Dialing into **Simulation** to Streamline **Cellular Phone Development**

Upstream model simulation reduces product **development time** and **enables** Motorola to meet critical market demands.

by **Dr. Kinzy Jones, Doug Carroll, Phil Green, Chris Bates** and **Dr. Marc Zampino**

Inspired by a vision of "seamless mobility," global communications leader Motorola has transformed the ubiquitous cell phone of the last century into today's universal remote control for life. Revolutionizing broadband, embedded systems and wireless networks, the company that pioneered the first portable two-way radio for the U.S. Army in 1943 now helps individuals reach the people, things and information they need in their homes, cars, workplaces and everywhere in between.

Today's cell phones are incredibly complex, with multiple printed-circuit boards and large, multi-functional liquid crystal displays (LCDs). They also have the ability to support multiple data protocols such as code division multiple access (CDMA), global system for mobile communications (GSM) and Worldwide Interoperability for Microwave Access (WiMAX) – all in a single, sleek hand-held device. At the same time, designs must be rugged and built to withstand the daily equivalent of a computer workstation and monitor taking a five-foot fall.

Like many of its competitors, Motorola is driven by shortened design cycles, increasing product complexity and reduced profit margins. Design cycles that took 18 months in 1998 from drawing board to plant floor are now pushing toward a six-month goal to meet business-critical product launches and fixed ship dates. Above all, to maintain a healthy profit margin, Motorola must keep down the overall cost of producing the product, especially to compete in countries where wireless providers rarely subsidize the cost of the phone.

Real-World Reliability

To understand "real-world" reliability well before next-generation cell phones hit the shelves, Motorola has increased its use of computer-aided engineering (CAE) earlier in the design cycle. For example, the company is using Altair HyperWorks for up-front simulation along with prototype testing to aid in the development process. Doing so has enabled the company to capture product-life behavior, predict areas needing improvement and generate high-quality products within a greatly reduced time frame.

Capturing product-life behavior is a daunting task, so simulation is combined with prototype testing to help in developing the product. The commonly used phrase to describe the external loading that the phones experience during testing is "large-motion, small-time scales." In using simulation to aid in product development, the concern is in determining what level of detail should be included in the model to capture the relevant physics. Moreover, since it is extremely difficult to predict actions that will result from a 5,000-g, 0.1-ms impact pulse, intuition is of little help.

With today's modern algorithms and vast computing power, simulations need not be simplistic models of the actual problem. However, this can lead to a number of challenges when looking at even the simplest cellular phone models. Since the behavior of many of the materials varies as the strain rate changes, additional material modeling must be done. In addition, if manufacturing variables must be considered, the challenges are even more complex.

In any case, while it is an intimidating task to predict drop performance, it is not impossible to manage its analysis. And, as difficult as the solution techniques can be, model setup is the largest contributor to the overall length of the solution process.

Up-Front Design

At Motorola, the use and customization of advanced CAE software have streamlined the mechanical prototype process while greatly increasing design robustness. Significantly decreasing simulation time has enabled Motorola engineers to identify and correct potential issues early in the development cycle. Reduction in simulation cycle time is also critical to shorten time to market, which, in turn, has a positive impact on the company's bottom line.

Moreover, the acceleration of the model-building process allows several simulation passes on concept geometry before costly injection molding tools need to be built – a luxury that even two years ago was impossible. For example, a new cellular phone model consisting of more than 70 unique components took 16 hours to go from geometry to a fully ready-to-run simulation model, rather than the standard 20-day model development time. This is a tenfold improvement in speed in less than a year – and has removed the model development cycle as the gating set of the prototype simulation process. Simulation can now become an up-front design tool.

On average, 40 system-level drop simulations (Figure 1 on page 12) are performed before a design is released for plastic injection tooling. These simulations allow the engineers to understand the performance of the displays, electrical components and plastic housings.

In 2000, finite-element mesh creation, contact and constraint definition, model debugging and result interpretation were highly manual processes and took more than two months to perform. At that time, Altair HyperWorks was chosen to automate time-consuming manual tasks, such as automated geometry cleanup, mesh generation, interference checking or post-processing. Using the software resulted in significant time savings and reduced model setup time from 20 days to only two days.

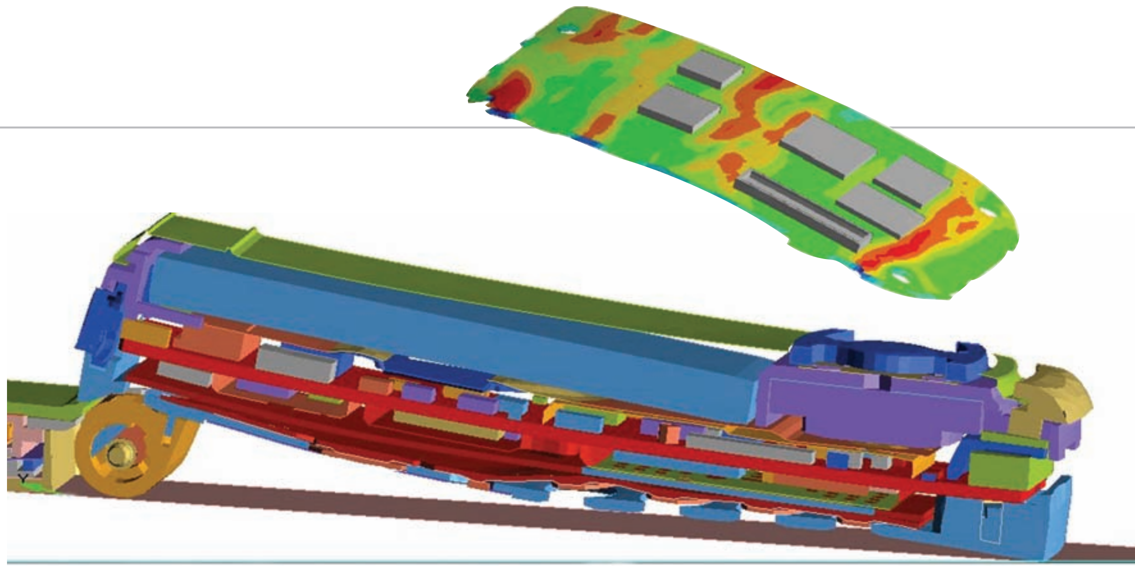


Figure 1. Typical FEM model of a cellular phone.

Motorola at a Glance

Motorola, Inc. – founded in 1928 and recognized around the world for innovation and leadership in wireless and broadband communications – pioneered mobile communications in the 1930s with car radios and public safety networks, coining the company brand that suggests "sound in motion." With approximately 68,000 employees, Motorola directs the activities of 320 facilities in 73 countries from its global headquarters in Schaumburg, IL.

For more than 75 years, the company has remained committed to engineering innovation. Harnessing the power of technology convergence, Motorola made the equipment that carried the first words back from the moon in 1969. Motorola led the communications revolution with the 1983 introduction of the first commercial cellular phone. Reportedly, the company spends as much as 10 percent of its annual income in research and development efforts.

Today, Motorola offers market-changing icons of personal technology and is a leader in multinode, multi-band communications products and technologies. The Plantation, FL-based Mobile Devices division designs, manufactures, sells and services wireless subscriber and server equipment for cellular systems; portable energy storage products and systems; servers and software solutions; and related software and accessory products.

At Motorola, that means designing and delivering "must-have" products, must-have experiences and powerful networks to keep people connected.

Simulation plays a critical role in product development, with a broad impact from package-level simulation to system-level modeling. To put this into perspective, typical design cycles decreased from about 18 months in the late 1990s to under a year in 2005. While cycle time has compressed, the functionality of the devices has grown tremendously. In order to design new products in fewer than 10 months, which is a goal at Motorola, the traditional "build-and-test" approach has been widely replaced by up-front simulation.

Finding Part Interferences

Cellular phone models typically consist of hundreds of components packaged within a small space. Often, after a mesh has been completed, there are portions of the mesh (elements and nodes) that interfere with each other. These interferences occur either because of underlying geometry or result from the tessellation of the geometry while being meshed. Using the traditional process, an analyst needed up to three days to manually find and correct the interferences in the virtual model. Moreover, these interfering nodes and elements can often be nearly impossible to detect manually.

If these interfering elements are allowed to remain in the model, it can lead to errors during the execution of the model. This results in unacceptable delays to debug the problem – and wasted central processing unit (CPU) cycles on the compute server.

To find and correct these issues, a custom interference-checking program was built, based on Motorola's internal requirements. The proprietary "interference matrix" shows modeling errors in a graphical format, and the "interference solution graphical user interface (GUI)" supports the analyst in resolving mesh problems.

Using the custom tool, the analyst can select the components that are of interest and generate the interference matrix (Figure 2). Then, each pair of components can be visualized by selecting the appropriate box on the GUI. This generates the populated interference solution GUI. A table then displays the nodes that interfere, as well as the amount of the overclosure. (This is shown in white in Figure 3).

This GUI also allows analysts to set the master/slave relationship of the surfaces. Once all the interference pairs are fixed, the interference matrix will show all green (Figure 4). That signals the model is clean and ready to run.

As a result of this automation, model checks can now be performed in just one hour, compared to the traditional 15 to 20 hours. This represents an approximately 80-percent to 90-percent time savings.

Automating Post-Processing

Now that model development has been largely automated and compute server speeds are faster than ever, post-processing of drop simulations remains the most time-consuming manual process. Interpretation of the results is the most critical step, and as such, there are no plans to automate that process. However, Motorola analysts agreed that HyperWorks' automatic report generation – consisting of images and 3D interactive animation result files using Altair's compact .h3d format – greatly speeds up the process.

Using HyperWorks' automatic reporting capabilities, analysts were able to create a standard report of drop-simulation results. The tool creates graphical, top-level overviews about potential failures from high-impact forces for every part of the cell phone.

The standard report contains an isometric view of the phone and cross-sections of the three main axes. Designers can interactively animate the drop in 3D to visualize the motion of the parts with a Web browser or PowerPoint using Altair HyperView Player freeware, a 3D web browser plug-in with ActiveX controls.

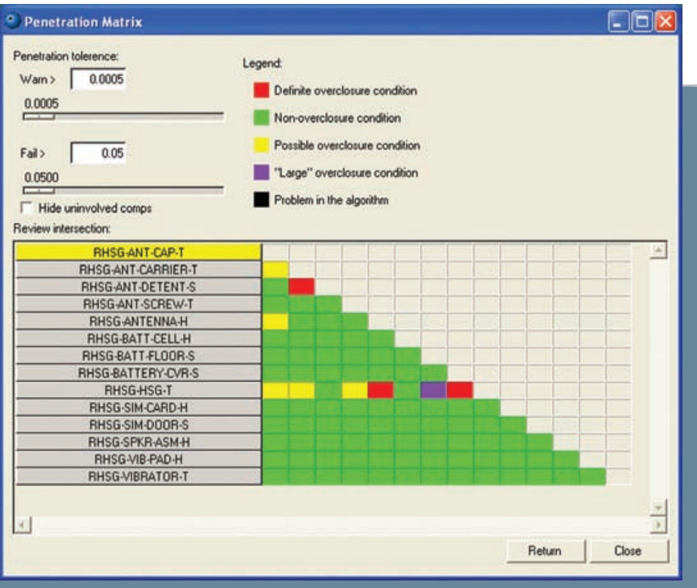


Figure 2. A custom interference-checking program, built to Motorola's internal requirements, speeds the model-checking process. The screen above shows the interference matrix for the overclosure process.

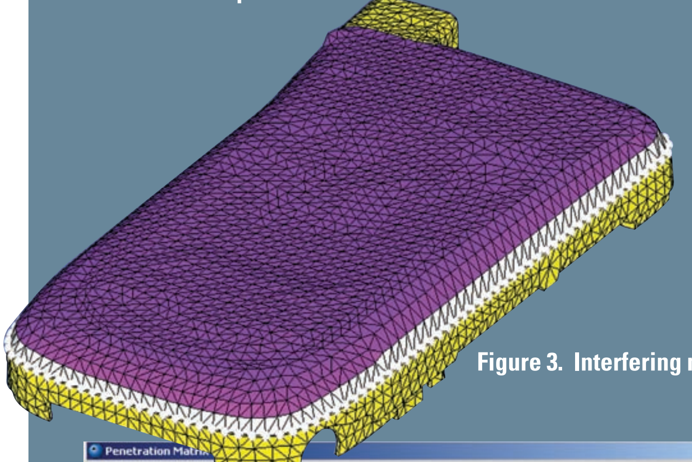


Figure 3. Interfering nodes.

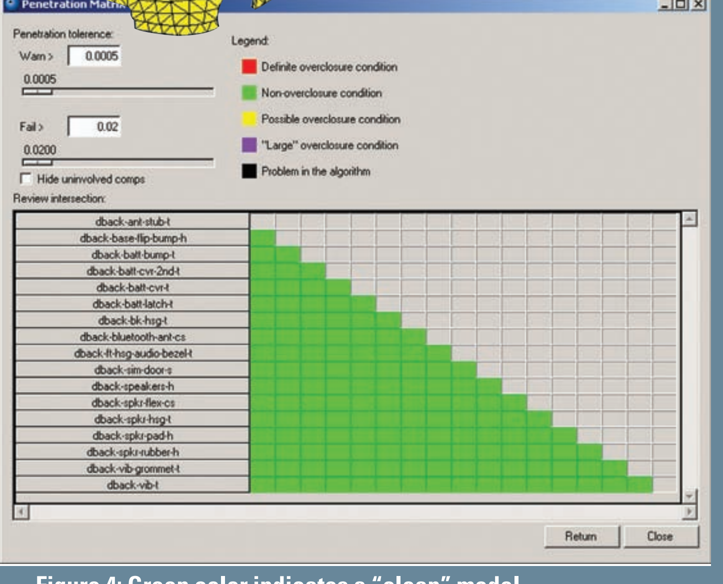


Figure 4: Green color indicates a "clean" model.

Prototypes Now Drive Design

Using advanced model development tools, simulation has moved from a design validation tool to a design tool, capable of generating system-level drop simulations so quickly that designs can be modified daily. Traditionally, cycle time ran up to eight weeks.

The model (top right) consists of 77 unique components, including two LCDs and two populated printed-circuit boards. It consists of shell, hexagonal and tetrahedral meshes.

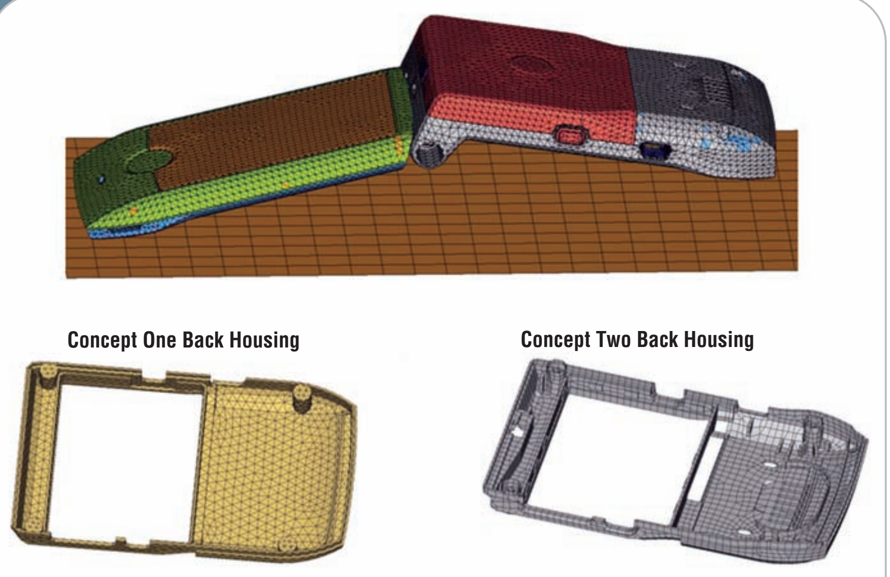
For the first phone concept geometry, it took two working days from the creation of the Initial Graphics Exchange Specification (IGES) geometry to full drop-simulation results (9.5 hours running 12 CPUs on an SGI Altix compute server). Using the automated geometry-cleanup and mesh-generation tools, it took eight hours to clean and mesh the parts.

An additional eight to 10 hours were needed for collision detection and correction, as well as to create surface constraints and boundary conditions. The total time for the first concept model setup was approximately 20 hours. Several simulations were run with this geometry to test early design concepts.

Improvements to the initial design, labeled Concept Two geometry, were usually available a week after the first set of results. The models (below right) show the level of part complexity in Concepts One and Two.

Only the new or modified geometry must be meshed, in this case, only 54 components. It took eight hours to go from the computer-aided design package exported IGES files to a completed finite-element model that had passed a data check. Fifteen hours were required to run one of the standard drop orientations on 12 CPUs on the SGI Altix compute server.

In this example, then, the model went from IGES geometry to post-processing of the .h3d file – generated using Altair HyperView Player freeware – in less than 24 hours. Advanced model simulation tools reduced the overall CAE cycle time from eight weeks to 24 hours – a significant savings in time and costs.



Models generated from automated mesh generation and collision detection.

As a result, analysts and designers can quickly review the phone's structural integrity and eliminate the risk of "missed results" due to the simulation model's complexity. The parts that have failed their respective material criteria are displayed on the first page, as are the number of failed elements. All the components can be viewed by selecting ALL on the bottom of the main page. Clicking on any of the components launches another page with detailed information on the component, including the values of interest for the entire event.

In the future, further automation of the model development process will focus on the use of Altair Data Manager. This new system will allow continual updates of the part meshes through the integration of the computer-aided design life management tool. The available customization of the tool will allow for many new additional avenues for process automation. C2R

Dr. Kinzy Jones is a Distinguished Member of the Technical Staff; **Doug Carroll** is a Distinguished Member of the Technical Staff; **Phil Green** is Senior Staff Engineer; **Chris Bates** is Senior Staff Engineer; and **Dr. Marc Zampino** is Principal Staff Engineer. All are part of Motorola – iMDC's Advanced Mechanics Group in Plantation, FL.

To receive a copy of the Motorola HyperWorks success story, visit *www.altair.com/c2r* or check 03 on the reply card.