

3D Rising:

Engineers harnessing the full power of 3D

by Chris Randles

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Introduction

Does this sound familiar? It's late at night, but the engineer is still hard at work. Shoulders hunched over his keyboard, staring at a CAD model of a hand-held electric drill. Before meshing the designer's model he wants to simplify it. He has the designer's native CAD file and software, but he's still struggling. He tries to remove some fillets, but the model regeneration fails. He tries to delete the air vents for the motor—same result. He can't figure out why. Finally he gives up and goes home. The next day he calls the designer to ask him to make the changes. He leaves a message—no response. He tries back after lunch—no answer. Finally, at the end of the day, he reaches the designer, who promises to make the changes and resend the model. The next morning, the engineer opens the new model only to find that the designer deleted the air vents but not the fillets—and the whole process repeats.

Days go by, time is wasted, and everyone is frustrated. Similar situations occur throughout product development. Some people try to use the 3D design model. Others don't even try—they just use the 2D drawings. It's all so unproductive, and unnecessary.

What if everyone involved in bringing a product to market could work and communicate in 3D?

This paper examines the growing trend of enabling 3D technology for mechanical design, beginning with an exploration of why 3D modeling has, until now, been widely adopted only by product designers. Next, this paper shows—by studying specific examples of 3D use in manufacturing, analysis, conceptual design, and design review—how 3D has been unleashed for the benefit of everyone involved in product design. Finally, this paper identifies several key features essential to any 3D tool for engineers who want to increase their personal productivity.

The Limited Role of 3D Modeling in Product Development

3D CAD systems have transformed product development within manufacturing companies, but they remain the domain of specialists—those dedicated CAD experts who understand the nuances of parametric solid modeling systems. The majority of you involved with product realization don't have the time to master the product designer's CAD tool, limiting your participation in a more fully automated product design process.

Consider the automotive die caster who uses a 3D modeler to review early design models for improved product manufacturability. In the 'old days', he relied on paper drawings and redlines. Without sufficient time to learn the designer's CAD system, his input was manual, intrinsically lessened by the 2D medium it was tied to. Now his review is done in the context of the design itself: he updates the model—increasing the wall thickness around a core, for instance—and then sends the revised and annotated model back to the designer.

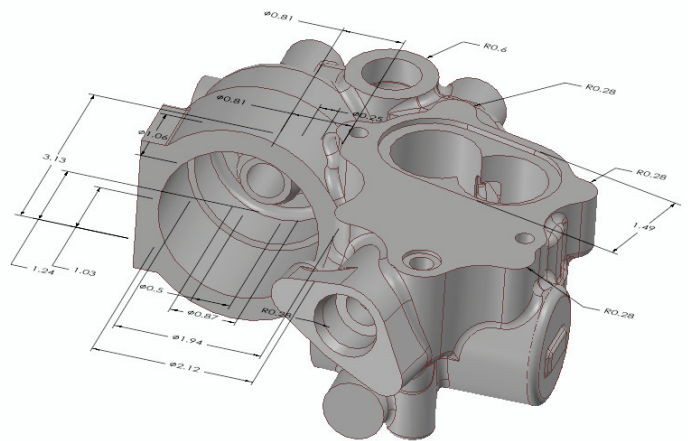
But most participants in the product development process still have one foot in the 'old days'. Concept design, manufacturing, analysis, QA, and others sing a common refrain—they want the benefits of 3D. They know it would enhance product development and improve their own productivity to boot. So if everyone wants 3D, why hasn't it been widely adopted? To get at that, let's drill down into who's using it and who isn't.

3D-Enabled

Who's served by 3D? Mainly the product designers: highly-specialized CAD operators using a parametric modeling system like Pro/ENGINEER®, SolidWorks®, CATIA®, NX®, or Inventor®.

Parametric modelers use variables to define model geometry ('the diameter of this hole is 0.75 inches') and relationships ('the hole is centered on this face'). If a variable parameter is changed, the model updates accordingly. In this way, a parametric modeler embodies the original design criteria. A parametric modeler is 'smart'—recording design intent during the modeling process and facilitating modifications—and it has become the de facto standard for mechanical design.

You may already have experienced a downside to parametric models: they become cumbersome to change. As the model gets more defined, the relationships become tangled, and the model becomes overly constrained. If you try to change one parameter, all sorts of other unexpected changes may result because of those tangled relationships. Even minor changes can require a detailed understanding of both the native authoring tool and the product model itself, rendering the model 'view-only' to everyone but the original designer. Think of a complicated Excel spreadsheet, overwhelmed with cross-references and formulas. It may be perfect for the financial analyst who created it, but it's almost impossible for anyone else to predict or validate what will happen when a formula is modified.



PARAMETRIC MODEL WITH DIMENSIONS SHOWN

Underserved by 3D

Who's not benefiting from 3D modeling? Most of the extended development team: those responsible for downstream functions from manufacturing to field engineering, as well as upstream functions involved in conceptual design and engineering.

It should be noted that many individuals in this group do employ 3D automation tools: CNC for manufacturing or FEA software packages for analysis, for example. But those individuals aren't working with the original 3D design model. The manufacturing engineer who needs to add draft to the model for manufacturability and the analysis engineer who needs to remove all rounds before meshing would get their jobs done more easily if only they could work directly with the original model. But they can't because the design model and the software used to create it are too complex.

The design review process is another area that could benefit from a broader use of 3D. When a view-only product model is projected on a screen for review in a graphic display format, such as JT, there's no ability for review participants to flex the model or directly make changes in real-time. The feedback loop is typically 2D or in text (which are error-prone and inefficient), and it's left to the designer to sort it out and manually update the model. This disconnect results in an over dependency on CAD specialists, who wish that others could communicate with them more effectively by using 3D.

Extending the Role of 3D Modeling

Innovation abhors a vacuum, and great strides have been made to extend the 3D experience to all the participants in the product development process so that they can provide meaningful input to the product design. New mechanical design systems are available that allow upstream contributors and downstream consumers to interact with a 3D design model, and even to create models of their own. These systems extend true 3D modeling to the underserved while complementing existing CAD systems.

As an example, let's look again at the consumer product manufacturer who is introducing a new hand-held electric drill. Since most consumers already have an old, clunky drill buried somewhere in their basements, the manufacturer's challenge is to introduce a new lightweight, stylish, 'fun' product—very low cost and available in stores in time for the holidays.

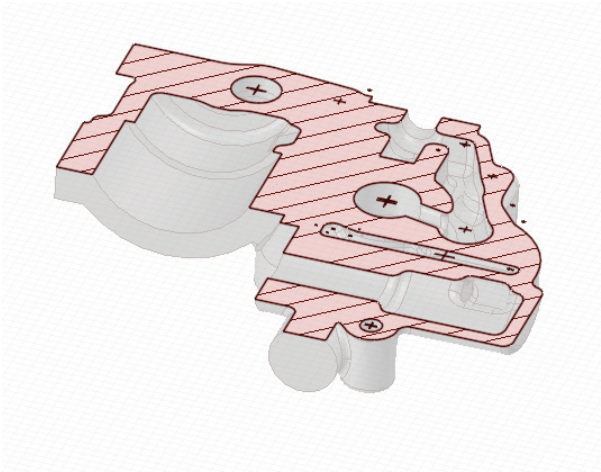
The conceptual design group must create sleek new body types with plenty of consumer appeal, so they use a 3D modeler to modify flat surfaces into shaped ones, uninhibited by the parametric constraints that are so useful in detailed design. To drive down the cost, manufacturing uses a 3D modeler to tweak the designer's model to accommodate existing tooling. For fast turnaround, the analysis engineer uses a 3D modeler to quickly simplify the design model by removing all rounds before analyzing it. Representing the voice of the customer, marketing uses a 3D modeler to get input on the early design from focus groups and key retailers.

3D for Manufacturing

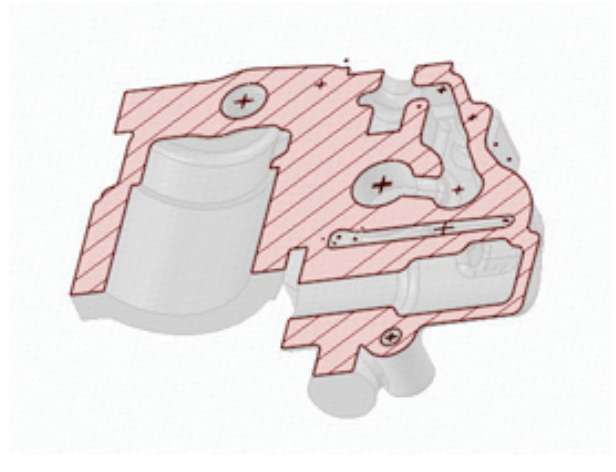
To understand the benefits of 3D modeling to manufacturing, consider an NC operator whose team can't afford the significant training and ownership costs of the designer's CAD system, so their product feedback is inefficient and infrequent. Their suggestions (such as, "you should make this change to accommodate tooling"), though perfectly constructive, tend to require last-minute design iterations, increasing production time and driving up costs.

But with a 3D modeling environment that's familiar to 2D users, manufacturing can contribute to the design more easily and, therefore, can do so sooner in the design process. Let's consider the die caster mentioned earlier who receives a pump housing design. His experience is that simple design changes can have a significant impact on the cost and speed of production, so he uses a 3D model to iterate on a more manufacturable design. He adds fillets and rounds that were missing from the original design, eliminating stress points in the casting and optimizing material flow. He adds ribs for strength. He then uses this 3D environment to communicate all of these model changes back to design so that they can update the CAD model in their system, and he goes on to build his own tools and fixtures around the design part.

"I've never had the time to learn the CAD system my designer uses. Instead, I rely on him to make all the changes for me. A 3D system that I could use without much training saves both of us a lot of time."



A 3D MODEL CROSS-SECTION



SAME 3D MODEL AFTER 2D SECTION CHANGE

3D for Analysis

The earlier that analysis can be done in the design process, the better. Often, the first step of analysis is to simplify the design model, removing unnecessary geometry that has no impact on the outcome of the analysis. Engineers often don't have enough (if any) experience with the CAD system to make the relevant changes to the model themselves. So they're forced to rely on the designers to simplify the parts. Remember that poor engineer, working late into the night trying to regenerate a model?

With their own 3D modeling tools, engineers are now able to modify the component themselves and play what-if's without having to go back to the CAD designer. They are contributing earlier in the design process because they're operating in parallel with the design process. In this case, the number of design iterations increases, improving the quality of the final products. For example, the plastic housing design for that hand-held, electric drill needs to be analyzed for stress. The engineer determines minimum wall thickness and stress points in the design and verifies the boss placements for fastening. She simplifies the part by deleting extraneous geometry, meshes it, runs the analysis, and finds the wall thickness is too thin. She adjusts the wall thickness and runs the analysis again—looks good! So she sends her validated input on the design back to the design team to revise the design.

3D for Conceptual Design

Conceptual designers need maximum flexibility in a 3D modeler—the flexibility to create the shapes and surfaces so common in today's products, as well as the ability to change those shapes in all sorts of unanticipated ways. The CAD systems used by the detailed design team are not well-suited for conceptual design.

A flexible 3D tool for concept modeling lets designers consider multiple product options without needing to anticipate them in advance. Think of a conceptual designer who is working on a faucet design—part of a whole product line launch aimed at the public's appetite for the opulent kitchens and bathrooms we see in commercials and magazines. He starts his new design based on a faucet from last year's line, which used a handle and filter similar to what he wants. The original CAD model of that design had a basic rectangular cross section that was swept along a curved profile, but that CAD system didn't allow him to make the changes he needed. Using his own 3D modeling environment, he changes the section's size and shape as it traverses along the sweep and also changes the sweep profile to be more aesthetically pleasing. Without the constraints of a parametric modeler, he is able to quickly create several concepts, all from the same base design, and with no model regeneration issues.

3D for Design Review

Most design reviews rely on graphic view-only 3D or 2D formats such as PDF or DWF. A lot of time is wasted creating and managing drawings or graphic files to feed these design reviews, increasing engineering time and cost. Comments come back via redlines, notes, 2D sketches, or over-the-shoulder recommendations. The process is error-prone and inefficient.

We've already looked at how 3D tools have enabled manufacturing and analysis engineers to offer feedback earlier in the development process. In addition, a 3D modeler should fit so well with existing technologies and processes that it enables even non-CAD users to participate in a 3D model-based review cycle. This makes it easier for everyone to understand the design and communicate their suggestions by actually interacting with the model. For example, the marketing manager reviewing the kitchen faucet design from above can modify the size of the swoop based on real-time review with a consumer focus group. Then, the supply chain manager can show the handle manufacturer how the handle should be resized to accommodate the new look. The design feedback is precise because it's based on actual geometry changes, resulting in more productive design iterations.

“Accelerating time-to-market is still a critical need for most manufacturing companies. There are huge time savings when everyone involved in the product development process can work in 3D.”

3D Modeling Checklist

You too can benefit from a 3D modeling system. When selecting a system, make sure you choose a 3D solution that was designed to meet your needs. It should be closer in use to Microsoft Word® or PowerPoint®, and run on your laptop or desktop.

At a minimum, check for these key features:

- ✓ **A superior user experience.** Take Microsoft Word for example: it may not be the world's best word processor, but it's the de facto standard because it's easy to use. One thing to look for in a 3D modeler that makes it easy to use is a modern user interface that takes advantage of the latest graphical interface technology found in popular business applications (such as Office 2007®). Minimal menu selections, clear graphical icons, and heads-up displays all make a good modeler easier to use.
- ✓ **A flexible modeling environment** that allows you to change an existing CAD model regardless of its origin or how the model was built. This overcomes the issue of an overly constrained parametric model mentioned at the beginning of this paper and minimizes the dependency on expert CAD specialists.
- ✓ **An intuitive modeling environment** where the software predicts what the user wants to do, making it easier and faster to change a model. Today's computers have the CPU capability to anticipate what you want to do and react accordingly. Look for a system that doesn't require you to explicitly select every command and qualifier or to slog through endless drop-down menus, dialogue boxes, and user clicks.
- ✓ **A 3D modeling environment that's 2D-friendly.** Everyone's comfortable with plan, projection, and section view drawings, so make sure your 3D modeler leverages 2D techniques. Look for a 2D sketching environment that you can use to quickly create a 3D model or that enables you to use 2D cross-sections to make 3D design changes. Having 2D tools in a 3D modeler serves a twofold purpose: it makes changes to 3D that much easier, and it shortens your learning curve.
- ✓ **A 3D modeler that complements existing technology and processes.** You need a system that fits in your environment, lets you interact with models from a variety of 2D and 3D CAD systems, and fits into your data management scheme. So it has to support both industry-standard data exchange formats such as IGES and STEP, as well as native import of vendor-specific formats like AutoCAD®, Pro/ENGINEER, or CATIA.

Summary

Today, advances in design technology make it possible for everyone involved in the product development process to contribute, consume, and share mechanical designs in a digital form. Even if CAD design is not your full-time job, and even if you've tried a 3D CAD system in the past only to find it took too much time to learn and for too small a gain, it is time to take a fresh look at what's available in 3D modelers.

Considerable advances have been made in terms of 3D usability, and engineers throughout product development are reaping the rewards in terms of personal productivity. To enjoy these benefits yourself, look for a system that's been developed to meet your unique needs, a system with greater ease-of-use than any of your previous experiences with 3D. Find one that's robust enough to handle your parts and assemblies while making it easy to modify existing models regardless of their original authoring system.

There are newer versions of existing products and exciting new 3D technology emerging that's worth looking into: check out the latest software versions from SolidWorks (www.solidworks.com) and Autodesk (www.autodesk.com). You should also evaluate a new offering by SpaceClaim, a company that was founded in 2005 by industry veterans and that targets non-CAD users in engineering and manufacturing (check them out at www.spaceclaim.com). Some accomplish just a few of the checklist features above, others go further. Find the 3D modeler that gives you the productivity boost you need to get your job done with greater precision and ease.

ABOUT THE AUTHOR

Chris Randles is an independent consultant and former CEO of Mathsoft (the Cambridge, MA-based developers of Mathcad, technical calculation software that is the global standard for engineering calculations).

Under Chris Randles' leadership, Mathsoft was transformed into a fast-growing and profitable provider of analysis and documentation solutions for engineering enterprises around the world. Chris led the management buyout of Mathsoft in 2001 and was the company's CEO until its sale in 2006 to PTC (Parametric Technology Corp.). Previously, he was Sr. VP and GM of the Engineering & Education Division of Mathsoft's former (publicly-traded) parent company.

Chris started his career working in technical roles in engineering computing. In the 25 years since, his career has encompassed a variety of sales, marketing, and general management positions in US- and Europe-based application and enterprise software companies, including: Olivetti, Lotus, Software Publishing, and Mathsoft. Chris has contributed successfully to new and established enterprises, and has managed business at all stages of development—startup, turnaround, and profitable growth—guided by his strong commitment to global strategy.

Chris was raised in England but has lived in the US for over 16 years. He has dual UK and US citizenship. Chris holds Bachelor's and Master's degrees from the University of Oxford and has also completed executive programs at London Business School and Caltech.

