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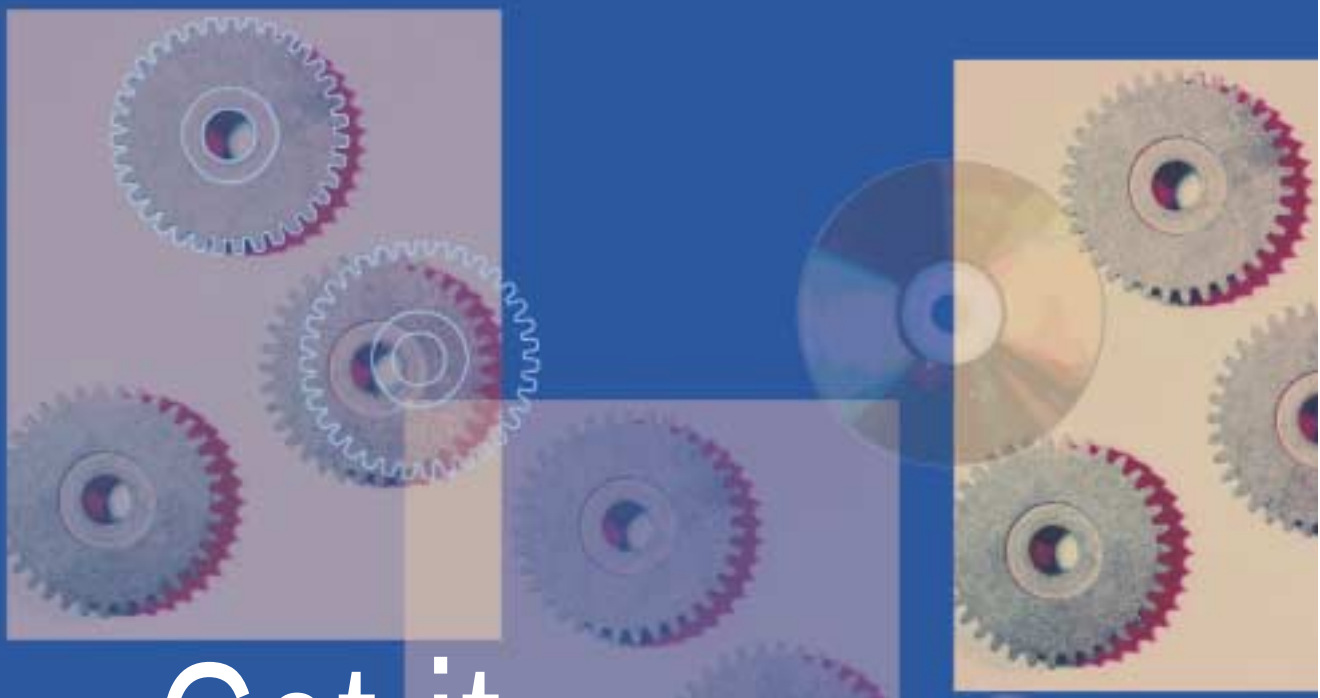


Get it RIGHT the FIRST TIME!

How to use software to shrink design time

PTC®

Get it RIGHT the FIRST TIME!

Manufacturers are using flexible engineering strategies to create smart virtual prototypes that converge on requirements, reuse existing knowledge, and validate performance—creating better products and shrinking design times.

A team of engineers faced the challenge of designing a yacht for an upcoming international race. How could they come up with a design that might win the race while working under the pressures of creating it as quickly as possible, all the while knowing they had numerous variables to contend with and various innovative ideas to explore?

What engineer hasn't found him, or herself, in a similar situation? Engineers are constantly under pressure to create new designs or update old ones as quickly as possible. It is a fact of life in the competitive manufacturing world, and engineering management expects fast results.

The engineers designing the yacht were able to test many virtual prototypes before a single piece of wood or steel was even cut. Using leading-edge technology from PTC, they could see, and validate, whether or not their design ideas would ultimately work in the real world. As a result, the design was right before the prototype.

This is the kind of scenario that manufacturers around the globe want to achieve. If they want their products to get to market before their competitors, then they need to be able to reuse their existing knowledge and shorten their cycle times by designing products right the first time.

Achieving leadership

Manufacturers know why there is an urgency in getting to market before their competitors: Eighty percent of companies that get their products on the market first become market leaders within five years.

Three supplements and webcasts will explain PTC's flexible engineering strategy

This supplement, "Getting it Right the First Time," is the first of three supplements, sponsored by PTC, which will appear in upcoming issues of DESIGN NEWS. The next two supplements will appear in the first and second quarters of 2001 in Design News.

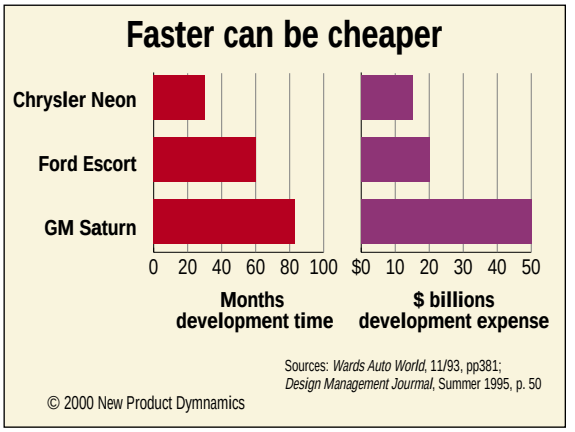
The upcoming supplements will examine two other areas that engineers need to understand to determine their degree of "flexibility." Those areas, which span the entire product development process, are how companies deliver rapid design customization and how they exploit global collaboration.

A special Webcast, moderated by Paul E. Teague, chief editor of DESIGN NEWS, will follow each supplement.

Join DESIGN NEWS on Thursday, October 26, at 11 a.m. (EST) for a free, live Internet broadcast sponsored by PTC. Participants will include Ken Versprille, a senior industry analyst for D.H. Brown Associates, Inc. (DHBA), a research and consulting firm based in Port Chester, NY; and Jon Stevenson, general manager and senior vice president, MCAD at PTC.

Find out how a Flexible Engineering strategy can make you more productive and more responsive to customer needs.

Many market leaders know first-hand the importance of "getting it right the first time." Take, for example, German automaker, Audi, which reduced its development time for its wheel cover design by 80% using PTC technology. Other companies that have seen similar results include Motorola, which shortened its time to market by 50% for a new cellular telephone, and appliance manufacturer Maytag, which drove its product to market three times faster than it had previously.



Automakers have found that they save money as they reduce cycle time.

Three concepts are key for companies to get it right the first time: reusing existing knowledge, driving designs to meet objectives using behavioral modeling, and virtual prototyping.

By providing tools to capture, apply and enforce company standards and best practices, platform design time can be significantly reduced. Less time is spent reinventing design approaches, and the resultant high quality model can be leveraged more readily downstream.

PTC's approach to behavioral modeling is an important aspect of "getting it right the first time." The concept behind it is to let designers capture functional behavior and make use of this to drive and adapt their product designs. Behavioral modeling streamlines the process of developing an optimal product solution that meets specifications, even in designs with numerous variables, constraints, and goals.

How you can converge quickly on the right design

As the Internet continues to collapse the time and distance between product manufacturers and their customers and suppliers, PTC offers solutions that allow design and engineering organizations to thrive in the shifting B2B e-commerce environment. PTC calls this approach flexible engineering: It connects distributed engineering knowledge to the enterprise to enable rapid response to market demands. It compresses innovation-to-market times and reduces risk. These benefits are delivered by Pro/ENGINEER, the PTC i-Series, and the Windchill Suite. Some details:

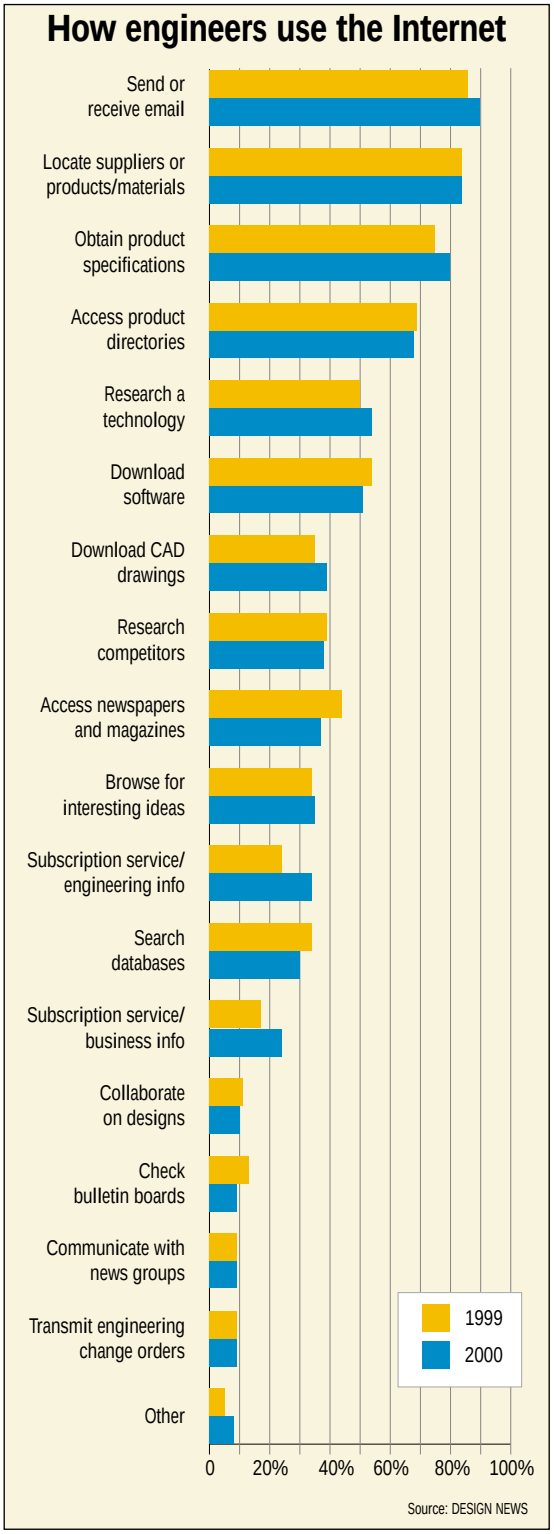
Pro/ENGINEER, the industry defacto standard 3D design and engineering system, is now Windows 2000 certified. PTC's leading flexible engineering platform provides a foundation of industrial strength modeling and assembly capabilities, embedded best practices, intuitive user interface and concurrent team data management. Pro/ENGINEER offers best-in-class, integrated capabilities for CAD, CAM, CAE and CAID. This includes the creation of detailed solid and sheet metal components, large assemblies, fully documented production drawings, complex routed systems, tool design and creating photorealistic renderings.

The Behavioral Modeler Extension uses standard Pro/ENGINEER features to capture rich functional behavior as features of the model. Design requirements are created and applied to features. Behavioral Modeler automates the explorative of candidate design solutions by creating many virtual prototypes. The engineer simply selects the best design and moves on to solving the next problem.

PTC i-Series™ is a group of design and engineering solutions focused at addressing engineering initiatives. The solutions, underpinned by PTC's Windchill® and Pro/ENGINEER, include Pro/DESKTOP™, a Windows 2000 certified conceptual engineering tool for rapid idea capture and design exploration; Pro/MECHANICA®, which offers engineering validation and advanced behavioral modeling studies; ICEM™, which offers styling, surfacing and industrial design; InPart, which offers 1 million parts online; DIVISION™, which offers collaboration and reduced lifecycle costs through up-front visualization studies; MEDUSA®, a 2D parametric detailing and design documentation system; and CADDS® 5i, an assembly-centric mechanical design automation suite.

PTC's Windchill Suite is Web-based collaboration software that focuses on all phases of a product's life cycle, from concept and definition to production, service, maintenance and retirement. Windchill advances Collaborative Product Commerce (CPC) initiatives by allowing manufacturers to collaborate over the Internet with their customers, suppliers, and partners throughout the product development and delivery process.

"It is extremely expensive and time consuming to do physical prototypes only to find that something is wrong and you have to rebuild and redesign another prototype," says Ken Versprille, a senior industry analyst for D.H. Brown Associates, Inc. (DHBA), a research and consulting firm based in Port Chester, NY. "There is a drive to do everything in a virtual environment; and not only the design but the design validation as well."



The influence of the Internet

The Internet has dramatically altered how people around the world communicate and how they *expect* to communicate. What they expect now, because of the Internet, are immediate results. They can easily compare products and make educated choices based on aesthetics and performance. That's why it's important to "get it right the first time."

Customers are accustomed to receiving information quickly over the Internet, and as a result, they expect faster response times from their suppliers. OEMs also want to collaborate with their suppliers, who are increasingly, scattered around the globe. The Internet has become the backbone of communication.

"A manufacturing company builds a product and wants to work with a certain group of suppliers," says Versprille. "Many are selling products globally, and manufacturing is happening everywhere. They will use the Internet to find potential suppliers and to find the right price."

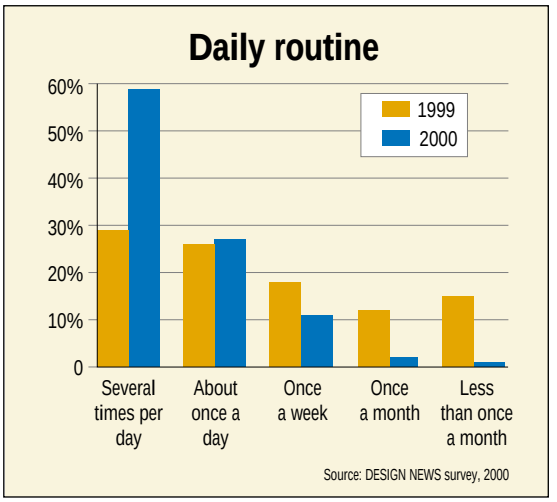
"More companies are going into the supply chain and offloading actual design work," Versprille adds. "To work effectively between teams it is important to get it right the first time to enable more efficiencies in the design process."

The Internet has changed peoples' expectations, which makes it all the more vital to design flawless products and get them to market quickly.

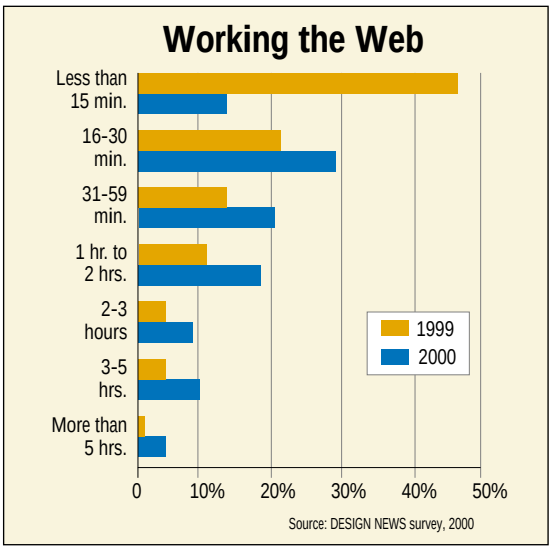
"The Internet started out as a passive interaction among users," Versprille asserts. "People would post information and people would access it; there was not a lot of interaction. What we're seeing broadly now is new and different information sites that enable people to link and talk to each other. There is more interaction and collaboration on the web with that data. Data integration is forcing people to come up with more open solutions to share data."

And therein lies one of the biggest challenges that manufacturers have faced for years and continue to face. "An OEM enterprise wants to be able to react in this environment; they have to be able to work across the Internet with diverse kinds of data and share knowledge—in fact they need to use it to collaborate," Versprille says.

And engineers are using the Internet in just these ways. According to a recent DESIGN NEWS survey, engineers depend on the Internet as an important information resource in their daily professional lives: 77% of engineers who responded to the survey said they use information from the Internet to solve their design problems. Of these engineers, 75% said they use the Internet to send or



According to a DESIGN NEWS study, nearly twice as many engineers use the Internet daily, and that usage is increasing to several times a day.



Engineers are also spending more time on average browsing or using the Internet for work.

receive e-mail, 29% use it to download CAD drawings, and 18% use their connections to collaborate on designs.

The DESIGN NEWS survey also found that time to market is driving engineers' lives, as customers are demanding more functionality and features in their products. In order to meet these demands, engineers need to use the right software tools.

Along these lines, PTC offers a variety of tools that let engineers, for example, build interchangeability into a product as it rolls down the production line. Products such as Windchill® and Pro/ENGINEER®, with its patent-pending behavioral modeling technology, address these engineering needs.

3D Solid Modeling paves the way for Behavioral Modeling

By now, the benefits of 3D solid modeling are clear to many engineers—its ease of use has boosted engineers' productivity compared with 2D systems. Using 3D solid modeling, engineers can create and evaluate virtual prototypes of their designs. Costly mistakes that used to be discovered further down the design process are now mainly eliminated.

As a result, manufacturers experience more productive design processes, lower-cost engineering and faster time-to-market compared to 2D technology.

Feature-based, parametric 3D solid modeling, which PTC introduced to the industry, lets engineers easily make design changes so that they can iterate frequently and get products to market in record time. "Your geometry may be quite complex, but that shouldn't hamper your ability to make changes," says Jon Stevenson, executive vice president and general manager of the MCAD business unit of PTC.

A robust, flexible solid model is also a pre-requisite for further reducing cycle times by providing a platform for automating design exploration and optimization. The combination of these technologies gives engineers the ability to quickly evaluate alternatives and drive to the right solution for their customers- a level of design automation they could not even imagine with 2D technology.

What solid models let you do

1. Visualize the product throughout the entire design cycle
2. Trouble shoot early to identify problems
3. Generate deliverables such as part and assembly drawings quickly
4. Gain advantages of associativity, so when you change a part the whole assembly and other deliverables update
5. Take advantage of downstream applications such as FEA and CAM

Behavioral Modeling: Automating the design process

The new behavioral modeling design process begins when an engineer gathers or defines requirements for the product, such as mass goals, balance objectives, desired volumes, clearances, pressure drops, and embeds them in a flexible product model. Then the engineer chooses aspects of the product design that can be varied and specifies acceptable ranges of values.

The job of exploring the realm of design possibilities is then delegated to the computer— or multiple computers— which automatically creates many virtual prototypes, measures their performance and lists the best candidates. The engineer can now select the most promising design after looking at it, and using engineering judgement to determine the best blend of performance characteristics.

This is a new design process that was introduced in Pro/ENGINEER 2000i^2. It provides behavioral modeling technology. Behavioral modeling transitions traditional CAD from being a documentation tool to being a true design tool and solving real design problems.

"The system does the grunt work," explains Stevenson of PTC. "Now through behavioral modeling and 3D designs the engineer can focus on product innovation."

The concept behind behavioral modeling is to allow designers to capture functional behavior and make use of this to derive and adapt their product designs. It streamlines the process of developing an optimal product solution that meets specifications, even in designs with numerous variables, constraints, and goals.

The Dana Spicer Heavy Axle and Brake Division adds 'intelligence' to design

Jim Ridge knew that he was going to have a problem. Ridge, a designer with the heavy-axle and brake division of The Dana Corp., a manufacturer in Kalamazoo, MI, foresaw a packaging challenge with a newly designed part.

But the problem was solved easily-in one hour. The reason: Ridge used PTC's Pro/ENGINEER and its behavioral modeling technology. "Before behavioral modeling, it would have taken me all day to solve the problem. It's a dramatic increase in productivity," says Ridge, who is in the advanced product's team.

Ridge, who designed furniture before joining The Dana Corp., spends his days designing new concepts for Heavy Truck customers. On a typical day, one of his colleagues will bring a concept to him and he will create a solid model of the idea. He also does part layouts, and creates the visualization of the concepts and documents for reusability of knowledge, company standard adherence and utilization of best practices. He has found enormous time-saving benefits to using behavioral modeling, especially with the moving parts in axle designs.

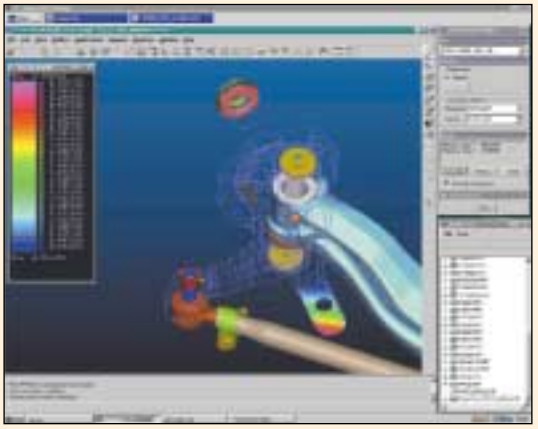
"Behavioral modeling added intelligence to solid modeling," he says. "With behavioral modeling, we were able to create a motion envelope of moving parts in its designed space, and use it as a reference to create a clearance envelope. It's a new dimension in solid modeling. Now we have a process for converging quickly on optimal designs, such as adding motion to an assembly that previously required programming to discrete positions."

Another advantage to the technology, he says, is the ability to drive designs by corporate objectives and perform design studies. Design studies allow engineers to get a better understanding of the factors that influence performance, rapidly identify potential candidate solutions, and fine tune parameters to get the optimal design.

"Behavioral modeling gives designers the tools they always wanted to have. We didn't have optimization before PTC introduced them in its product. Now we have tools right in our design interface to automatically generate new deliverables."

And as companies are continually pressured to get products out in shorter amounts of time, the technology is saving Ridge precious time.

"Now when I'm given a design of 30 pieces I can do it in two days instead of two weeks. With PTC technology, Pro/ENGINEER and behavioral modeling, we can go through more iterations getting the design right the first time. The end result is a better product, which gives us more flexibility to deliver brand, regional and customer variations," he says.



Dana Corp. engineer Jim Ridge solves problems quickly by using behavioral modeling.

"What behavioral modeling allows for the first time is a circle definition of a product's geometry," says Versprille of DHBA. "You can take the derived values, and feed them back in an iterative loop to set optimization goals. The software churns to come up with the best height, length, and depth for the design."

As problems are solved, the solutions are captured in the model so they can be reused to improve productivity on future designs. The Pro/ENGINEER implementation of this technology uses the product's inherent capabilities for capturing intelligence and modifying parametric models.

"If you look at software produced by PTC and our competitors in the last decade, it was focused on increasing an engineer's productivity," Stevenson says. "Today, PTC is focused on creating solutions for engineers that are more innovative, such as mechanical design synthesis."

Dallara Automobili, a supplier to the Kelly Indy racing team, makes extensive use of 3D modeling from PTC. These composite car bodies with aluminum honeycomb structure are ready for shipment to the team.

Reusing company standards and best practices

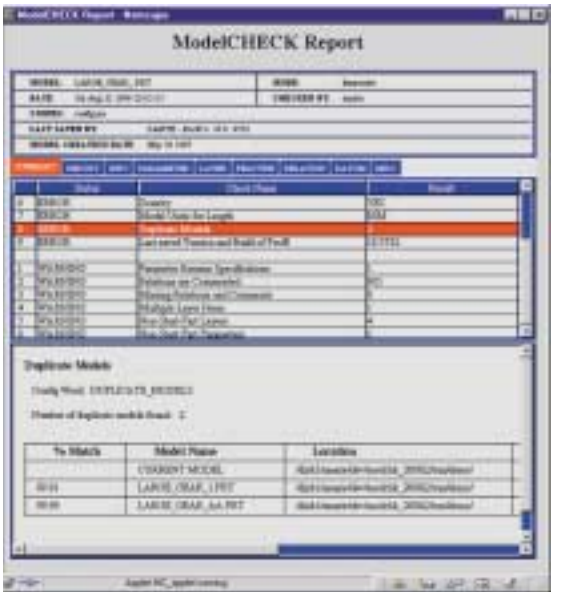
Raytheon mechanical engineer Israel Pabon faces the same problem engineers at other companies and in other industries face: ensuring the quality of his CAD models. But he uses a weapon that helps him immensely. It's called ModelCHECK, and it's a module in PTC's Pro/ENGINEER family. Similar to an engineering spellchecker, it highlights areas where an individual model may violate company standards or best practices so the engineer working on the model can make the necessary corrections.

"We wanted to make sure we were adhering to best practices," he says. "ModelCHECK has helped us reduce errors."

And, it has shown where engineers may need more training. "We have been able to develop training programs targeted at the most common errors," he says.

ModelCHECK enforces company design standards.

Making sure that engineering models conform to naming, layering, and other conventions is much more than just good housekeeping. It's critical, especially when companies plan to use the models and the engineering knowledge and intent they contain for downstream applications such as rapid prototyping, analysis, mold design, NC, visualization, and bills of materials generation. If the models don't conform or if the



Conformance to standards, enabled by ModelCHECK makes it possible to use models in downstream applications.

engineer creating the original model doesn't use the company's standards—others may have difficulty reading and using the model. That wastes time.

And time is the critical element in design today. Many companies are eliminating drawings and physical prototypes to speed the product development process. They are focused on developing one computerized engineering model for each product, and making it the master that everyone in the product development chain can use. Engineering can use it for stress and other tests. Marketing can use it for presentations to the customer. Purchasing can use it for ordering components. Production can use it to manufacture the product. And Shipping could even use it for building the box the product ships in.

But for the single-model strategy to work, each department must make use of the work of other departments—the solid model must be understandable by everyone. ModelCHECK ensures that the models meet the standards the company has set for streamlining communication and

Case Study: John Deere

Engineers at Deere & Company's Construction Equipment Division spend more time creating innovative designs and less time performing mundane design work.

"The whole idea is to reduce product delivery cycle time," says Jim Alexander, manager of Product Delivery Process Services at the Dubuque, Iowa engineering center. "What is key to reducing those times is building and maintaining configurations of the product model and bill of material and communicating what the configuration means across the entire supply chain," he adds.

The products that John Deere engineers use to help them achieve this are from PTC, and include Pro/ENGINEER and PTC's data management solutions.

Pro/ENGINEER and PTC's data management solutions give Deere engineers more time to create innovative designs.

'We model everything'

Together Alexander's PDP Services team, and Pro/ENGINEER users from many disciplines develop and implement product modeling solutions that support Deere's Product Delivery Process. His team ensures that the complex geometry created for John Deere construction equipment resides in a central data base location on a flexible and modular platform so that it is easily accessible to anyone who needs it, thereby saving engineers time. However, not every supplier has the same technology tools as John Deere.

"The master models for our products are stored in our geometry management solution. For us it is preferable to do business with suppliers who can use that geometry directly. In those cases, the supplier can go directly to the Pro/ENGINEER product model, instead of asking the engineer for drawings to review design information. It reduces the opportunity for error," he adds.

Deere engineers use PTC solid modeling technology to "model everything," Alexander says. The solution has helped the division improve quality and reduce total product delivery cycle time. "By using solid modeling for every part, we can turn our resources to respond quickly to customer requirements by reusing existing designs," he added. "As a result, we get our new products to market faster and increase our opportunity for market share growth."

John Deere has been using Pro/ENGINEER since the early 1990s after doing an evaluation of the major solid modeling systems that were available. "We found in Pro/ENGINEER some key features, such as industrial strength solid modeling, parametrics and associativity. These characteristics were important to us because we were creating home grown solutions to build associations between geometry and bills of material," Alexander explains.

In fact, Alexander pointed out that the geometry management team was trying to integrate three different databases, one that contained drafting and drawing files, another that contained engineering bills of material, and the third that stored geometry. The goal, he says, was to "synchronize them so that the product data was consistent and accurate." The solution for Deere was to convert their product models to PTC technology. "Whenever we redesigned a product, we used PTC, because of Pro/ENGINEER's ability to integrate geometry with structured bills of material and product data attributes," he says.

Alexander says that the "design anywhere, build anywhere" concept is a very real requirement for global manufacturers.

incorporating best practices. "It enforces conformity to standards and best practices," says Dante Dell'Agnese, product line manager for ModelCHECK at PTC.

The module catches mistakes by responding to certain triggers, such as when a user asks Pro/ENGINEER to update a model or save the model. Engineers can also activate ModelCHECK through a menu pick.

Bruce Rotolo, CAD applications manager at NACCO Materials Handling, has found that ModelCHECK is saving him about 15 minutes minimum per part as he moves models from one data management system to another. The models have thousands of parts, and without ModelCHECK, he says, the company would have to check each model for conformity by hand.

ModelCHECK also helps engineers find similar models so they can reuse them. While an engineer is building a model, ModelCHECK's Shape Indexing technology scans the model's geometry to determine if a similar one already exists in the company's files. If one does, ModelCHECK tells the user and displays the degree of similarity so the engineer can decide if they can use it.

Without such capabilities, engineers would be hard-pressed to reuse the detailed technical knowledge that already exists in their companies.

Build prototypes virtually

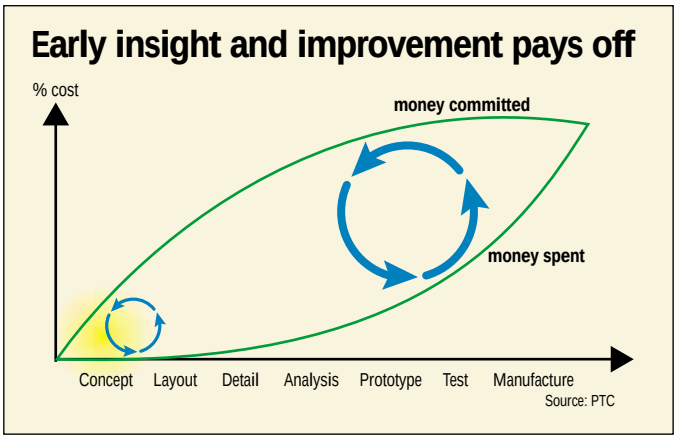
All design projects follow a similar pattern: First, you begin with objectives and a concept. Then, you try different design strategies, manipulating shape, weight, size, and other factors until you have a configuration you think is optimal.

At that point, you're work is only half done.

Traditionally, engineers have gone to physical prototyping next to see how their designs will work under real-world operating conditions. Will the internal components clear or interfere with each other? Will the product break? Will it succumb to thermal stresses? How does it look? Will it work?

Catching errors is critical. But catching them at the physical prototype stage, which is normally late in the development cycle, is costly—not just financially, but in terms of time.

Many companies exceed budgets and launch dates because their design teams find major problems while testing physical prototypes, says Paris Altidis, head of structural analysis in the automotive transmission systems division of Borg Warner Automotive. While sometimes you need physical prototypes, it's far better if the engineering team can test prototypes up front on



Up-front engineering gives you low cost iterations and greater freedom to change.

From months to hours

Engineers can design in hours what previously would take them weeks or even months using PTC technology. That was the case for engineers at Pre-Star, a supplier of pressed and fabricated chassis suspension parts to automotive manufacturers such as Rover, Jaguar, and Ford. They were able to cut their design cycle by 90% using Pro/ENGINEER and Pro/MECHANICA to optimize a part even before it was shaped.

A customer asked Pre-Star to increase the stiffness of the axle ends on a 4 × 4 vehicle. The bottom arm was bending elastically on rough roads and under continual severe impact, causing the drive shaft to move up. The drive-shaft movement caused oil-seal damage, and the leakage meant premature failure of the axles. Pre-Star engineers remodeled the original design in Pro/ENGINEER and optimized it using Pro/MECHANICA. Within four hours, they succeeded in increasing the stiffness of the part from 14 to 30 kN/mm; this task normally would have taken weeks or months.

The new part, however, gained 2.5 kg. Because the CV joint was rotational, the engineers did a new design, wrapping the sides upwards to get a more effective section. This change increased the stiffness value to 38 kN/mm, while reducing the weight to 0.5 kg less than the original part.

the computer as they do their design work, he says.

"You can test for form, fit, function, durability, and strength electronically," Altidis says, using physical prototypes only to verify the computer's results.

But traditional computerized testing and examination, such as finite element analysis (FEA), has required the knowledge of highly trained specialists. And, says Ken Short, director of technical marketing at PTC, there aren't enough of those analysis specialists to go around.

"The key is to give design engineers the tools to do virtual performance prototyping early in the design phase," says Short.

PTC offers a full suite of products to give its customers the capability to prototype virtually. These include: Pro/MECHANICA for FEA, ICEM Surf for surfacing and shape modeling, CDRS for turning conceptual sketches into accurate surface models, and DIVISION, for simulating form, fit, and function as well as assembly/disassembly sequences.

"Even if engineers cut the number of physical prototypes from, say, five to four in a project, they get huge savings," says Short. The more virtual prototyping they do, the less risk and the less time they have to spend in testing and validation, he concludes.

Enabling engineers to 'do it right the first time'

How engineers design products will continue to change as technology advances. Demands on getting it right the first time are going to grow as product complexity and choice increase to meet consumer demand and a greater number of suppliers are brought into the design process. All of this data is available faster and more readily as a result of the Internet.

In the future, says Ken Versprille of D. H. Brown, a flexible engineering approach will enable companies to implement design processes that will differentiate them from competitors. Technology will be able to slice and dice data so that they can give different individuals the information that's relevant to them.

Flexible engineering will enable companies to differentiate themselves.

As information is shared with many different sources such as customers, suppliers and other internal departments it will be important for individuals to access the data relevant to each task. For example, an engineer may be looking at a shaded solid from a geometry aspect because he's making changes to the shape.

Down the hall, a manager may be working with a procurement person. The same data takes into consideration the task they are looking at. "It's called the domain-specific presentation of data," Versprille says. "The whole openness of data exchange-everything needs to work together," he adds.

Real-time design collaboration will continue to be the goal for companies worldwide. "Instead of an engineer designing on his desk in isolation, he will design with others in real time," says Jon Stevenson of PTC. "I believe in this decade we will see the wall between design and manufacturing come down. I also believe design synthesis is going to be more common in the design industry."

Design synthesis, or behavioral modeling, gives engineers more time to develop innovative products while the technology figures out design solutions. This is important since, some predict, engineers in the future will need that time to develop new products that are more stylized in nature. PTC has product under development to address this trend. Since styles change and fashion is fickle, companies want to be able to make design changes as late in the design-to-manufacturing cycle as possible.

Increasing engineering flexibility doesn't end with the ability to create a winning design on the first attempt. Two other areas that companies need to examine include how rapidly they can customize products and how well they collaborate globally with the supply chain. PTC will address those topics in subsequent supplements in DESIGN NEWS.

Don't forget to register for the upcoming PTC webcast that will take place on Thursday, October 26, 2000 at 11 a.m. (EST). To register visit www.designnews.com.

Attend the webcast to learn more about how PTC technology can help your engineers create designs right the first time that will work in the real world and enable companies to be more competitive.

To learn more about these topics, register for the Design News webcast at www.designnews.com.