Utilizing Cross Disciplinary CAD Tools in New Product Design and Development

The use of CAD tools has become fairly widespread since their inception roughly 15 years ago. Designing in 3-D solid and surface geometry has replaced conventional 2-D design in many areas of industry. Countless 3-D software packages are available to aid engineers in nearly all aspects of product design. These disciplines include industrial design, mechanical design, tool design, analysis and printed circuit board (PCB) layout and design, to name a few. While individuals in these various groups have utilized CAD tools amongst themselves to aid in their respective tasks for several years, it is only recently that these different, multi-faceted groups have begun to "cross communicate" amongst each other. And it is these various CAD packages that are providing the very means for this communication breakthrough. There are several reasons contributing to this recent breakdown of "cross communication" barriers. This article examines these issues in terms of how a new product was developed across numerous global locations, on time and within budget.

Bill Jennings

Photos courtesy of Stone Mountain.

R250s Pro — GSM cellular phone.

The term "CAD" has become a rather generic term utilized by many to refer to the host of computer aided design tools available. There are, in fact, three major computer aided design tool groups, CAD (computer aided design), CAE (computer aided engineering) and CAM (computer aided manufacture). In the above groups typically, industrial design, mechanical design, and PCB layout and design use CAD tools. Tool design engineers utilize CAM tools and analysis engineers use CAE software.

However, this is not black and white, some of the CAD tools can be utilized by different disciplines. In fact, some of the high-end CAD software manufacturers have realized the importance of this ability to exchange information throughout the entire design process. To this end, they developed discreet design "modules" which can be purchased as software options on the main CAD package. These modules offer a seamless interface between various design functions, greatly facilitating the transfer of 3-D solid models from one group to another. For example, a 3-D solid model of a clock front housing generated by the mechanical design team can be directly downloaded to a CNC machine for the generation of electrodes for the injection molding tool.

A cellular/push-to-talk radio hybrid that offers group call capability and other features similar to trunked radio systems.

Other factors are responsible for the increase in cross communication. To accommodate situations where various design groups are using different tools, numerous software translation packages have been developed. For the translation of 3-D CAD files, IGES and STEP are the standard tools. IGES translates solid models into surfaces while the newer and preferred STEP software supports solid-to-solid translation. This is especially useful when translating 3-D solid models from one CAD system into another.

Probably the biggest reason why interdependent design groups are beginning to communicate through 3-D CAD models is necessity. Competition has become fierce, especially in the electronics packaging industry. Product development cycles are getting shorter and more aggressive. Design teams are being asked to do more with less people. The demand for product quality is at an all-time high. Packaging is being pushed to smaller, lighter and more efficient levels. All of the information necessary for the five groups outlined above to do their respective jobs is contained in the 3-D model(s). Basically, each group utilizes information provided by the other groups, adds to it and passes it back through the loop. What is the advantage? Here are a few:

- Photograph quality pictures (photo realistic rendering) at early concept stage of the product for final marketing appearance approval.
- Thermal and stress analysis of the system during early design phase.
- Direct download of mechanical models to prototype houses for early design verification before hard tooling is generated.
- Analysis of PCB for produceability and interface to mechanical package before PCB tooling and artwork is generated.
- Direct download of 3-D CAD files for tooling generation rather than waiting for 2-D documentation to be developed.
- Ability to create and evaluate multiple design approaches before committing to one.
- Unlimited capability to create complex, sculpted geometry to maximize on packaging volume opportunities and meet aesthetic requirements.
- Ability to electronically download, via File Transfer Protocol (FTP) or similar, 3-D CAD files to tooling houses, thus saving shipping costs and, more importantly, time.
- Opportunity for multiple, remote or off-site design groups to work in parallel on discrete tasks to develop a product more quickly and efficiently.

When CAD tools are used correctly and efficiently between cross-functional design groups, the results can be remarkable. A textbook example is the case of a recent product development effort for Ericsson Inc., a major telecommunications company. The company needed to design and develop a new, cutting edge GSM cellular phone for its European market. Referred to as the R250s PRO, this new system was unique in several ways. The product was actually a cellular/push to talk radio hybrid (also referred to as Radio Over Cellular or ROC). The first of its kind, the system offers group call capability and other features similar to trunked radio systems, such as public safety, rescue, etc., in addition to full cellular phone functionality. The product is geared toward outdoors enthusiasts as well as industrial and utility applications. As such, overall product quality, ruggedness and reliability were tantamount to the success of the design. In addition, unit product cost and time-to-market were critical in order to maintain a competitive advantage.

Management set several goals for the chosen design group:

- Reduce the typical product development cycle by 33 percent.
- Meet rigorous European IEC environmental requirements, including drop, shock, salt fog and driven rain.
- Incorporate new, cutting-edge technologies, such as two-shot revolving platen injection molding and inductance welding of materials.
- Reduce part count and design complexity to enhance manufacturability.
- Develop a unique aesthetic, sculpted industrial design package.

In order to meet the extremely aggressive schedule and rigorous requirements, Ericsson elected to distribute the various development tasks to numerous, discrete design and development groups located all over the globe. The various tasks, the responsible parties and their locations are listed below:

- Industrial Design (Product Styling) — Ericsson Industrial Design group in RTP, NC, USA.
- PCB, RF, logic and software design — Ericsson Indelec in Bilbao, Spain.
- Mechanical design — Stone Mountain, Ltd. in Huddleston, VA, USA and Ericsson Indelec in Bilbao, Spain.

In the above mechanical development, Stone Mountain, Ltd., an independent electronic product design and development company, was tasked with the overall design concept responsibility and the detailed design and development of 60 percent of the mechanical components, including the front cover, keypad, LCD light guide, keypad light guide, environmental seal, speaker mode switching mechanism, custom connectors and snap dome array to name a few.

Following a quick analysis of the various CAD tools utilized by the different groups, file translation processes between the various disciplines were implemented at Stone Mountain and a video conferencing system was installed at Ericsson Indelec, enabling "virtual" design reviews to be conducted between the mechanical team in the U.S. and Spain.

The Industrial Design group conceptualized the new product using powerful 3-D surfacing software.* The industrial design assembly consisted of the front and back cover, battery pack, three keypads, LCD window, LED light guide and antenna. The models were extremely sculpted and complex, consisting solely of spline-generated surfaces. While the models were extremely detailed, including keypad artwork and LCD characters, they consisted only of the external appearance surfaces, i.e. there were no internal geometries. The 3-D surface models were used to generate photorealistic full-color renderings and prototype** appearance models for review by marketing. Design iterations resulting from marketing input were quickly incorporated into the industrial design models.

The final, accepted industrial design was translated via IGES, electronically transferred via FTP, and brought into 3-D CAD solid modeling software*** with excellent free-form feature capability, ease of model manipulation and selective parametric utilization properties. Each component of the assembly consisted of discrete surfaces, some containing as many as 600. Three dimensional surface defining geometry, called isoparametric curves, were extracted from the individual surfaces, analyzed, simplified and used to generate free-form features to sculpt a 3-D solid, much like one would carve a piece of wood. After generating the outside appearance geometry of the front and back cover, each solid was hollowed to produce a pre-determined wall thickness. Concurrently, IGES-translated solid models were forwarded to the Industrial Design team to verify adherence to the original surface models. The PCB outline and the available volume for surface mount electrical components were determined. A 3-D PCB — including component "keep in" volumes — was generated, translated and forwarded via FTP to the radio frequency (RF) engineers and the PCB designers in Spain.

The PCB designers used a combination of ECAD and Mentor Graphics, both extremely powerful PCB CAD software systems, in their development. The translated mechanical solid models were brought into both ECAD and Mentor Graphics, where they proceeded to populate the 3-D PCB with the 450 plus surface mount electrical components. These components were pulled from a "library" of stored parts. Each library part included 3-D information. Consequently, the finished product was a six-layer, three-dimensional, populated PCB that could be analyzed for produceability. This 3-D PCB was translated and forwarded back to the mechanical design team at the two locations for incorporation into the development of the mechanical package. The PCB was analyzed in the mechanical package for form, fit and function. Upon approval by the mechanical and electrical teams, the PCB layout was signed off and sample boards were ordered.

The PCB and mechanical package development continued in parallel. Critical mechanical components were translated from the 3-D CAD solid model into a non-linear FEA software package**** for mechanical and structural integrity and an injection molding analysis software package***** for injection molding process evaluation. The individual components were modified and optimized accordingly. As various components of the design were completed, STL files of the solid models were imported and FDM rapid prototypes were immediately created in-house. SLA and high end, two-shot RTV mold prototypes also were generated for marketing appearance models within days of receipt of the files.

The entire mechanical design was done in assembly mode, allowing in-depth analysis of component fits, clearances, tolerances, etc., so crucial in highly sculpted, tightly packed electronic assemblies. This, coupled with the production of concept prototypes, allowed the mechanical team to order all hard tooling with confidence. Early vendor involvement was critical to the schedule. Solid models of components requiring long lead tooling (die castings, injection molded parts, custom connectors, etc.) were forwarded to the vendors at 50 percent completion, so that preliminary tool design could occur in parallel with final component design. While a truly global vendor base was utilized for the various components, the tooling cycle moved quickly and efficiently. The integrity of the mechanical design coupled with direct downloading of CAD files for all tooling generation resulted in a flawless integration of the various components into the final assembly.

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The fully detailed, 3-D assembly enabled the team to have in-depth design reviews which provided test engineering, manufacturing engineering, quality control, clear insight regarding assembly fixtures, test fixtures, line rates, special assembly tools, etc. Consequently, all related manufacturing hardware was generated in parallel to the component hard tooling. This accommodated a smooth, seamless transition from the design team to the industrialization team.

With presently over half a dozen patents pending, the resulting design is a quantum leap in cellular terminals. Featuring such innovations as a two shot, revolving platen front cover, integrally molded front cover rubber side keys, acoustic side porting for the massive 36 mm, diameter speaker in loudspeaker mode, and a high/low speaker switch with a fail safe sound pressure level mechanism to name only a few, the R250s is as technologically advanced as it is rugged. The design has met or in most cases exceeded every environmental operating requirement imposed upon it. Amazingly, the product was designed on two different continents with four different teams, on time, and within budget! The modeling capabilities will make them very attractive to companies in marginal need for powerful 3-D CAD design capability.

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R250s is so successful that the U.S. faction of Ericsson has adopted the design for stateside marketing. This success is directly attributable to the skill with which the various groups utilized their CAD tools as well as the high degree of cross-communication between the design groups via their translated CAD models.

This type of success is not restricted to the telecommunication industry. It can be achieved in any product development. Interestingly enough, the more diverse the various groups in the design team, the greater the relative increase in productivity when they begin cross communicating through their respective CAD tools. Conversely, for products that involve relatively simple geometry, minimal analysis, few discrete design groups, etc, this approach may not be suitable. The CAD design tools used in this project are expensive — ranging from several thousand to over $100K per license. Furthermore, the UNIX workstations necessary to run them generally start at $15K minimum. Training, system support and software maintenance agreements are equally expensive. There are other options, however. The growing popularity and increasing performance of the NT class computers has prompted many high-end CAD software suppliers to develop and market NT versions of their software. Coupled with the NT computer, these CAD systems are presently somewhat less powerful than their UNIX "big brothers," however, their much lower price and strong modeling capabilities will make them very attractive to companies in marginal need for powerful 3-D CAD design capability.

New product design and development is beginning to see the full benefits of broad use of CAD, CAM and CAE. Crucial to the success of any new product development is communication between all design groups of the team. The greatest mechanism for that communication today is 3-D CAD. While the various disciplines utilize different CAD tools, recent refinements of numerous translation software packages provide a common language that allows discrete design groups to share information and design more efficiently.

*** Alias**
**** Stratasys FDM prototypes**
***** Unigraphics**
****** Ansys**
******* Moldflow**

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Bill Jennings, *a mechanical engineer, has been designing electronic packaging for military and consumer customers for 18 years. He is president of Stone Mountain, Ltd. of Huddleston, VA. The company provides comprehensive engineering services, specializing in electronic packaging product development.*