secondary cellular antennas, as well as GPS and Wi-Fi antennas. The cellular antennas are of flex type mounted on a plastic antenna carrier, with small PCBs for antenna impedance matching and for feeding clips (Figure 5). The GPS antenna is etched on a separate PCB and Wi-Fi antenna is of a ceramic type (Figure 6).

Convergentia found that the correlation of simulation and measurement was very good. Impedance matching was made with two coils and two capacitors. Convergentia found that differences between the simulation and the measurement were caused by differences between the model and the physical reality: The material properties of the ceramics were unknown as well as the details of the PCB groundings, which lead to some discrepancies in Wi-Fi antenna frequency response (Figure 2). With slight tuning of the antenna and the material properties, they found the expected performance. There was a good correlation of the primary cellular antenna simulation results with the measurement (Figure 3).

With virtual prototyping, the number of prototype rounds was reduced together with the device development time. This speed-up came from two factors. First, there was no need for mechanical changes or PCB changes due to antenna performance issues during physical prototyping. Only fine tuning was needed in order to get all the potential from the antenna into use. Second, because all antennas worked as constructed, testing of other areas can begin without waiting for the antenna designers to get antennas working first. For example, EMC and data throughput tests can be started immediately. The prerequisite for the successful virtual build is that the simulation model corresponds with the upcoming prototype including the matching network layout and grounding structure of the device. The combination of the powerful CAD import tools and accurate solver technologies in CST Studio Suite, together with Convergentia's simulation expertise, allowed them to implement an effective virtual prototyping workflow.

“The power and versatility of CST Studio Suite let us take full advantage of our simulation expertise in order to deliver cutting-edge virtual prototyping solutions to our customers.”

– Dr Sami Hienonen

Technology Manager, Convergentia Ltd

ABOUT CONVERGENTIA

Convergentia provides simulation-aided design solutions to devices where high quality, low cost or fast time to market is important. Convergentia has antenna, audio, mechanics, EMC and thermal design teams to cover the most critical parts of the customer product. The antenna team develops antenna solutions to a wide scale of devices, from tiny Bluetooth headsets to the complex LTE antenna systems used in smartphones and tablets. The power and versatility of CST Studio Suite let us take full advantage of our simulation expertise in order to deliver cutting edge virtual prototyping solutions to our customers.

For more information, please visit
<http://www.convergentia.com>

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