Going 3D:

Survival Guide for 2D CAD Users

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Why Delaying the Move to 3D is Not a Viable Option

CHAPTER 1

We all know that making a few relatively simple changes in our lives – like losing that last 10 pounds, committing to a daily exercise regime, or giving up an unhealthy vice or two – can lead to tremendous payoffs down the road. We all know it's for the best in the long run, but we often seem to fixate more on the short-term pain, discomfort, and starvation as compelling reasons to put off these changes.

Transitioning product development from a 2D design system to a 3D solid modeling design system falls into this same category. While you might be convinced that ultimately it's the right move and believe wholeheartedly in the bottom-line competitive benefits of making the move, you might also cringe at the thought of the immediate problems that this conversion would bring. Productivity downtime, data translation woes, high initial entry costs, loss of legacy data, increased hardware requirements, and the need to retrain staff are just the tip of the iceberg.

In today's manufacturing world, who has the time to deal with even one of those problems? There certainly is a case for some design work to remain in the realm of 2D – AEC, GIS, and schematic design, to name a few. However, the majority of design done by manufacturers would greatly benefit from the use of 3D design tools.

Throughout this e-book, we'll take a closer look at all the concerns that manufacturing companies have when evaluating a conversion to a 3D design environment. We'll examine topics such as the evaluation of 3D software packages; implementation issues, both technical and cultural; the preservation of legacy data; and the use of downstream, add-on software tools.

We'll also talk to engineers and engineering managers who have navigated such a path, and you'll read in their own words what their obstacles were and how they were ultimately overcome in the real world. You'll also read how migrating their designs to 3D resulted in big payoffs to their product development process.

Bottom-Line Benefits

Trade magazines and design consultancies have long proclaimed the benefits of 3D design techniques and how these benefits can drastically improve a manufacturer's ability to compete. Among the benefits touted are shortened design cycles, streamlined manufacturing processes, faster time-to-market due to the improved flow of product design information and communication throughout an organization, reduced design costs,

Image courtesy of Haumiller Engineering

By designing its automated machine assemblies in 3D, engineers at Haumiller Engineering have a better way to reconcile the behavior of individual parts within an assembly, drastically reducing costly physical prototyping and also cutting its design cycle by 20 percent.

faster design changes, and, ultimately, higher-quality products.

Though these advantages have been heavily publicized for years, many manufacturing companies have been productive using 2D design tools and might question why they need to make such a transition. To answer this question and more, we'll take a look at these proposed benefits one by one and examine why so many companies are deciding to migrate to a 3D solid modeling design environment.

In the 2D world, drawings are continually modified and reinterpreted throughout a product's lifecycle. While all designs go through multiple iterations, designers working in a 3D design environment can create production-ready detailed drawings automatically, eliminating time-consuming drawing view creation, manipulation, and maintenance. They can also show their designs from multiple angles and can enlarge details of specific components with just a few mouse clicks.

Image courtesy of Daka Designs Limited

For the design of the DOLPHIN water scooter, Daka Designs Limited used a 3D solid modeling design system and was able to reduce its design cycle by 50 percent, cut its development costs by 50 percent, expedite the development of molds and tooling, and accelerate time-to-market.

Every new product design must undergo changes as it evolves through the development cycle. Each change a designer makes to a 2D drawing or a 3D model created in a 3D CAD system is reflected accurately throughout all associated views, sheets, and drawings. All drawing views, dimensions, and annotations update automatically, so the designer never has to redraw a section, detail, or isometric view manually, greatly reducing the possibility of errors.

Speeding Up Product Design

To compete in today's manufacturing environment, companies are under tremendous pressure not only to crank out new products surpassing that of their competitors, but to beat them to the shelves as well. Few would argue that once mastered, 3D solid modeling systems provide a faster and more efficient means to create product designs.

In the 2D world, creating a detailed component in orthographic views can require four to fives times the number of command entries than it would in 3D, most of which are duplicates of other commands. Drawing creation adds substantial time and expense to a design project, especially when the task involves intricate parts or complex assemblies.

Conversely in the 3D world, one line can be used to establish the *x*, *y*, *z* coordinates and then can be moved, copied, scaled, or somehow manipulated to create the 3D model. Once the 3D model is created, isometric, exploded assembly views – or detail and section views of a drawing – can be easily generated by most 3D CAD packages. Alignment and dimensioning in most CAD software programs are automatic by simply clicking on the edges or centers of what must be dimensioned.

Being able to use online 3D parts libraries also save significant design time when creating 3D CAD models. These 3D parts libraries produce native, feature-based, mechanical design components, such as fasteners, bearings, and steel shapes, which are based on industry standards or on manufacturer catalogs. Every part has custom property data associated with it, such as the part name, manufacturer's name, part type, and size.
Several million parts are available online through various resources, and all parts can be edited to fit users' specific requirements. These online 3D parts libraries enable designers to add the components into their designs without having to remodel them from the manufacturer's specifications, a huge timesaver.

Design Changes on the Fly

One change to a part often impacts multiple views of the drawing, requiring the engineer to manually update all assembly models, drawings, views, details, and bills of material (BOMs), an inherently error-prone process. Making a change in 2D also often necessitates an additional round of drawing checking, a time-consuming and tedious process.

On the other hand, making a change to a 3D solid model is much simpler and faster. Solid modeling systems offer bi-directional associativity, which assures the user that all elements of a model are associated or connected. When a change is made to a 3D model, it is automatically reflected in all related drawings and associated views.

Parametric design functionality is another feature of many solid modelers that facilitates engineering change orders (ECOs). Originally developed for the aerospace and automotive industries for designing complex curved forms, parametric modeling works like a numerical spreadsheet. By storing the relationships between the various elements of the design and treating them like mathematical equations, it allows any element of the model to be changed, and then instantly regenerates the model in much the same way that a spreadsheet automatically recalculates any numerical changes.

In parametric-based solid modelers, all features and dimensions of a model are stored as design parameters, allowing designers to make fast design changes by simply changing the value of the parameter. When a value is changed, the model is automatically updated to the new value, and all other model features and dimensions affected by that change update automatically. Solid modeling systems that offer both bi-directional associativity and parametric design functionality not only speed design changes, but also greatly reduce the chance of errors.

Maximizing the Value of 3D Product Data

One problem inherent to 2D design is the fact that, after all the work is done to create the many levels of drawings that ultimately represent a product, that data is practically worthless to other applications such as structural analysis and downstream manufacturing processes, including tooling creation and numerical control (NC) programming. These functions require 3D data, which must then be created from the original 2D drawings.

Another way to derive value from a solid model is to analyze and test designs while they are still digital. The ability to test products when designs still reside in the computer not only saves on prototyping costs, but also provides engineers with a way to quickly iterate and optimize designs without worrying about delays or prototyping costs that might derail production schedules and budgets.

Traditionally, designers have had a defined window of opportunity to improve upon a design before having to move it forward in order to adhere to product schedules, often resulting in an "it's good enough" attitude – hardly the hallmark of truly optimized designs. Today, however, due to solid modeling tools that are fully integrated with analysis, as well as simulation tools running on affordable yet powerful PCs, engineers can simulate models, go back and make a change to the CAD model, and then very quickly see the effects of that change.

Modularity is another trend in manufacturing that has benefited from design reuse. As consumer markets become increasingly finicky, manufacturers have responded by creating families of products, each with subtle differences to appeal to distinctive groups of users, while still using common components. These modular products may vary in size, weight, dimension, or capacity. For the manufacturer, products that share common modules within a product family are more efficient to design and manufacture, are easier to upgrade and maintain, and enable the reuse of product data – all of which reduce the overall lifecycle costs of new products.

Using 2D, it's nearly impossible to develop various configurations of products, assemblies, or families of products efficiently, since each individual assembly must be redrawn from scratch. Some 3D CAD systems offer configuration management tools, which enable users to create multiple variations of a product in a single document. These tools also help users to develop and manage families of parts and models with different dimensions, components, properties, and other parameters.

Another area in which 3D product data can be leveraged is downstream in product documentation and assembly. While 2D drawings can support some documentation needs, usually these functions require customized isometric and exploded assembly views and 3D graphics. Often, this would require additional work in the 2D system, as well as special technical illustration or 3D graphics software. With 3D design, all graphics, drawings, and exploded assembly illustrations can be easily exported from the original solid model.

Furthermore, some 3D CAD systems offer software components that enable engineers to publish their 3D CAD models to interactive online catalogs. By accessing these online parts catalogs, customers can configure, view, and download a manufacturer's 3D models of products directly into their designs. Publishing an interactive online catalog of 3D parts makes it easy for customers to incorporate these parts into their products regardless of which CAD system they use, ultimately leading to increased sales, higher generation of sales leads, and lower sales support costs.

One Model for All

Now that the model has been created, everyone involved in product design has access to the product data. Whether personnel need a mold, a drawing, a sketch, a fixture, an NC program, a BOM, or a rendered image for sales and marketing efforts – all the data is contained within that one solid model, which feeds the entire enterprise.

With 2D designs, the brain must interpret the three views of the drawing and mentally put together an isometric representation of the product, which might be easy for skilled engineers but may prove difficult for nontechnical members of the design team. Misinterpretation of 2D drawings can result in a loss of the engineer's original design intent, leading to costly delays and reworks.

A 3D model, on the other hand, needs no interpretation, which greatly simplifies the communication of design intent to the rest of the design team – the machinists, sales and marketing staffs, materials resource planners, process engineers, and customers and supply chain partners.

Solid models also enable collaborative or concurrent engineering practices by enabling 3D CAD data to be shared online, so everyone involved can iterate on designs simultaneously. Solid modeling systems also offer revision control and built-in security features. As a result, users can be assured that they are working on the most current version and that only authorized personnel are allowed to make changes.

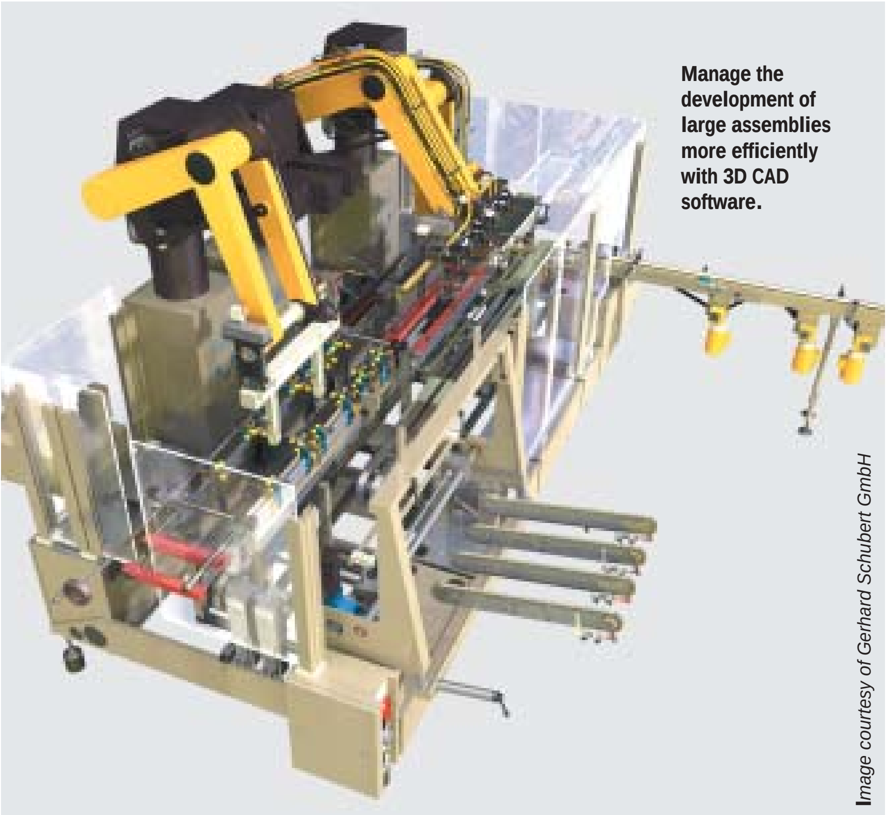
Get a Better Look

It's been said before, but bears repeating: If a picture is worth a thousand words, then a 3D model is worth a thousand 2D drawings. Simply said, solid models are infinitely easier to interpret than a series of 2D static drawings that represent the same design. Since hidden lines and mass properties are removed automatically in solid modeling systems, it's easy for both engineers and laypeople to have a better understanding of design intent.

Using 2D drawings of product components, subassembly interfaces, and working envelopes, engineers cannot fully determine the fit, interface, and function of assembly components. Consequently, problems often don't surface until physical prototypes are created late in the design cycle, when problems are extremely costly and time-consuming to resolve. By being able to visualize parts and assemblies in 3D, engineers can assess fit and tolerance issues early in the design process, long before parts are manufactured. This capability is often referred to as "virtual prototyping."

What's more, solid modelers allow users to easily create more realistic, fully rendered models of the product early in the design cycle. Because of this, marketers can get a head start on assessing customers' opinions on new products while they're still in the conceptual design stage. Taking visualization a step further, many solid modelers also offer animation features so that product data can be brought to life – even before products exist in physical form – to assist with sales, marketing, and customer service efforts.

Improved design visualization also greatly improves the ease and speed of obtaining design approvals, because designs can be better communicated to management, marketing, clients, and end-users.



Manage the development of large assemblies more efficiently with 3D CAD software.

Image courtesy of Gerhard Schubert GmbH

Designing the Large and Complex with Ease

Using 2D to design large, complex assemblies composed of thousands of moving parts is a tedious, labor-intensive, error-prone, and extremely slow process. Simply managing the numerous production-level drawings for these large assemblies is a huge undertaking.

Most 3D solid modeling systems offer features that help manage the accuracy and completeness of assembly production drawings. For assembly design evaluation, many of these modelers offer built-in tools for interference checking and collision detection, and also allow multiple designers to collaborate on assemblies.

Danger: Curves Ahead

Often, designers are asked to create the kinds of complex swooping surfaces that so many products, from toys to consumer electronics, now possess in order to distinguish themselves on increasingly crowded store shelves. Because of a market trend toward ergonomically correct products, there's more pressure on designers to create products that mesh perfectly with intended users. Designing these types of complex surfaces and ergonomic forms is nearly impossible with traditional 2D software.

To handle these design requirements, many solid modeling packages provide engineers and designers with tools to create curves, blends, fillets, and many other complex design features that are required of these complex shapes and surfaces. In addition, users of solid modeling packages can use specialized surface modeling software to create highly stylized and extremely complex surfaces that fully integrate with their 3D CAD software. These packages use the existing solid model as the basis for surface creation, so users don't have to start from scratch with new software.

Don't Get Physical

Another enormous benefit of solid modelers is that they can help manufacturers ease their reliance on physical prototypes. Building and testing physical prototypes – an expensive, time-consuming bottleneck in the creation of new products – is one area that manufacturers are critically examining to reduce overall design costs and speed time-to-market.

Product development teams that rely on 2D design methods must create physical prototypes of their designs to test the performance of assemblies, detect whether parts will collide with one another, and ensure that components all have adequate clearance. By visualizing assemblies in a 3D design environment, engineers can quickly assess and resolve fit and tolerance issues using the built-in interference checking and collision detection that are offered in most solid modelers, thereby reducing the need to build prototypes.

Simulation and analysis tools can also significantly cut down on a manufacturer's prototyping needs. While physical tests are often still required for product certification, simulation is more cost-effective and repeatable than physical tests. Analyzing more product configurations on the computer, without the need for costly prototypes, results in better products and reduced testing requirements.

Opening the Door to New Technologies

By creating a solid model, the designer or engineer has opened the door to a host of additional integrated software tools that can further help test, manage, and manufacture products. These integrated solutions not only use the same 3D data as the CAD system, but also often use a common user interface, making them easier to learn. Plus, some add-on solutions are integrated in a manner that allows the user to launch the software from within their CAD system.

Simulation tools offer manufacturers tremendous competitive advantage. Daratech, an information technology market research consultancy, predicts that increased competitive pressure, easier-to-use software, and powerful computers will further fuel the adoption of digital simulation tools by manufacturers. These tools include structural finite element analysis (FEA), computational fluid dynamics (CFD), motion simulation, crash, process integration, and design optimization. Besides increased productivity, Daratech says that these digital simulation tools promise faster time-to-market, lower warranty costs, and – above all – products that outperform, work better, are safer, and fail less often.

Another integrated add-on software tool that a company might deploy is product data management (PDM). Besides facilitating real-time collaboration on design projects to ensure accuracy, PDM systems organize everything from quotes and office documents to installation measurements and analysis reports. With an abundance of floating software licenses spread throughout a manufacturer's various departments – engineering, manufacturing, sales, purchasing, quality, and field personnel – it's critical to have a system for tracking and managing files and documents.

While many 3D CAD systems offer some PDM component, it's important for manufacturers to carefully evaluate the available options and the reputations of those vendors, as well as the degree of integration provided. The use of 3D solid modeling also opens the door to the use of highly specialized applications, such as sheet-metal tools, optical design applications, reverse engineering, and tolerance analysis software.

Reality Check

User Q&A: Adam Stevens, Industrial Designer, McCue Corporation

Keeping kiddies happy while shopping is no easy task and can be taxing to even the most patient parent. McCue Corporation is striving to make these quick trips easier, more fun, and safer. The company designs, manufactures, and sells protective and decorative bumper and shopping cart management systems for customers in the retail industry. The company also makes Bean, the combination grocery cart and children's car used in supermarkets around the world.

Adam Stevens, an industrial designer in New Product Development at McCue Corporation, explains what he thinks are the biggest benefits of moving their designs from a 2D-based AutoCAD to a solid modeling environment.

Q: What do you feel are the biggest benefits of using 3D solid modeling to create new products at McCue?

A: The top three benefits that McCue has seen are dramatically increased speed of design creation, faster design changes, and increased support of marketing/sales materials.

Q: What specifically was the problem with using 2D design methods to create drawings?

A: With 2D methods, there is room for misinterpretation. If the parts do not meet the initial design intent after review, then rework will be required. This, in turn, will lead to elongated timelines as the parts are redrawn, then modeled, reviewed and, if approved, sent off to production.

Q: How does using 3D solid modeling alleviate these problems?

A: With solid modeling, we can draw and manipulate the parts in virtual space, review either on-screen or on prints, then send them directly for an SLA prototype for final review. If there are any changes to be made, these can be done immediately. From here, the parts are dropped into a 2D drawing, if necessary, and sent directly to the manufacturer electronically (both the 2D and 3D files).

Q: How has this improved the overall quality of your designs?

A: We can explore many different configurations and ideas at the same time to get the most effective and pleasing design. Here at McCue, we are a very hands-on company, and in our market, there are not many key players. So fast time-to-market is crucial. As a result, the ability to quickly turn around 3D prototypes for review is key.

Q: How was prototyping done when the company was still creating designs in 2D?

A: For our Bean product, the initial prototype was produced by hand from sketches at full scale. During design reviews, if a change was necessary, the large model had to be sent back to the model makers for rework and then reviewed again, which typically resulted in a seven-day turnaround time.

Q: How has the prototyping process changed since migrating to 3D design?

A: The latest rendition of this product was produced entirely using 3D. All reviews were done using either renderings of the solid model and/or scaled stereolithography (SLA) rapid prototypes, which we could usually get back with changes in a two-day turnaround time.

Q: What about the reuse of design data?

A: With 3D, we now have a definite record of the design from its very beginning, compared to the first rendition where the entire pattern was created by hand. Our design team had to attempt to recreate this design in 3D by using crude measurements and our eyes. If we wanted to expand on a design and incorporate features into a second product that was similar, we had to model a second part by eye from the initial hand model. With the 3D program, we can copy features and shapes exactly; there is no human interpretation involved.

Q: How has using 3D sped up your design changes?

A: In the event of a change, the part can be updated and sent directly to the vendor electronically for the revision. The time spent converting from 3D to 2D is literally a click-and-drag operation, whereas before it was drawn in 2D and then created in 3D (either by hand or programmed into the CAD/CAM system). Once again, we can also rapidly explore options for the update in a "virtual world," as compared to reviewing sketches or waiting on models.

As I mentioned, the initial design of the Bean was created by hand, and we had to re-create it at a later date. Because we had no definite starting geometry, any design changes consisted of manipulating our 3D models, translating that to the molding patterns, and then reviewing to ensure the design intent was captured. With the new Bean, all design changes captured using the 3D modeling software were known to be true. This reduced the time spent on reviews, as well as the time needed to make the part changes.

Q: How does using solid modeling facilitate downstream sales and marketing efforts?

A: With our constant product innovation and product improvement, the ability to support marketing and sales literature is crucial. We work very closely with our marketing department to create product literature with the use of realistic, fully rendered solid models produced in our 3D CAD system. These renderings are also used in installation/assembly instructions, training materials, customer mailings, and a quarterly industry newsletter called *Solutions*.

User Q&A: Kevin Quan, Senior Engineer, Cervelo Cycles Inc.

Cervelo Cycles Inc., Canada's leading bicycle maker, uses 3D solid modeling to create the carbon fiber bicycles that have been ridden to victories in the Tour de France, Ironman Triathlon, and Olympic Games. Now we'll hear from one of the company's senior engineers, Kevin Quan, on why 2D design was no longer cutting it for the design of this industry leader's cutting-edge bicycles.

Q: What do you feel are the biggest benefits of using 3D solid modeling?

A: From our perspective, the biggest benefits have been the ability to visualize and create complex surfaced parts, to assemble parts together and check interferences, and to create associative geometry between parts.

Q: What do you feel are the shortcomings of using 2D design?

A: With 2D design, it's too easy to "cheat" and create drawings that reflect nonmanufacturable parts. Also, 2D drawings are easily corrupted, and their views often contradict one another. What's more, in 2D drawings, curves are often not tangent, or they may overlap or have gaps.

Q: How does using 3D solid modeling alleviate these shortcomings?

A: 3D modeling encourages you to create clean sketches; otherwise, a solid cannot be created. In addition, 3D surfaces easily illustrate when curves are not tangent. Automatic view creation in drawings eliminates the contradiction between views.

Q: How has using 3D design improved the overall quality of your designs?

A: Now that we've transitioned to 3D design, we can create parts with more accurate fits and tolerances. We can also create more aesthetically pleasing bicycle designs using surfaces, as well as anticipate the needs of manufacturing with industry-specific feature creation.

Q: How was prototyping done when the company was still creating designs in 2D?

A: We relied on the abilities of the machinist or vendor creating the prototype to correctly interpret our 2D drawings.

Q: How has the prototyping process changed since migrating to 3D design?

A: We now give solid models to the vendors who use CNC machines to create our parts. We still have 2D drawings of our parts, but fewer dimensions (just the critical ones) are depicted. We have greatly reduced the need for prototypes and can frequently go straight to final tooling.

Q: How has using 3D affected making design changes?

A: Our pace and volume of making changes have significantly improved. We can create images of many more design alternatives for management, and we can analyze the changed designs using FEA to qualify them.

Q: How does using solid modeling facilitate downstream sales and marketing efforts?

A: Realistic images can be created for marketing at an earlier stage. And now, decals can be created with improved accuracy because we can model those in 3D too. Also, 3D design has provided us with faster time-to-market, which is a powerful weapon against our competition.

From the Manager's Perspective

Manager Q&A: Steve Callori, Vice President of Engineering, Schilling Robotics

Schilling Robotics is using 3D solid modeling to create the critical parts of an "exoskeleton" that will someday help soldiers, firefighters, and rescue workers carry backbreaking loads without feeling the weight. The company – known for its remotely operated deep-sea work vehicles and manipulator arms – is designing the hip/thigh/knee assembly for the second-generation Berkeley Lower Extremity Exoskeleton (BLEEX), which will enable people to carry a 70-pound backpack, yet feel as though they are carrying five pounds.

Q: What do you feel are the biggest benefits of using 3D solid modeling?

A: 3D design makes it easier to visualize parts and assemblies, thereby helping to identify problem areas in a design. Parametric models allow users to see the effect of making changes to particular features. It also enables our engineers to quickly see stress analysis information. 3D design also provides mass and volume properties, as well as a model for the complex 3D shapes that can be used to machine parts.

By moving to a 3D design system, Vermeer Manufacturing improved product performance and styling, shortened prototyping and analysis time, reduced scrap and rework substantially, and increased collaboration and efficiency across multiple workgroups.

Image courtesy of Vermeer Manufacturing5

Q: How has using 3D design improved the overall quality of your designs?

A: Solid modeling makes it easier for our engineers to create designs and drawings, and it also facilitates their ability to perform simple stress analysis. It provides an easy way to quickly see the system-level impact of making changes to the parts at a lower level in the system, which makes it easier to optimize the design.

Q: How was prototyping done when the company was still creating designs in 2D?

A: The same way as with 3D. After designs were reviewed, a prototype part was created. However, 3D provides us with a better way to visualize the design before an actual hard copy is created.

Q: How has the prototyping process changed since migrating to 3D design?

A: It hasn't really changed, other than providing a better look before a prototype is created. Theoretically, this should make the first prototype better when using 3D, but that is difficult to measure.

Q: How has using 3D affected making design changes?

A: For our new designs that are in 3D, the changes are easier because the models are parametric. Plus, 3D forces the engineer to deal with the impact of changes on higher-level assemblies. While this information was available using 2D, the engineer could choose to ignore the effect. That is not allowed using 3D.

Q: How does using solid modeling facilitate downstream sales and marketing efforts?

A: Using 3D design makes it easy to create lifelike models so customers can visualize the product.

User Q&A: Clint Hudson, Applications Specialist, Vermeer Manufacturing Company

Vermeer Manufacturing Company is a global leader in the manufacture of machinery and equipment used for agricultural, tree clearing, and excavating purposes. Since migrating to a 3D design system, Vermeer has increased product complexity, eliminated design and manufacturing steps, shortened prototyping and analysis time, reduced scrap and rework, and improved the style of its products.

Let's hear what Clint Hudson, an applications specialist at Vermeer, thinks are the primary benefits of moving new product designs to a 3D solid modeling environment.

Q: What do you feel are the biggest benefits of using 3D solid modeling?

A: One of the biggest benefits is the similarity between the way models are built in 3D and the way they are built in production. Because the users are designing in 3D, they get to better experience the model in much the same way that an assembly worker experiences the results, including tough-to-access assembly locations, fit-up, and weight. Personally, I think the best part about our 3D CAD system is that an engineer gets to teach the software how to design a product. You can explain the rules, limits, and reactions to different changes, and allow the software to follow up with them. The more you teach the software, the more it can help you in the long run.

Q: What do you feel are the shortcomings of using 2D design?

A: Companies designing in 2D have to do most of their design outside of the drawings. They use their drawings to essentially record what has already been designed. The components shown in a 2D drawing are a collection of nonintelligent lines, circles, and other geometry. The software doesn't understand which lines represent a particular part or assembly, and which lines belong to another part. This means that maintaining a BOM through the course of the design is a more manual process.

Q: How has the use of 3D design improved the quality of your designs?

A: More complex parts are being designed now that we have software that enables us to visualize and control how the complex shapes interact with each other. Solid modeling also allows us to readily use FEA on more accurate representations of their finished designs instead of cutting corners or using oversimplified models. The parts are able to undergo the first rounds of testing without yet being part of reality.

Q: Vermeer products consist of assemblies with 500 to 4,000 parts. How does 3D solid modeling help you deal with these large assemblies?

A: Fit-up problems can be identified, the full range of motion can be explored, and all potential interference issues can be resolved since the model more accurately represents the finished goods. Each solid model part in a solid model assembly represents a physical part in a physical assembly. If a solid assembly is composed of a handful of parts in varying quantities, the software can quickly generate a BOM.

Q: How do other personnel on the design team use 3D product data?

A: At Vermeer, marketing personnel, FEA analysts, and CNC programmers are able to use the 3D models generated by Engineering with little or no reproduction of effort for their own purposes. Additionally, the model reflects the BOM, which prevents errors on the administration side of the business.

Overcoming Cultural Barriers to 3D Adoption

CHAPTER 2

Once a company recognizes the need to move from 2D to 3D design, there is a plethora of hurdles – both technical and cultural – that must be overcome. Engineers and designers must be retrained on the new system, which is often radically different from the system with which they're accustomed. Executives must be firmly on board with the project, ultimately convinced that the initial costs and loss of productivity are worth the investment over the long term.

Often, CAD managers, as well as the engineers and designers who report to them, are the first to recognize the benefits of designing in 3D. Faster design creation, easier and more accurate design changes, better communication of design intent, and the ability to test designs while still digital are among the many benefits that come to mind when pondering such a transition.

Upper management, however, might see the situation completely differently. The first objections that might pop into their heads when thinking about embarking on that same path could be increased costs, the need for additional staff training, reduced productivity, and the possibility of losing legacy data that have taken years to accumulate. While some of these concerns might be easily mitigated, others are grounded in reality and should be carefully addressed before an implementation is initiated.

The first task is to attain upper-management buy-in. The only way to successfully implement a new technology, such as a 3D CAD system, is to ensure that executives have a full understanding of the time savings and competitive benefits that are obtainable using 3D CAD. Though certain costs might prove difficult to predict, upper management must also be told upfront of all definable costs – both monetarily and in the loss of productivity – that the company will incur as a result of this transition.

Once upper management has been convinced, it's essential to keep them in the loop, holding monthly internal user-group meetings to assess how the planning and implementation are progressing. Keeping management abreast of the implementation via regular reports will help to alleviate uncertainties and to assure their continued support, which is crucial to the success of the project.

Hartness International, a manufacturer of custom packaging machinery, needed 3D solid modeling capabilities to quickly explore part and assembly alternatives in real time in order to optimize machinery performance. Using 3D solid modeling, Hartness engineers were able to design assemblies and test them before building parts, which ultimately enabled them to shorten the design and manufacturing cycle from five months to just two months.

Protecting Investments in 2D

One indisputable fact to present to management is that 2D CAD technology has matured to the point where it has achieved all the productivity benefits it is capable of providing. Conversely, 3D CAD is a different, relatively new technology, which is capable of delivering even more benefits to everyone within the manufacturing organization and its collaborative supply chain.

The adoption of 3D solid modeling enables a company to make design changes much faster and with fewer errors than with 2D CAD. After a design change is made to a solid model, all drawing views, dimensions, and annotations update automatically. So the designer never has to manually redraw a section, detail, or isometric view, greatly reducing the possibility of error. Unlike 2D techniques, solid modeling design methods allow engineers to produce drawings much faster.

Implementing a 3D CAD system at Intertape Polymer Group (IPG), a manufacturer of specialized polyolefin plastic and paper packaging products and systems, resulted in shortened development time by 10 percent; lowered development costs by 35 percent; decreased errors by 50 percent; and reduced rework by 75 percent.

In addition, solid models greatly facilitate the communication of design intent throughout the organization. An accurate 3D model, with all its associated nongeometric engineering data attached to it, becomes a complete digital product for design reviews, analysis, procurement, and manufacturing. Plus, its form is immediately usable by all personnel involved in product development, both technical and nontechnical, making it infinitely more valuable to a company than its legacy 2D data.

Despite this fact, many companies have large amounts of intellectual capital tied up in their 2D systems – from the actual drawings to the knowledge of their designers – which often makes them hesitant to shift gears and move to 3D. At these companies, the management might fear that they will no longer be able to use their previous design data efficiently and that extensive training will be required on new systems. They may also fear having to reorganize the processes on which their 2D drawings were based in the past.

Some of these fears are reality-based. Designers will require training on the new systems, their productivity on those new systems will not initially be up to par with what it was on the 2D system, and some processes will change. However, most 3D CAD systems do allow for the import of 2D data. Therefore, a company's investment in 2D legacy data will not be lost as a result of the implementation.

For these companies, a safer path to 3D might be a transitional 2D/3D design system that employs 3D design for new design projects while maintaining the 2D design process for design modifications. This way, projects are not disrupted, the transition can take place over a period of time, and designers will have time to receive proper training.

Myths Versus Reality

Let's take a look at some of the common objections that upper management often have when considering a move from 2D to 3D CAD.

Myth: Senior-level engineers don't get 3D design.

In reality, we all live in a 3D world and have an innate sense of how to navigate within it. The developers of 3D CAD systems have worked hard to create not only intuitive user interfaces but also logical work structures for designing 3D models. As a result, these systems are surprisingly simple for engineers to learn.

Despite this fact, it's realistic to assume that most engineers over the age of 30 were taught engineering in the 2D world. These engineers – many of whom are now senior-level engineers and designers – were trained on 2D, either CAD or drawing-based systems. The good news is that these same designers also understand firsthand the inherent weaknesses of 2D; therefore, many will easily recognize the areas in which 3D methods excel over 2D.

While some designers will remain resistant to learning 3D, insisting that they are still productive using 2D methods, many will view this change as an opportunity to advance their skill set and will eagerly embark upon 3D training. In fact, many of these proactive engineers may have already participated in some level of 3D design self-education – via tutorials, online guides, or VAR seminars – as a way to bolster their future job security.

Often referred to as "early adopters," these engineers and designers should be among the first to be trained in 3D CAD. After seeing the productivity gains achieved by the early adopters' group – or perhaps spurred on by concern over future job security in today's uncertain manufacturing industry – more engineers will follow the same path.

Myth: It costs too much.

When asked by upper management if this change is going to cost a lot, your answer should be, "Yes." However, this is also your first opportunity to begin building the case for the following fact: The savings in labor and the benefits derived from the new system will ultimately make for a solid return on the company's investment. More on that later, but let's first take a look at the specific costs.

One way to divert disaster and discourse down the road is to be completely honest with management from the outset. Inform them upfront of the exact costs of the software, hardware, training, and ramp-up time required for a 3D implementation.

After these costs are discussed, evaluate what the projected labor savings will be once the system is up and running. Labor savings, coupled with the savings derived from a reduced number of physical prototypes, can quickly – often within the first year – pay back the startup costs for the implementation.

Let's break down the specific costs of an implementation. First, there is the actual cost for the software as well as the integrated third-party software. Fortunately, the cost of 3D CAD systems has come down significantly since their introduction, due in part to the surge of midrange CAD products that have driven down costs while giving high-end packages a run for their money in terms of functionality.

According to Daratech, a market research firm, these midrange or value-priced 3D CAD packages – which were previously billed as 80 percent of the functionality at 20 percent of the price – now offer closer to 90 percent of the functionality and, in most instances, at 50 percent of what the high-end packages cost.

Most likely, there also will be increased hardware requirements, though these costs have been somewhat mitigated in recent years as high-powered, Windows®-based PCs have plummeted in cost. Other hardware expenses might result from the need for 3D graphics accelerators. There will also be costs associated with training engineers on 3D design systems, which can be measured both monetarily and in loss of man-hours.

Though these initial costs will be significant, perhaps the best way to overcome cost objections is to point out that your company's transition to 3D CAD is an investment in its future, a way to better compete in the years ahead. Migrating to 3D CAD will have long-term impacts on both sales and costs by enabling companies to build better products in shorter design cycles – with less waste of time and materials.

With varying skill sets, backgrounds, and ways of learning, 3D CAD training for engineers should be individually tailored. Options include traditional training classes, tutorials, VAR seminars, user groups, and online guides.

Myth: 2D works for us. Why change?

While 2D CAD can be an efficient way to create product drawings, 3D CAD furthers efficiency by speeding up every activity and by optimizing designs through the removal of many sources of potential inaccuracy and error. Moreover, the benefits of 3D CAD will be seen not just in the engineering department but also throughout the entire enterprise. The transition to 3D design will have a significant impact on areas such as quality, warranty costs, manufacturing, and assembly as well as sales and marketing.

To counter this objection, point out the areas in which 3D CAD can solve current problems more efficiently and, in the process, shave enough time off existing processes to pay for itself. To quantify this argument, make a list of all the ways in which 3D CAD could improve upon current processes and then calculate – in both labor and time – the rough time savings associated with each one. Though this is one way to quantify the benefits of 3D CAD, the real savings will ultimately result from higher-quality products that are designed and manufactured faster.

Some companies will contend that 3D solid modeling technology is of competitive advantage only to companies designing and manufacturing complex parts and assemblies. The reality is that any manufacturer – even those designing relatively simple products – will gain a competitive advantage by designing and manufacturing better products faster.

Picking the Right Project and the Right People

It might prove difficult for some companies to stop using 2D abruptly and move completely to 3D for all designs. Engineering managers need to assess carefully which project and which people to start out in 3D CAD. The best way to begin a 3D implementation is with a pilot project to ensure the decisions made during the earlier stages are well thought out. Pilot projects allow small, focused groups to test the implementation, documentation, and training processes within a smaller, more controlled environment. They also allow the team to make minor adjustments or changes to these processes as they are being established.

It's essential to the success of a 3D implementation to choose the right time and task in which to try 3D CAD. Since many designs are merely modifications of existing systems in which just a few areas of the design need changing, it would be impractical to use 3D design on these types of projects. A better approach might be to maintain legacy data in 2D and hold off on using 3D until a new design project arises.

Pilot projects should be shorter-term projects that are easily manageable and relatively low risk. After the completion of the pilot program, it's important for the engineering team leaders to conduct a postmortem of the project with the entire project team to assess what did and didn't work, and to determine the best ways to improve upon these processes.

To avoid disrupting and overwhelming designers, engineering managers might also try a step-by-step implementation that slowly introduces 3D modeling methods, depending upon the task at hand and the various skill levels of individual users. At this point, the manager must honestly analyze which engineers are qualified and motivated enough to make the first transition to 3D. Additional training and possibly extra work may be required of these engineers, so managers should be both realistic and honest in their expectations of these early adopters.

These engineers and designers will probably become the project's champions who will mentor other users during their transition – the ones whom other engineers will seek out when they encounter problems or have questions. One way to encourage these mentors is to provide simple rewards to acknowledge their efforts. While these rewards need not be elaborate, they are an important way to recognize the above-and-beyond efforts of employees who are crucial to the success of an implementation.

After implementing a new 3D CAD system throughout its organization, ECCO, a manufacturer of backup warning alarms for trucks and heavy equipment, increased revenue by launching a new, configurable product line, cut its design cycle by 40 percent, reduced scrap by 5-10 percent, and achieved higher levels of collaboration, communication, and efficiency.

In order to determine who will be on a pilot project team, as well as what type of training will be most appropriate for users, a manager must ask several questions: Do they have a 3D CAD background? Will they be "power" users? Will they be required to work with complex assemblies or parts? Will they be required to import geometry from other systems?

Another critical component of any successful technology-related implementation is training. Because all engineers have different skill sets, backgrounds, and ways of learning, training must be individually tailored. There is no such thing as "one class fits all." Several educational options are available, including traditional training classes, tutorials, VAR seminars, user groups, and online guides. Before any engineer participates in a full-fledged training class, it's imperative to do some preliminary investigation into 3D techniques, thereby ensuring that time is not wasted when the formal training begins.

The Manager's Perspective: Todd Mansfield, Systems Engineering Team Leader, ECCO

ECCO is the world's largest manufacturer of backup alarms and amber warning lights for commercial vehicles. The company's transition from AutoCAD to a 3D solid modeling system improved collaboration, communication, and efficiency; helped cut design cycle time by 40 percent; and reduced scrap by 5 to 10 percent. Let's hear from Todd Mansfield, systems engineering team leader, on how they overcame the cultural barriers to implementation at ECCO.

Q: How did you identify which engineers to transition first to 3D?

A: I would say there are two ways to look at it:

Who are the most agreeable people? And where is it most needed? You might have someone who's very proactive, but they really don't have any issues that are costing the company time and money. Conversely, you might have someone who's not that proactive, but they might be in a situation in which – if you don't fix it – you're going to have bigger issues as far as productivity is concerned.

Q: How do you motivate the engineer who's hesitant to move to 3D?

A: If you look at the people who are most down on implementing new technology, it's often the senior people in the shop who are holding on to systems that they may well have set up themselves. So they have a real sense of ownership on those older, antiquated systems. If you can go after them initially, turn them around, and get them into a proactive position, then you suddenly have a tremendous asset. You'll have turned your biggest critics into your biggest advocates, and that just changes the whole face of implementation.

They say, "I've done it this way forever, and I don't want to change." So you say, "What if I can show you how to take all this administration stuff off your plate? Instead of spending all day creating drawings that are just a by-product of 3D design, you get to spend your time doing what you went to school for and what you love to do – and that's design." Change is scary. But if you can partner with them and assure them that this is what you have to do to remain competitive, you can hopefully work with them to drive out that fear. It's a big ship, and it turns slowly. But once it starts to turn, suddenly it's just like a windfall for you.

Q: How did your company begin its implementation?

A: As painful as it was, we set a drop-dead date after which all future work – both new and existing – would be done in 3D. We had this huge, huge pile of legacy AutoCAD drawings. It was painful, and initially a five-minute change sometimes took a few hours. But if you don't draw a line in the sand, you're going to waffle between two systems forever. Initially, there's going to be some pain, but the rewards beyond that are well worth it. Last year, we had a 42 percent increase in documents created and revised.

Q: How important is it to a successful implementation to have management buy-in?

A: It's paramount. It's the number one issue. If you don't have that, you have no authority and no authenticity in what you're doing. If management doesn't share your vision, then you're dead in the water. You have to implement this while acting on the authority of senior management.

Q: How important is it to perform some type of advance ROI study on moving the company's new product development to 3D?

A: I think it's very important. ROI is easily calculated and important, but I think it's really secondary to pinpointing what your exact issues are. You might think you know what your problems are; but if you did some analysis, you'd realize that they might be different. If you don't know where you are or where you're going, any road will get you there. Until you define your issues, you don't know what the possible solutions are.

We made the decision to move to 3D for business reasons, because customers are expecting that level of modeling. Many of our customers today would not accept a 2D drawing at all. They are asking for solid geometry, as well as IGES and STEP files, outputs that only 3D can give you. You can't lose your focus on the fact that it's a business decision to go to 3D these days. It projects your technical competence. Today, 3D is no longer something only the latest and greatest do. You're shooting par golf if you're using 3D. It's no longer birdie golf; it's par and heading for bogey because things are moving so fast. Once you make the business decision, you get out your checkbook and ask, "Okay, what's it going to cost to get us there?" You know it's going to take time and money, but you do it. And once it's done, you're damn glad you did it.

User Perspective: Jeff Hallgren, Engineering Systems Software Analyst, Paper Converting Machine Company (PCMC)

PCMC has been a global manufacturer of paper-converting equipment since 1919. Let's talk to Jeff Hallgren, engineering systems software analyst, about how the company made the transition from 2D to 3D CAD.

Q: How did you identify which engineers to transition first to 3D?

A: Usually you look at starting with the engineers in the new product development area. They are the ones who typically start out with a clean sheet of paper. They are usually the go-getters, more innovative, and ready to accept new challenges. They also typically have more time as opposed to an engineer working in an engineered-to-order environment with anywhere from a couple of days to a few months' turnaround time. You need to transition them differently than the new product development team. Also, the new product development group can usually squeeze in the time to do the experimentation, so the productivity hits are not as great.

Q: How important is it to attain management buy-in for such a transition?

A: It's absolutely critical. If management doesn't drive it, it's doomed to fail. You really need to sell management on the benefits, and you also need to make sure they understand how long it's going to take and what the ramifications are. Management needs to understand that there is no magic button. There is no light switch you can turn on – one day you're on a 2D system, and the next day everyone is up and running and as efficient as possible on the new system. You really need to sell them on the fact that this is not an overnight process, that the benefits are real and tangible and there at the end; but you don't want to go too fast, and you don't want to drag it out.

Q: Should you perform some type of ROI study on moving to 3D design?

By deploying a 3D design system, JK Mold, a leading provider of high-end, complex molds for plastic injection-molded parts and aluminum and zinc die casting, cut its mold design cycle by 50 percent, increased its ability to import and export various data formats, improved design communication with customers, and enhanced its mold analysis capabilities.

A: You need to do the research. Get a VAR involved to do a lot of the legwork for you, and get a lot of references from companies who've done it – go speak to them, and then sit down and say, "OK, how is this going to help the organization?" It's important to look at ROI not just from engineering but also as a total organization tool because it's going to impact the entire company. Typically, the ROI does not come from just engineering; in fact, sometimes you actually take a cost hit by going to 3D in the engineering group. The real tangible benefits are seen in quality, warranty costs, reworks out on the shop floor. This is going to improve the manufacturing process and the assembly process, because now you can create these exploded views, e-drawings, and animations that will be used on the shop floor by those doing assembly work. They'll have a better understanding of the design.

A financial evaluation needs to be completed prior to the movement of any engineering group to a new MCAD platform; this holds especially true for 3D. When evaluating the cost elements of moving to 3D, all aspects of the migration must be assessed so that a reflective "total cost of ownership" is obtained. Financially, this includes the costs associated with developing the required infrastructure (training, VAR support, standard library creation, standard/best practices), PLM software, engineering analysis software (FEA, motion analysis), manufacturing CAM software, and frequent updates to users' workstations to ensure optimum performance. Additionally, costs should include conversion of legacy data.

A firm ROI can be extremely difficult to obtain because some of the intangibles do not correlate directly to fiscal return. The benefits of 3D modeling are more far-reaching than as a design tool utilized solely by and for engineering. Those organizations that don't migrate to a 3D system in the next 3 years will be left behind and will be placed in a position where they will be at an extreme disadvantage to their competitors. Four distinct benefits of 3D modeling recognized by PCMC were improved design efficiency, improved design quality, shortened development cycle, and improved assembly efficiency. We completed a projected ROI based on a sensitivity analysis that evaluated the impact to corporate workflow resulting from the 3D modeling migration. Although an ROI was projected, the 3D modeling project was really evaluated/sold on the total cost of ownership and the fact that as an organization PCMC couldn't afford not to complete a migration.

Q: How did you determine which project to use for your pilot program?

A: I highly, highly recommend a phased approach. It's best to manage it through new product development or products that are going to be around for a while; as far as legacy-type conversion goes, you need to track the products you work on most. Don't worry about small, obscure products. You need to really look at what products are going to be viable for the corporation over the next year, two years, or five years. There's no benefit to converting a product line that isn't selling.

Q: What were the important factors to your company in choosing the right 3D CAD system?

A: We looked for large assembly performance, configuration management, ease of use, and the support of the company itself. Which company is the leader? What's the financial health of the company? When you're doing the evaluation, realize that each of these systems is going to grow, and the technology is changing at a rapid rate, so look at which organization is responding best to the needs of their customers.

User Perspective: Alan Larsen, Engineering Analyst for IT at Autoliv Asp, Inc.

Autoliv Asp, Inc., a subsidiary of Autoliv Inc., is a global manufacturer of automobile safety restraint systems. The company began the road to 3D implementation in 1998. Though not completed, let's speak with Alan Larsen, an engineering analyst, to see how they got the ball rolling and how they overcame initial resistance to the project.

Q: How did you identify which engineers to transition first to 3D?

A: We picked the guys who moved the fastest, like those in new product development, who have to move fast. I was a member of that group. Once we realized the value for us, we looked at how we could mainstream it. Then we went out and found engineers who have repeating processes that took 2D or 3D and remodeled as they moved to each step – whether it was analysis for gas flow, such as CFD; structural analysis; or an illustration step, where they had to make illustrations and remodeling as they were hand-programming into CNC.

Q: How did you determine which project to use for your pilot program?

A: There was a pilot project group with just a few seats that were doing tooling, process equipment, and fabrication, but they were just hanging out there without a net or any support. Now we've turned the resources of the company to support that effort and have rolled out company standards. So the pilot project was kind of a case study for the company to prove it works. Then we went to the R&D group who has a lot more CAD diversity. They're the harder ones to bring in. But they were also isolated, so I could roll it out with them originally and not impact the rest of the company.

Q: Did these early users help transition other users?

A: Not really. Our pilot project was used primarily to remove a roadblock in the company. From that project, however, we created company standards that made it okay to do what we were doing, which was a significant step in trying to roll it out in the company.

Q: How did you attain management buy-in for the transition?

A: I picked my battles very carefully. We looked for areas in which it would be a slam-dunk, where we were getting rid of work processes. It isn't hard to define that to management. You say, "This step is going to be gone tomorrow," and they immediately see the value in it. When you try to tell them that it's better, there's always someone who's going to question everything you say. We didn't want to turn this into anything other than a slam-dunk. Even though they didn't entirely understand it, they understood it on their level. Now we're going back to reeducate them. We've done phase one, so now what does phase two entail? They can't really digest it in one bite, so there's a continual element to that.

Q: Have you completed your implementation of 3D?

A: No. We're about a year away. We started moving to 3D in 1998, but the company didn't fully support the effort. It was an underground effort. It's important to make it a grassroots effort rather than an underground one. Now we've made it visible to management – a solution that gets rid of redundant solutions.

Tackling the Technical Hurdles to Implementation:

Hardware Considerations

CHAPTER 3

Once an organization decides to plunge into the world of 3D design, a plethora of technical issues must be resolved. The computer systems on which you were running 2D design software will not be able to handle the increased demands of 3D. In addition, once computers and their related subsystems are obtained, a solid upgrade plan must be implemented to assure continued productivity in the future.

One common error companies encounter when embarking on a 3D implementation is thinking that they can run 3D CAD systems on their current hardware. Todd Majeski, president of Ohio-based 3DVision Technologies, a value-added reseller (VAR) of 3D CAD systems, says, “The most common mistake we see is people who believe that their existing hardware will be sufficient just to get started in 3D. They load the software, and it runs horribly. Then they realize they have to spend more money, and they get really upset. That usually comes from management who aren’t 100 percent committed to making the change anyway, because they are trying to save money here and there.”

Companies transitioning to 3D need to carefully specify all necessary hardware components to handle the increased demands brought on by 3D. You need to select powerful and easily upgradeable computers with ample memory (RAM), enough hard disk space to meet increased file-storage needs, a professional-quality 3D graphics card and driver, a stable network, and, if possible, a server dedicated to the needs of engineering.

What’s under the Hood?

Solid modeling requires substantially more computing resources than 2D. In the past, CAD software, because it is graphic- and computing-intensive, required expensive UNIX®-based workstations to run. Entire companies, such as Computervision and Intergraph Corporation, were founded on the basis of providing a hardware platform powerful enough to run CAD software. Even Sun Microsystems, Inc., today a major systems vendor, started out by providing technical workstations for the CAD community.

Today’s 3D CAD systems run on powerful Windows®-based PCs, sometimes referred to as “CAD workstations.” That’s good news for manufacturing companies who are upgrading to 3D. More good news is that chip vendors Intel Corporation and AMD have been embroiled in fierce competition for years, which has significantly driven down the costs of their respective chipsets – resulting in lower-priced PCs.

A good-quality workstation capable of running 3D CAD systems will cost approximately $2,000 to $3,000, excluding the monitor. Factors that could increase the price include added memory or the need for a high-end 3D graphics card.

In most cases, system performance is proportional to the processor speed of the PC's CPU, though it is far from being the sole contributor to performance. Most CAD systems will run well on systems based on Intel's Pentium® 4 or Xeon™ chipsets, or the AMD Opteron™ chips running either Windows 2000 Professional or Windows XP Professional (32-bit). A performance advantage of Windows XP Professional is the 3GB mode, which isn't available in Windows 2000. Recently, Microsoft introduced the Windows XP Professional 64-bit operating system, which will greatly benefit engineers working in 3D CAD.

Another factor to consider is the cache size of the computer. A CPU with a 2MB cache will offer better performance than one with only 1 MB. To better evaluate the various systems, you can run benchmark tests with real models, if possible, or check out standard benchmark scores of systems running various 3D CAD systems at http://www.spec.org/gpc.

How Much Memory Is Enough?

Memory is one of the most important components to consider, as most 3D CAD systems are fairly memory-intensive. When a system running 3D CAD runs out of memory, you will experience a significant decline in performance, due to the fact that hard disk access times are infinitely slower than memory access times.

So how do you know how much memory is enough? The answer to that question depends largely upon the datasets being loaded, as well as on the number of programs that you will run simultaneously. Most 3D CAD systems require a minimum of 512 MB of RAM, although for most engineers working in 3D CAD, that won't be sufficient. If you will be running multiple programs or working with large assemblies, the recommended RAM shoots up to 1 GB or more.

"The first thing I tell my customers is that they'll need more RAM than either they or their IT department thinks they'll need," says Jeffrey Setzer, Technical Services manager for Graphics Systems Corporation, a Wisconsin-based 3D CAD systems VAR. "I recommend they start out with 1 GB of RAM and go up from there, depending upon how complex their individual part models are or the size of their assembly models."

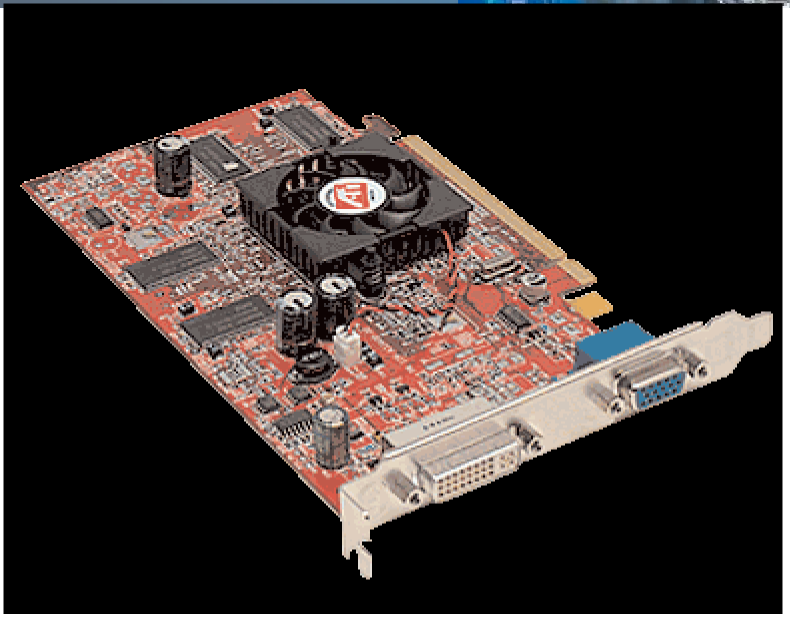
To test how much RAM you will need, test the software with real-world datasets. In order to get the most accurate picture, launch the 3D CAD system along with other applications that you would typically be running on your system. You can track and report memory used in the Windows Performance system monitor.

Keep in mind that as the complexity of the models developed increases, so does the demand for memory. Fortunately, memory upgrades have become fairly inexpensive. However, you need to anticipate the need for future memory upgrades. One rule of thumb is that the RAM on CAD workstations should be doubled every three years.

For those users who have very complex models or pull together pieces into an assembly, they may find that they are reaching the limits of a 32-bit operating system. If your machine has 4 GB of memory and this condition is reached, it is often seen as a "blue screen" condition or an "out of memory" error. These users will need to install the Windows XP Professional 64-bit operating system and upgrade their 3D CAD application to a 64-bit version.

The Importance of Networking

While raw CPU processing speed is important, don't forget the importance of a stable network, where bottlenecks can bring productivity to a standstill. Overlooking the network is the biggest



mistake companies make when implementing a 3D CAD system, according to Lutz Feldman, the marketing director of SolidLine AG. Headquartered in Germany, the company is a VAR of 3D CAD systems.

"In most cases, customers tend to focus on the workstation," says Feldman. "But network performance is even more important. From our experience, we have found the greatest bottleneck there. Performance is a must in this area for all components, including network cards, routers, and switches." When implementing 3D CAD, Feldman believes a good network is the most important component to consider.

The presence of an engineering server dedicated to the use of engineers is another critical component. At 3DVision Technologies, Majeski notes that one of the first questions he asks of companies transitioning to 3D is whether or not they have a dedicated engineering server.

"If they don't, then it's a red flag for us," says Majeski. "We tell them that you need to get an engineering server if you're going to work in a collaborative work environment, especially if the datasets are large. I would say that 80 percent of the time, companies have an engineering server. For the 20 percent of companies that are still on one big network, the datasets are going to become a bottleneck. They'll call us and complain that the CAD system is running slowly, and that's often the problem."

Another common mistake is ignoring the server when it comes time to upgrade. Companies will often set a schedule for upgrading engineers' personal workstations but will forget about the server, even though an outdated server will significantly slow down the performance of everyone's systems.

The Power of On-Board Graphics

Even with the fastest computer available, an inadequate graphics card can lead to slow refresh rates and jumpy screen behavior. To display geometry on the screen, most current 3D applications use either OpenGL (developed by SGI) or DirectX® (developed by Microsoft). Think of OpenGL and DirectX as APIs, which applications, such as CAD programs, use to place "calls" through to display geometry.

Both standard and professional graphics cards support OpenGL and DirectX; however, CAD users will need a professional graphics card. The main difference between the two types is the driver. A professional graphics board will offer many more supported commands than a standard card, which directs the actual processing of the commands to the card, freeing up the computer's CPU for its main computing task.

Software vendors test each of the professional graphics cards and drivers to certify which ones work correctly with their software. These tests check for issues such as screen errors and dual display support. On their Web sites, vendors list the supported cards and drivers. If you purchase a 3D graphics board and driver, make sure that the CAD vendor has certified them.

When you choose a graphics card, the two most important things to consider are its graphics processing unit (GPU) and the software driver that takes advantage of it. The bus between the CPU and the graphics card is another important consideration. The PCI Express bus provides a computer with a bidirectional line to communicate with the graphics card, thereby enhancing both the look and speed of the computer's graphics. With a clear path to the CPU and the system memory, PCI Express provides a much faster, more efficient way for a computer to get the information it needs to render complex graphics.

Some professional 3D graphics cards also offer optimized drivers that work with certain professional applications. The type of designs you are working with will best determine what type of graphics card you will need. If you are modeling fairly small assemblies in your 3D CAD system, a good-quality card that supports your application will work. If you are using a surface modeler to create the complex skins of a car body, for example, you'll need a high-end card to deliver the quality images that you require.

Changes in future operating systems will give graphics boards an increasingly important role in computing power. With the introduction of Microsoft's new operating system, codenamed "Longhorn," the GPU will handle much more of the computing than in previous releases of Windows, making the graphics card quality even more critical.

Hard Disk: How Much Space Is Enough?

By utilizing the fast read/write times of a hard disk/controller, you can improve the rate at which CAD software is read into a computer's memory. Fast disks and controllers also optimize the reading and writing of data, making them another important component. The hard disk type, spindle speed, and data transfer rate all affect the system's overall performance.

When determining how much hard disk space you will need, be generous. Calculate how much space you think you will need over the next three years and then double it. You will need it – and the larger the hard disk, the lower the cost-per-megabyte of disk space. In addition, regularly review the amount of free disk space available on CAD workstations. If there is less than 400 MB of free disk space, it can cause performance problems. If the operating system has little or no disk space, the system can become unstable or freeze up.

The available disk space should be periodically checked on local hard drives, the CAD system's backup directory, the Windows temporary directory, the Documents and Settings directory, and the network drives. If any of these locations start running low on available space, you have two options: add more disk space or remove files and/or applications to free up additional space.

Fragmentation of the hard disk is another problem that can affect your system's performance. This happens when files become scattered on the hard disk, and it requires more time to access files. If the disk becomes highly fragmented, it will take multiple iterations to defragment your disk to an acceptable level. To prevent fragmentation, run regularly scheduled maintenance on your system.

Multiple Monitors

There have been some major changes in the monitor market that benefit the engineering and CAD industries.

For one, graphics cards and today's operating systems, such as Microsoft's Windows XP, now provide support for dual monitors, which can provide big productivity gains for engineers working in 3D CAD. The other change has been the deflating prices of flat panel displays over the last couple of years.

The higher resolution of high-end monitors enable engineers working in 3D CAD to see more detail in their models – as well as more of their design layout – due to the additional screen real estate provided by bigger displays. In addition, dual monitors enable engineers to display their models on one screen, while keeping the commands on another screen.

Partner with a VAR

Today, the value-added reseller (VAR) plays an essential role in 3D implementation. A good VAR will do most of the legwork for a customer implementing a 3D CAD solution and will help down the line as companies add the use of integrated third-party software tools. VARs were once primarily in the business of reselling software; however, their role has evolved. Customers now expect the "value-add" to include support and expertise.

As a result, VARs are no longer simply pushing "boxes," but rather are playing a key role in delivering total solutions to their customers. VARs will be involved in all facets of 3D implementation: product selection, integration, training, implementation support, and automation. VARs can make recommendations regarding hardware needs as well as troubleshoot potential pitfalls, such as network issues, file management, and dealing with legacy data.

"We are much more a partner with our customers than we were in the past," says Setzer of Graphics Systems Corporation. "In many ways, we've become offshoots of their IT department, as it becomes more and more difficult to separate software issues from network issues from graphics card issues. So we've become much more involved in other areas of the company's business. Plus, we're educating not only the engineers on new techniques in 3D, but the IT people as well."

The Manager's Perspective: Todd Mansfield, Systems Engineering Team Leader, ECCO

Q: What's the biggest hardware change a company should anticipate when moving to 3D?

A: It takes a lot more of a computer to run a 3D system than it does a 2D system. With AutoCAD®, you can get away with not upgrading your machines on a regular basis. But when you move to 3D, there's going to be more data to crunch and that requires a higher-level system. With the cost of PCs dropping, that really is no longer a barrier. Back in 2000, to buy a nice CAD workstation you had to spend $2,000 to $3,000. Today, you can buy one that would run 3D CAD software with no problem for $1,000 or less, even with 1 GB of RAM on-board.

Q: What do you feel are the most critical hardware components to consider?

A: Everyone always talks about CPU, but RAM is definitely going to be a primary, if not the primary, component to consider. The amount of processing you can hold in that random access memory is key. Because once you fill it up, it starts to page out and utilize the hard drive – and then it becomes much slower.

Hard disk is the only other key component that CAD engineers need to consider. I would recommend a decent-sized hard drive that's going to be able to hold your files, because now, instead of dealing with 250K files, you're going to be dealing with 25MB files. These 3D files are bigger because they obviously hold more data. One of our lenses is a 25MB file, and that's just one part.

Though those are important factors, it's really the entire system. You need a fast processor to crunch the data, a big front-side bus to pass the information, lots of RAM so you don't page out, a big hard drive to hold all the files, and a high RPM hard drive so it can seek very quickly.

Q: What changes do companies need to make in regard to networking?

A: File transfer will be critical. Instead of passing 256K files, you're passing 3, 5, or 7MB files over the network. So network speed and connectivity are paramount. You must have at least a 10-to-100 Ethernet network with good hubs and switches, because the time you're going to spend sitting at your desktop waiting for files to come down directly relates to the quality of your network.

Q: What considerations do companies need to make regarding the network's server?

A: The key here is not only the size of the server, but also the fault tolerance. If the server is going to be your repository, you need to mirror your drives and write them to tape backup. You also want to have a server that performs decently. There are two mistakes companies make when it comes to servers. One is ensuring that your server is good enough. People will typically build a server and then never upgrade it. Unlike a desktop machine that you work on every day, all day, they don't realize that they work on a server every day too. Since it's not visible to them, they don't see performance degradation over time. Because it gets ignored, it's never upgraded.

The second mistake involves the number of services running on a server. Smaller companies will have one or two servers. They're going to be running DNS, print server, network antivirus, on down the list. At the end of the day, traffic matters. So a dedicated server, if at all possible, is important. All those services are taking up CPU time. So once again, you're not seeing the performance out of your server that you otherwise would. In our case, engineering purchased a server dedicated just to our PDM vault and our engineering files. It's tougher for smaller companies because resources are finite, but sometimes they're really shooting themselves in the foot. Many people don't do the ROI on what it costs to have an expensive engineer sitting there waiting for data.

The Manager's Perspective: Thad Perkins, Director of Mechanical Engineering, Paper Converting Machine Company.

Q: What's the biggest hardware change a company should anticipate when moving to 3D?

A: Increasing the frequency with which you replace your machines, which means going from a two- to three-year cycle to a 12- to 18-month cycle. The actual longevity of the workstations themselves is key. The power of the workstations, the amount of the memory, and the video card are also important. You need to do a very thorough analysis to evaluate what the best setup is for your application. When we're getting ready to upgrade our machines, we actually conduct the benchmark testing provided by our 3D CAD vendor to evaluate different workstations and video cards. I think that's really critical.

Q: What do you feel are the most critical hardware components to consider?

A: The RAM is critical, but the CPU and the video card are all key ingredients.

Q: What changes do companies need to make in regard to networking?

A: You want the limitation to lie within your workstations, not within your network. Whether you're working locally or remotely with other facilities, you don't want your network to be the weak link. You also have to consider what hardware upgrades you need to make to stay current with your network in order to support the CAD system.

Currently, we're looking at separate repositories that would give us the capability to only pass the data that changes, instead of passing everything. We're trying to get our Italian operations up to speed. They share some of the designs that we do, so we need better connectivity to them. If we go with a typical connection, it's going to be way too slow. We might even have to go to the extreme of getting a server setup that is identical to what we have here, and only pass data with changes.

Q: What considerations do companies need to make regarding the network's server?

A: The biggest issue is compatibility. You have to make sure your server is compatible with your actual CAD systems – not just mechanical but also electric (ECAD) and hydraulics, pneumatic, and lubrication (HPL) systems.

Managing Data in the

3D World

CHAPTER 4

In the first chapter, we discussed the many benefits of 3D design, among which are faster engineering changes, automated drawing creation, design reuse, and easier design and management of assemblies. Another by-product of a 3D implementation is a huge explosion of 3D data a company must manage and share with other departments, such as manufacturing and purchasing. While legacy 2D systems produce one type of engineering file – drawings – 3D CAD systems produce several types of engineering files, including assembly, part, and drawing files.

Part files are commonly reused in multiple assemblies and drawings: so, careful tracking of the relationships between parts and their respective assemblies must be maintained to effectively manage. There may also be a need to associate non-CAD documents – product images, analysis, and test results – to the CAD file from which it was created. In companies implementing 3D CAD in a multiple-user workgroup with supply chain partners as well as customers needing access to that 3D data, some form of data management system may be needed.

Factoring in File Management

An important factor in the ultimate success of any 3D CAD implementation is effective file management. With 2D design systems, engineers themselves often name files in ways that differ from those of other users. While this might work with 2D systems, it most likely will lead to chaos in a data-rich 3D environment. A carefully thought-out control scheme that fully outlines the proper procedures and standards should be developed very early in the implementation.

Most 3D CAD systems have a means by which assemblies are created by combining parts – a logical approach, since different engineers might design individual parts and assemble them later. This approach, however, can lead to confusion later if the process isn't controlled. Users need to be able to find the latest version of 3D files and be able to easily distinguish 3D assembly and part relationships. The relationships between parts must be tracked, and engineers must be able to quickly determine "where-used" to ascertain the impact of design changes.

Todd Majeski, president of 3DVision Technologies, a value-added reseller (VAR) of 3D CAD systems, believes that the vast increase in data produced by 3D CAD systems makes it difficult for companies to continue using manual methods of managing files.

"In a 2D CAD system, the file structure is fairly easy to manage in a manual fashion, but when using 3D, you incorporate a minimum of three different file

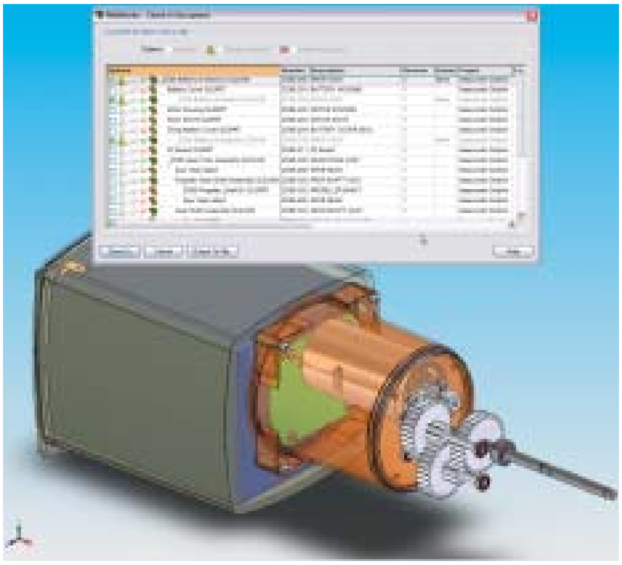
PDM systems help design teams manage all types of design information, both documents and data, including properties such as description, status, number, and costs.

types: part, assembly, and drawing," says Majeski. "Because of change propagation in a parametric system, most 3D applications maintain knowledge of the interrelationships between files. Managing them in a manual process is a bit overwhelming when you are in a multi-user environment. Product Data Management (PDM) simplifies the process of determining where the files are located and which revision is the most current."

Data Management: Why You Need It

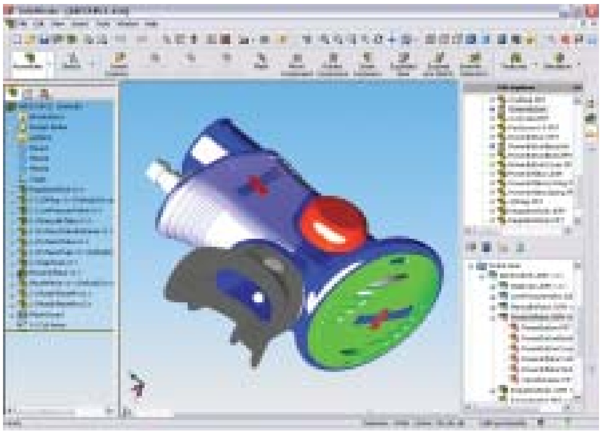
Most 3D CAD systems offer some basic data management functionality built into their system, which may provide features for managing data, collaboration, and viewing and markup capabilities over the Internet. For smaller companies and engineering workgroups, this type of functionality might suffice, but for most manufacturers, an add-on data management system will be required.

PDM solutions typically fall into two categories: workgroup and enterprise-level systems. Workgroup PDM solutions, which focus on the specific needs of the engineering workgroup, capture file revision histories automatically, allowing members of the design team to instantly access files, determine who has worked on them, and see exactly what changes were made. Workgroup PDM solutions are easy to set up, require minimum technical support, require no customization, and provide controls to help design team members avoid making other errors that can sidetrack design schedules.



PDM solutions offer vaulting, which enables members of the design team to share files systematically, checking them in and out of the vault one at a time to avoid overwriting files or working on the wrong revision.

To prevent engineers and designers from overwriting files or spending time working on the wrong version of a file, workgroup PDM systems secure files through vaulting. Vaulting allows members of the design team to share files systematically, checking them in and out of the vault one at a time. Access to vaulted data is only possible through the user interface using administrative controls established by the workgroup, prohibiting unauthorized access to valuable design data.



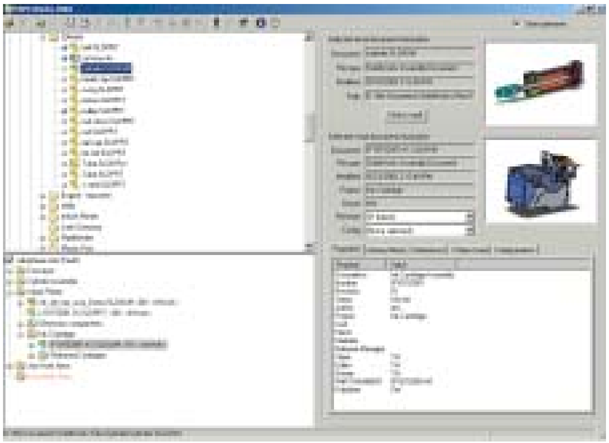
Workgroup PDM software captures file revision histories automatically and allows all member of the design team to instantly access files, determine who has worked on them, and see exactly what changes were made.

Besides engineering files, workgroup PDM systems manage all types of design documents and data, including properties such as description, status, number, and costs. Some workgroup PDM solutions also offer automatic updating of bills of material (BOMs). To make changes to vaulted data, engineers simply select the items, key in updated values, and the software automatically updates all related BOMs and reports.

PDM for the Enterprise

With increased outsourcing, companies also need to be able to effectively collaborate on design projects with manufacturers, suppliers, and customers who might be located thousands of miles and many time zones away. When design teams working on a virtual model of a product are connected using a digital network, the process is referred to as collaborative engineering. A by-product of collaborative engineering is the vast amount of digital information captured during the development of co-designed products.

Enterprise-level PDM solutions provide manufacturers with a way to automate processes and to efficiently create, manage, and share design data not only across the organization but to outside supply chain partners and customers as well. By improving data management and automating workflow across multiple sites, enterprise PDM solutions help integrate product development activities of widely dispersed corporate divisions, departments, customers, and suppliers.



To facilitate collaboration, some PDM software systems allow non-CAD users such as manufacturing and purchasing staff to access all documents and to add non-CAD documents to the vault.

Like workgroup PDM systems, enterprise-level PDM software permits companies to easily control the storage, evaluation, and modification of 3D files. A secure vault enables all authorized workgroups to quickly find and access the most up-to-date files. Providing access to the latest version of documents and data streamlines the product development process and keeps all members of the development team, including engineering, manufacturing, purchasing, and marketing, in sync.

Enterprise-level PDM solutions facilitate collaboration and automate processes, such as engineering change orders (ECOs) that can help reduce errors and improve efficiency. These higher-level systems can also help companies automate the creation of BOMs, which can eliminate error-prone manual processes and enable better collaboration between engineering, manufacturing, and other product development groups.

Regardless of what type of solution you choose to implement, PDM will greatly facilitate your company's ability to manage the copious amounts of product data created by today's 3D CAD systems and to prevent errors that could add time and cost to design projects. Both types of systems can also foster better and more effective design collaboration, either within the workgroup or throughout the extended enterprise.

Jeffrey Setzer, technical services manager for Graphics Systems Corporation, a Wisconsin-based VAR of 3D CAD systems, says that PDM systems greatly facilitate collaborative engineering efforts and prevent network overload within companies using 3D CAD. "3D design tools create volumes of data that need to be shared over a network in a collaborative environment. Without a PDM system, users would be loading all of that data across the network every time they opened the files, swallowing enormous amounts of bandwidth," says Setzer.

He adds, "A PDM system mitigates the network bandwidth problem by copying all of the files needed to work on a project to the user's local machine so their minute-to-minute save operations are completely local. Only when the user wants to 'check in' the changes does anything flow back over the wire, and even then, the PDM system will automatically send only the files that have actually changed, as opposed to the entire dataset."

Taking PDM One Step Further

A product lifecycle management (PLM) system enables a company to automate, monitor, and track product development and revision processes with their customers, suppliers, and employees amid increased regulatory compliance, outsourcing, and product accountability. Typically, PLM systems are integrated with the company's Enterprise Resource Planning (ERP) system, thereby extending critical product information visibility and processes beyond engineering departments, and propagating it throughout the supply chain.

While PDM systems control the product's movement throughout the engineering process, PLM systems guide the product through its entire lifecycle. PLM technology promises to enhance the design environment by providing an integrated view of product engineering, manufacturing, and plant resources. PLM systems apply a consistent set of business solutions in support of the collaborative creation, management, and use of product definition information. PLM systems require a much higher level of IT support, maintenance, and customization than most PDM solutions.

Dealing with Legacy Data

Most new design projects are not initiated from scratch but are based on existing designs. Often this legacy data exists solely in 2D form, more often than not stored in DWG (AutoCAD®) format. For many companies, legacy data is an important asset and one they will go to great lengths to protect and retain. These companies have spent years accumulating this repository of data, and being able to use and manage this data is an important component to consider when moving to 3D.

For these types of companies, it's important to choose a 3D CAD system that provides a means of converting legacy data to a usable form. The 3D CAD system should support the conversion of existing 2D drawings to solids, and clearly some systems do this better than others.

For some drawings, conversion to 3D might be simple. For others, it won't be. Simple 2D drawings without auxiliary views drawn accurately may be of little value. Some 3D CAD programs offer automatic constraining tools that may or may not be able to salvage these types of simple drawings. Parametric-based CAD systems can help by enabling the user to align edges and features across views of the drawing.

Conversion of 2D drawings – those that have been defined using 3D matrices to position the projection planes of each view – is much simpler. The conversion of these types of drawings by the solid modeling system is fairly clear-cut.

The conversion of complex 3D wireframe and surface models can also be difficult. While the data is 3D, the drawing's dimensions might be unclear and incomplete. Older systems used to create some of these wireframe drawings might not be supported by newer 3D CAD systems. Users may be required to repair the drawing by sewing or stitching surfaces together to be able to convert it to 3D.

Most 3D CAD systems provide some form of import tools with which users can move their 2D designs into the 3D system. Once the drawing has been exported into the 3D system, some type of editing tool must be provided so the user can edit the files. To make the editing easier, some 3D CAD systems provide commands and an interface that mimic that of the 2D program so users can easily edit drawings without learning a completely new interface and command structure. Taking this a step further, some CAD systems provide editing tools in native DWG format so users can open and save any native AutoCAD file with file conversion.

Another potential bottleneck to converting legacy data to 3D is the use of solid modeling systems that don't support industry-standard translators. Take into account the time, cost, and effort required to convert legacy data to 3D before proceeding. It might not be necessary to move all legacy data to the new 3D CAD system; perhaps just certain components will require conversion. There are many alternatives to converting all legacy data, and these should be carefully evaluated before any conversion begins.

Lutz Feldman, the marketing director of SolidLine AG, VAR of 3D CAD systems headquartered in Germany, believes that it's not essential to try and convert all 2D data to 3D. "In my real-world experience, I would have to say convert nothing," says Feldman. "Design new products in 3D and maintain old data in the source system of this data. If you have DWG data, use a DWG editor. If there is a concrete need for 3D library parts, seek an external partner to convert the necessary data for you."

Many agree with this approach to dealing with legacy data. 3DVision Technologies' Majeski believes that organizations have common misperceptions regarding the value of 2D legacy data. "They still feel like there is a lot of value in that 2D data; but in reality, once people are up and productive in 3D, the need for that 2D data diminishes exponentially. They just don't access it as much. They will occasionally have to make small edit changes, or ECOs, on existing products that are out in the industry, but I recommend that they use their legacy 2D system to make those small changes," says Majeski.

One option Majeski recommends to his customers for maintaining 2D data is to create PDF or TIFF files of all their permanent documents from their legacy files so that data can be accessed and re-created in 3D later, but only on an as-needed basis.

The Manager's Perspective: Todd Mansfield, Systems Engineering Team Leader, ECCO

Q: As a company, how did you deal with the increased file management issues brought on by the use of 3D CAD?

A: We dealt with that by implementing a PDM system. A lot of companies do a really good job of managing their drawings or their paper, but they don't do too good of a job managing their electronic data from which those drawings are created. As part numbers and configurations explode as companies grow, it becomes unruly. In an unmanaged system, you'll get little kingdoms on both local drives as well as the network for each operator who saves files in a different folder structure, names things differently, and makes revisions differently. What you end up with is a workgroup of 10 people who have 10 different ways of storing their data. As you grow, you find an ongoing need to standardize the work environment, and a tool such as PDM does that for you very nicely. It requires formalized naming, revision, and file structures so everyone is working out of a same location, i.e., the vault. You don't want to squelch people's creativity, but you do have to have some standards.

Q: Why is PDM so essential to companies migrating to 3D design?

A: I think it's extremely important. In 2D, you have one file; but when you design things in 3D, you now have four files that make up that one part. The level of file management required for 3D is economies-of-scale larger than with 2D systems. When you move from 2D to 3D, you move into multiple files with lots of relationships and references, so the requirements to keep all those files straight increase correspondingly. Obviously, what you get is much better, but there's a cost to that.

Q: How is PDM used at your company?

A: We have a vault with 10,000 files and 80 gigabytes of data that our PDM software is managing for us with all the revisions and history. We also purchased an additional Web portal/advanced server module for the software, through which 30-plus additional users can access the vault for read-only access to these documents. It's been awesome because it enabled us to push the application out to an unlimited number of users without having to buy additional software. On top of that, we went one step further with the Web portal and pushed it to our supplier and customer base.

On the supplier side, we give them access to our data in real time. For instance, our printed-circuit board (PCB) manufacturer in the Pacific Rim has direct access; so if we roll a revision from A to B today and place an order, they would go into our vault, pull the latest set of drawings, and build to that. It's really streamlined our supplier communications and also improved supplier quality.

Q: Can your customers access data through the same vault?

A: We've extended our customers' access to project files so they can see 24/7 the progress of their projects and their finished goods products. In that vault, we not only have all the finished goods drawings and the subassembly drawings but also the certifications. We really consider this a customer intimacy tool that allows us to partner with those customers who have a need for such an application.

Q: How does this differ from other manufacturers' Web sites?

A: Usually when companies have a Web site, they'll drop a bunch of drawings into a virtual directory, and those are the ones the Web site always pulls up. The problem is that drawings change every day, so the downside is you always need to remember to put the new drawings into that directory or customers are pulling up outdated drawings. We created an active server page that directs our customers to the vault to get the latest revision, so all of our customers can be guaranteed that they are getting the latest revisions of everything.

Q: How much IT administration is required to keep the system running?

A: Everyone does his or her part in maintaining the system, so we don't have a full-time administrator. It's stable enough that it just runs, and each individual who works in the system has been trained to do certain things as far as inputting data, so we've really been able to spread the load of any overhead to every team member. There is no IT overhead at all. The real beauty of the system is that we're not having to manage it because it's the same tool we work out of every day, the same tool that our suppliers and customers are pulling from, and the same tool the general public is pulling from, so everyone is always on the same page. It's the tool we would use anyway, so it's allowed us to kill three birds with one stone with no additional overhead.

Q: Were people initially skeptical about having to learn yet another software system?

A: Initially, you might have people who are apprehensive about moving into such a system, but then they see the benefits. A PDM system takes away the time they spend looking for stuff. With all the data and information that a PDM system provides, it takes the 20 to 30 percent of an engineer's day spent doing administrative tasks off their plate and allows them to focus on design.

Q: What was the plan for dealing with legacy data?

A: When you move to 3D, the first thing you have to do is to decide if you're going to work into a controlled vault or not. You can't work in two worlds. We decided to move everything from our network drive into the vault, but not to allow garbage in and garbage out, so we used it as an opportunity to clean up and clear out.

Unfortunately, we'd had some bad practices, so a lot of our assemblies were busted, and in many cases, it was easier to delete them than to fix them. When we come into contact with an engineering change notice (ECN) on an AutoCAD drawing, we're going to convert it to 3D. So we literally uninstalled AutoCAD off of all the workstations and said we are now on 3D. We made the decision, drew the line in the sand, and uninstalled it so it was unavailable. In doing so, we realized that, for the next year, when a five-minute change to a 2D drawing comes up, it's going to take two hours because we're going to convert it to 3D. It's going to be painful, but in the end, it's going to benefit us; and in all reality, it has. That's how we did it, on an as-needed basis, and the pain was the added time to convert in-house as need be. A lot of companies – and I have now shifted to this approach – will use an outsource service to do some of those conversions. It's an organization-by-organization decision.

Using 3D to Improve All Aspects of

Product Development

CHAPTER 5

One of the more significant benefits for companies moving to 3D design is the fact that it opens the door to a host of add-on software and hardware products that can further sharpen their competitive edge by enabling them to shave more time off development schedules and deliver higher-quality, truly optimized products to their customers. Though there are too many add-on products to discuss in this article, we'll take a closer look at some of the products that can help manufacturers further leverage the value of their 3D design.

Certified Software Programs

Over the years, the vendors of 3D CAD systems have worked hard to build key relationships with third-party vendors, providing users with best-in-class, integrated solutions that can help reduce production costs and decrease time to market. These partner programs include add-on software for a myriad of functions, from manufacturing and analysis to reverse engineering and rapid prototyping.

Most CAD system vendors provide users with an ample selection of industry-leading complementary software that is fully integrated with the base CAD system. In order for software to be certified as fully integrated, it must go through rigorous testing to ensure its quality, compatibility, and level of integration. Following certification, the software must maintain compatibility with subsequent releases of the CAD product in order to keep up with new functionality.

Levels of integration differ, however. Integration may mean that the software can read native files into their own software. Some software products offer single-window integration, the highest level of integration offered. Providers of tightly integrated software products have access to the CAD system's application programming interface (API). So their add-on software can use the same solid modeling environment and seamlessly activate from within the CAD system.

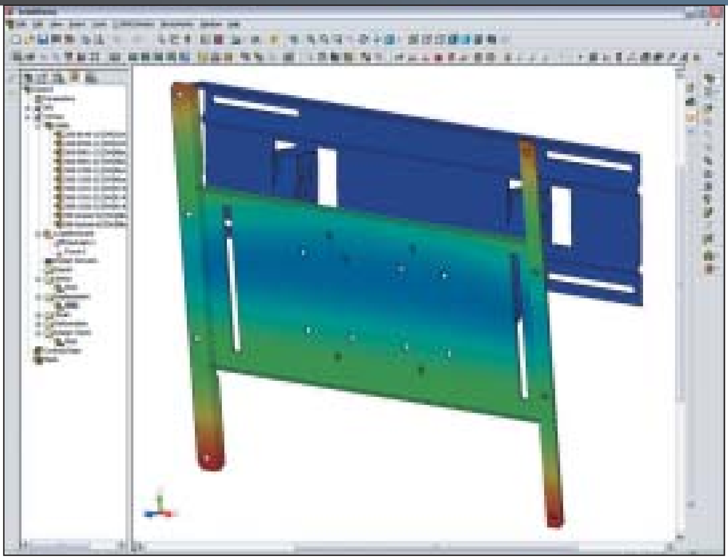
The upside for users in choosing from these certified software lists is the assurance that these products will offer interoperability, associativity, and data integration with their CAD systems. This, in turn, results in faster design times and less room for errors.

Simulation and Analysis

Analysis and simulation software delivers tangible and quantifiable benefits to the product development process. Analysis software – including tolerance analysis, finite-element analysis (FEA), computation fluid dynamics (CFD), and kinematics/dynamics software – enable designers to test the structural integrity, thermal and flow characteristics, and physical motion of new products while the designs still reside in digital form.

The advantages to the product development process – both in terms of reducing the overall design cycle time as well as the costs associated with traditional testing methods – are numerous. Simply put, engineers can design better products faster when allowed the luxury of running multiple "what-if" type scenarios while designs are still fluid and easily changeable. Once metal or plastic parts are cut, any subsequent design changes can bloat design budgets and derail schedules.

Several factors have contributed to the growing use of CAE tools among design engineers. The cost of the materials used to build prototypes has increased, making it more expensive than ever to do without some form of analysis or simulation to prove out designs. Conversely, computer hardware costs have decreased significantly, which has led to a wider adoption of analysis tools since CAE software requires significantly more computing horsepower than other types of software.



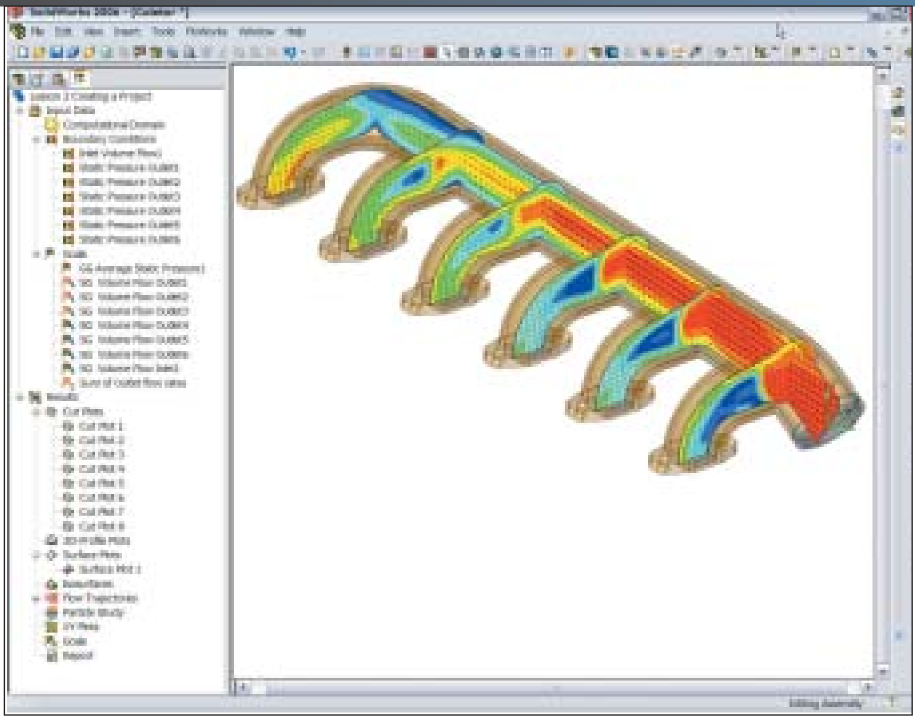
Analysis software enables users to study multiple designs with unique parameters, so they can quickly compare design performance. In this example, a mounting bracket designed by Peerless Industries for plasma televisions is tested under a variety of loads.

Once the domain of specialists, a growing number of analysis software vendors are now designing their analysis tools specifically for engineers who deal with geometry created in a myriad of CAD systems and who want quick answers to "what-if" inquiries, so proposed designs can move forward rapidly and with greater confidence. As a result, more analysis tools are now closely integrated with 3D Mechanical Computer Aided Design (MCAD) systems. Engineers and designers can perform simulations and analyses on native MCAD geometry, eliminating the need for any data conversion. Some fully integrated software also offers fully associativity with leading MCAD systems, so changes made to the original MCAD model are automatically reflected in the simulation model.

CFD. Computational fluid dynamics software is increasingly being put to use by product development engineers early in the design process to validate proposed designs while still on the digital drawing board. CFD software enables engineers to analyze fluid flow and/or heat transfer in and around new designs. Without such software, expensive and time-consuming bench testing must be conducted. Even with such physical testing, many flow and heat transfer phenomena occur within a product – a valve inside a faucet or airflow through an electronic enclosure, for example – making it impossible to visualize without computer simulations.

FEA. FEA is a numerical technique that calculates the behavior of mechanical structures. Using FEA, structures are divided into small, simple units called "elements." When FEA software solves an equation, the system displays the physical behavior of a structure based on the individual elements. Engineers use FEA tools to calculate strength, deflection, stress, vibration, buckling, and other behaviors, in order to reduce the weight or maximize the strength of a part.

Jeffrey Setzer, technical services manager for Graphics Systems Corporation, a Wisconsin-based value-added reseller (VAR) of 3D CAD systems, believes that FEA tools help engineers guide designs through the development process. "FEA allows the designer to make quicker and better-informed decisions," says Setzer. "This is possible because virtual 'testing' can be done directly on the solid model, right in the software. Anytime an engineer comes to a fork in the road, where they ask themselves 'should I go this way, that way or try a third option,' FEA will give them the insight they need to make a sound decision."



By analyzing this automotive manifold using CFD software, engineers can better understand how much gas moves through each individual outlet of the manifold to make design modifications in order to attain specific design criteria.

Both FEA and CFD are used to innovate and optimize mechanical designs without the need for extensive physical testing. When used properly and throughout the design process, beginning with the concept phase, FEA and CFD software can lead to lower material costs, a reduced number of physical prototypes and engineering change orders (ECOs), shorter design cycles, and possibly reduced product-liability issues.

Computer-Aided Manufacturing

Fully integrated CAM software can help companies shave time off design cycles, reduce production costs, and avoid costly errors that often don't rear their ugly heads until parts are ready to be cut, at which point fixes are extremely expensive and time-consuming. Integrated CAM software, on the other hand, enables a company to go straight to manufacturing using the same solid model created in the design phase, thereby eliminating any data translation woes that could lead to mistakes on the shop floor.

CAM software that is fully integrated with MCAD software shares a common interface, because the CAM vendors of fully certified software have access to the CAD software's API. Through the API, CAM developers can use the same solid modeling environment, so users can seamlessly activate complex CAM functionality from within their solid modeler.

Users beware, however. While some companies may claim to be fully integrated, that may only mean that the software reads native CAD files into their stand-alone system, which may have limited solid modeling capabilities. This can result in the loss of data that would have proven useful for manufacturing. Often in these types of systems, MCAD data and CAM data must be saved in separate files.

Fully integrated CAM requires no translation of 3D CAD data; therefore, manufacturing can use all the data to determine the best process for machining. When working with file formats from other MCAD systems, the data can be imported into the solid modeler and repaired, if necessary, before generating the machining data. In addition, both CAM data and the CAD data are saved in the same file.

Because design changes are inevitable, having a fully integrated CAM solution is a significant asset. At this stage of the process, changes nearly always have an effect on production deadlines. When design changes occur, these programs either automatically update the CAM file to reflect the change or provide notification to users that additional changes are required. A stand-alone CAM program may provide limited associativity or may require starting over when importing the model after it's been changed, increasing the probability of mistakes and delays.

Mold Design

For 2D users doing mold design, there are many compelling reasons to take the plunge into 3D design. Making molds for complex 3D parts in 2D requires long lead times. In the mold-making business where time is money, staying in a 2D design environment will eventually lead to lost business. And, with rework being the biggest threat to profitability, being right the first time is of utmost importance.

Some 3D MCAD systems offer mold-design specific tools such as draft and undercut analysis and advanced draft features. For complex mold designs, tools such as automatic core and cavity features, side core and lifter creation, parting lines and shrinking controls can all help mold designers get the job done right. Surfaces can be used to help design core and cavities in a mold.

Add-on software products can further optimize the design molds by eliminating the guesswork traditionally required to create mold designs. These applications help engineers construct and analyze all types of sprue, runner, and gate systems; automatically balance runner systems to achieve uniform flow in multicavity and family molds; determine the best gate locations and the optimum combination or processing parameters; estimate clamp tonnage, shot size, and cycle time requirements; and perform detailed part cost estimates.

Rapid Prototyping

Despite the beautifully lifelike renderings created in today's 3D CAD systems, there are many intangibles in designs that simply cannot be accurately conveyed through digital representations. Being able to physically hold a proposed design in your hand can answer questions such as, how do the pieces fit together? How will the design be used? Does it work the way it is supposed to? Does it have the right feel?

Rapid prototypes (RP) can also aid in collaboration, especially with nontechnical members of the design team, such as sales and marketing people, whose input is crucial early in the design process. Many of these team members have difficulty accessing the nuances of an isometric view of a part on a computer. In addition, a real part best conveys the actual physical size of the part or product.

Using rapid prototyping can also help avoid manufacturing mistakes down the line. Some problems are difficult to pinpoint on-screen, but they will be all too apparent when you're examining a physical part. Solid modeling systems are capable of generating products of almost any shape and size; however, these same products might not be possible or cost-effective to make. RP parts force engineers and designers to think through the manufacturing steps and can result in design changes that make the final part easier and less costly to build.

For certain industries, physical prototypes are especially important, says Setzer of Graphics Systems Corporation. "Rapid prototyping, sometimes called 3D printing, is indispensable for anyone designing items with ergonomics in mind," says Setzer. "No matter how good the model looks on the screen, you can't tell how it will feel in somebody's hands unless a physical model is built. With today's 3D printing technologies, a durable ABS plastic model can be printed in a matter of hours. After passing it around a design-review meeting, the solid model can be changed and another physical part printed on the 3D printer."

The two most popular technologies for building rapid prototypes are stereolithography (SLA) and Fused Deposition Modeling (FDM). Manufacturers can either buy RP machines for use in-house or can use one of the many outside service bureaus. Several online services are now available that enable engineers to obtain quotes for rapid prototypes online in minutes and have that part in their hands within days. The engineer simply uploads the 3D CAD geometry and defines the project's specifications; the service bureau evaluates the part geometry, required materials, lead time, and quantity; and then provides the user with a quote for the production of the requested part.

Despite the growth in RP service bureaus, Todd Majeski, president of 3DVision Technologies Corporation, a VAR of 3D CAD systems, says that his company has seen a growing number of companies purchasing their own in-house RP machines. "We're seeing a lot of interest in rapid prototyping machines, especially in the consumer products and medical design industries," says Majeski. "These are companies that have been outsourcing in the past but are now buying their own machines since machine costs have come down. The cost to acquire a machine and keep it operating is lower than the cost of using a service bureau."

Reverse Engineering

Mechanical engineers often have a need to quickly re-create or transform an existing physical part or prototype into reusable 3D geometry that can be edited or modified. The process of re-creating a part that was originally created without computers or drawings is called "reverse engineering." With 80 percent of new designs originating from existing designs, reverse engineering is gaining in use among manufacturers.

The first step in reverse engineering is to capture the 3D geometry of the physical part, which is done using either a coordinate measuring machine (CMM) or 3D laser scanners. After the data points are captured, they are imported into reverse engineering software, which also comes in two varieties.

One type of reverse engineering software, sometimes referred to as "bridging" software, allows the import of point cloud data from the digitizing equipment, and then modifies the data into a format that can be brought into the user's CAD system for editing. The other type of reverse engineering software captures part data directly from the imaging devices to create fully editable, parametric models.

The latter type of reverse engineering software is fully integrated with 3D CAD systems, enabling users to capture data from an existing part and create an intelligent, feature-based model – all from within the CAD system. With this feature-based approach, you can quickly create solid models from existing parts or prototypes using a process that is much faster and less data-intensive than the more traditional, point cloud-generating scanning methods.

Electronic Design

At many manufacturing companies, two types of designs are often undertaken simultaneously: the design of the electronics and the mechanical design of the product's structure or enclosure. This design scenario represents many different types of products, from relatively simple toys and radios to extremely complex computers and cars. Several software products exist that facilitate the exchange of design information between the mechanical design (MCAD) and electronic design (ECAD) environments.

These software systems act as bi-directional translators between the CAD system and the Intermediate Data Format (IDF). An electronics industry standard, IDF allows for the exchange of printed-circuit board (PCB) design data between ECAD and MCAD systems using ASCII data. These electronic design systems enable engineers to create mechanical assemblies of their PCB designs, modify them if necessary, and then send the changes back to their PCB design software.

Some of these software products use parts libraries to position component models onto the board, producing a very accurate assembly of the populated board. If a component model is not available in the part library, some systems will use the component footprint and extrude it to the given height in order to generate a component model for future use.

Once the mechanical assembly of the PCB is created, engineers can then place it into their product assembly to check for mechanical interferences or other mechanical design errors. If problems are detected, engineers can correct them in the PCB assembly. Users can change part locations, move mounting holes, or edit the PCB shape, and then send the changes back to the PCB design system by creating IDF data from the assembly.

The Manager's Perspective: Todd Mansfield, Systems Engineering Team Leader, ECCO

Q: What type of add-on software products do you currently use at ECCO?

A: We are currently using a photorealistic-rendering software, a feature recognition software, a web-publishing tool, an electronics design package, and analysis software.

Q: How is the rendering software used?

A: We use it to illustrate products for which we don't have physical prototypes. Many times, we are under pressure to meet catalog dates. The marketing staff wants pictures of these new products, but we don't have parts for them in-house yet. For our new catalog, we provided sales and marketing with a photo-rendered image of several products that they used in lieu of an actual photograph. We also use it internally for concept and visualization during the concept phase of product development. They will hand us a napkin drawing of what they want, and the engineers will use the rendering software to come up with two or three concepts of that idea. It's really a good conceptual tool we use quite a bit, and it's very easy to learn.

Q: What does feature recognition software do?

A: When you bring in a model from an IGES, STEP, or any other neutral format, it loses all its history and becomes basically just a dumb block of geometry. That imported body is usable but not editable. The feature recognition software interrogates that imported body and tries to re-feature the component or part. It goes through the part and re-populates the feature manager with all those features. The big benefit is that once that's done, a user can go into those features to edit them. Once the model is re-populated, you can go to the feature, change the value of it, and it resizes automatically, which makes it parametric again. It's a very powerful tool. We purchased another company a few years ago, and they were using another CAD system. When we brought in their CAD files, they were not fully populated. By running this software, we were able to re-populate a lot of the features in those components to make that part more editable and complete.

Q: How does ECCO use the web-publishing tool?

A: This tool allows the user to post a website instantly to a server, so you can publish a 3D instant website to the web, which allows for a collaborative environment. If I'm doing a design and want others to check it out and give me feedback, I can post it on a website and send you a URL to it. You receive it, click on it, and it pulls up the instant website. You look at the design and then can give me feedback. The upside of that to me is that at this company, we have people all over the world constantly working on designs, so if we're trying to run a design by our sales team, we'll blast one of those out and they can be anywhere in the world and give us feedback at their leisure as long as they can access the Internet. I just spent a couple of weeks in China and never missed a beat because of this tool. It's very powerful.

Q: How about the electronic design automation software?

A: This software allows us to take data from our electrical (ECAD) package and convert that data into native MCAD assembly models. We have a layout designer who will lay out a printed-circuit board (PCB) and get it designed. Then we convert that data into a mechanical assembly, so the mechanical group can wrap a housing around it. They use the add-on software to convert ECAD data into native MCAD data that can then be used for mechanical design.

Q: What was the procedure for this prior to using the EDA software?

A: Either they didn't include a printed circuit board assembly, which was scary because the only way to prove out its fit was to physically build it, or we would do a representation of the circuit board assembly. However, a representation is not always dimensionally accurate. These packages help us build a dimensionally perfect representation of not only the PCB, but also all the electrical components loaded onto it. We've built up component libraries, so the software pulls from those and loads the board with real components. Dimensional accuracy is very important because we do not have any room for error. We're running tolerances under a hundredths-thousandths of an inch.

Q: How is analysis software used at ECCO?

A: We use it to perform basic stress analysis on our components in order to see where the stress concentrations are. If we have issues in our tests, we'll go back and do an analysis to see where we can optimize the design to improve strength or reduce weight. We don't have a full seat of analysis software; but that's probably the next software we'll buy, because we're getting to the point where we could sure use some of that functionality. They now have drop tests as well as solar and thermal analysis in the full product so we're hoping to do more with analysis and less with physical testing in order to get it right the first time. You can't afford to build it until it breaks, as we used to do. The name of the game now is "optimization."

Q: How important is buying add-on products that are certified by your CAD vendor?

A: From a customer's standpoint, what's nice about the partner program is that knowing the rigid criteria the partners have to meet is a nice guarantee. I would be very hesitant to buy a product that was not in the partner program. It gives the customer a good feeling, because you know these products are well-tested.