

# The New Competitive Edge: 3D Conceptual Design

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## Executive Summary

This paper describes how emerging 3D modeling tools enable manufacturers to modernize their design-through-manufacture process, resulting in improved innovation and cross-functional collaboration. The concept models developed with these 3D tools allow early-phase stakeholders, including concept engineers, analysts, and product stylists to converge on critical design decisions before detailed design takes place in production CAD systems, thereby mitigating costly design iterations.

## Introduction

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

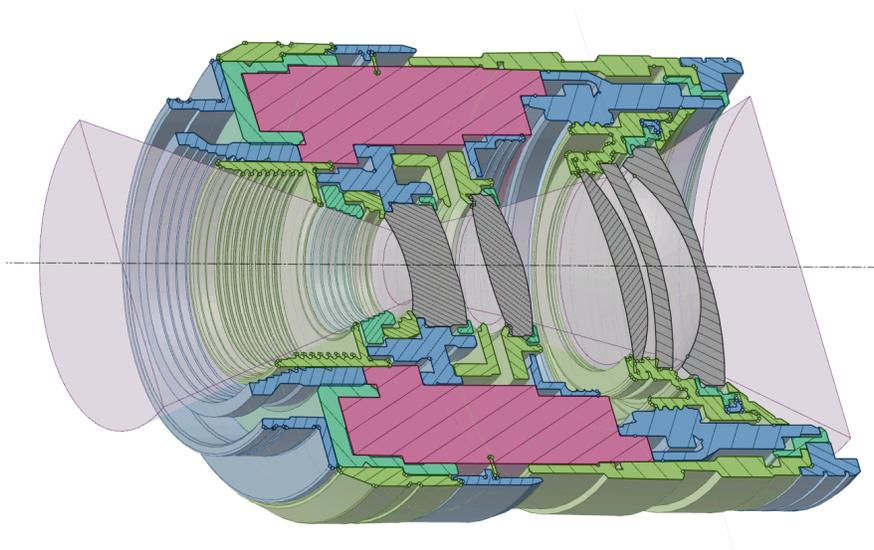
Engineers and designers are learning something amazing about how to improve the products they create by evaluating their design processes and identifying new ways to foster innovation, reduce development time, and deliver more value to their customers. They're discovering that emerging tools can empower more engineers to collaborate on concept models in the early phases of the design process to address cross-functional challenges. The advent of direct modeling, a new approach to 3D design, is making 3D solid modeling accessible to all engineers, bringing 3D to a wider audience beyond dedicated CAD users. This fundamental improvement in the design process is revolutionizing the way products come to market.

Organizations that are expanding the reach of 3D tools beyond the detailed CAD design process are dramatically improving product quality and time-to-market by creating a focal point for the conceptual engineering teams, delivering:

- **Accurate Specifications:** Engineers can provide solid parts and assemblies to the CAD team, which is the most accurate way to drive the detailed design process. CAD users receive accurate, unambiguous models that take the guesswork out of planning design intent.
- **Shared Concept Models:** The driving stakeholders of the design, including mechanical engineering, product styling, electrical engineering, and component suppliers, can confirm in short iteration loops that their designs are compatible before the detailed design process commences. In addition, management is able to review and comment on product designs directly in the 3D environment, bringing them closer to the design process and providing greater ability to monitor the progress of the workflow.
- **Concept Validation:** Rather than merely being used to validate polished, detailed models, analysis can drive the detailed design process. Engineers can be confident that if the conceptual models pass the tests, the detailed models will pass too. Conceptual 3D tools enable rapid what-if analysis, thus mitigating redesign late in the process.

Conceptual 3D tools extend manufacturers' investment in CAD by enabling engineers to leverage and edit CAD data from existing designs and from suppliers and customers. When updating and modernizing product lines, engineers can understand the impact of their changes and maximize component reuse. Throughout the design cycle, anyone on the team can review and suggest corrections to the detailed designs without burdening the CAD team with unnecessary extra work. When it's time to validate the detailed models, engineers can directly open and de-feature the CAD models to prepare them for analysis.

With direct modeling, every engineer can finally operate in a 3D environment. The entire extended design team can communicate in the same language, from the earliest concepts to the shop floor. Designing or editing a solid model becomes as ordinary as typing a specification document.



*To ensure short iteration loops between engineers across disciplines, emerging 3D direct modeling tools help all stakeholders share conceptual 3D models. In this example, optical, mechanical, electrical, control, and industrial engineers can balance design trade-offs to create a new product concept in the context of CAD data from existing products.*

## Concept Models Add Predictability from Concept-through-CAD

Consider, for example, the design cycle for a highly-engineered product such as an auto-focus camera lens. How does introducing a concept model simplify and improve the concept-through-CAD process?

Let's first consider the stakeholders involved:

- The **CAD team** provides the detailed designs for existing product lines and creates the new detailed model once the concept and design intent have gelled.
- **Optical engineers** own the light path and optics and must claim space for those components.
- **Mechanical engineers** design the basic mechanism and structural components of the lens, relying heavily on previous designs.
- **Electrical and control engineers** design the electronics and servos that compose the auto-focus mechanism. These engineers specify weight and force requirements, while ensuring that the design fits into the tight space between the mechanical parts.
- **CAE analysts** confirm that the structure is sound under specified structural and modal conditions.
- **Product stylists** design the outer markings, grip, and hood in the context of the engineering model.

In the traditional process, the design and engineering teams begin with the best data available. The process might start with several activities in parallel:

- Optical engineers sketch out a new light path in a 2D CAD system and choose the appropriate lenses.
- Mechanical engineers lay out the structure and high-level mechanics. In highly engineered designs such as a lens, most of the difficult decisions occur inside the housing, so typically the engineers perform this work in 2D cross sections. As part of the process, the mechanical engineers allocate a space claim for the electrical and control engineers who design using a variety of math-driven modeling tools.
- Product stylists sketch and render concept images in their artistic tools of choice, not knowing precisely what the outer geometry will look like.

Once each concept team decides that their design is ready, they send it to the CAD team to sort out the details.

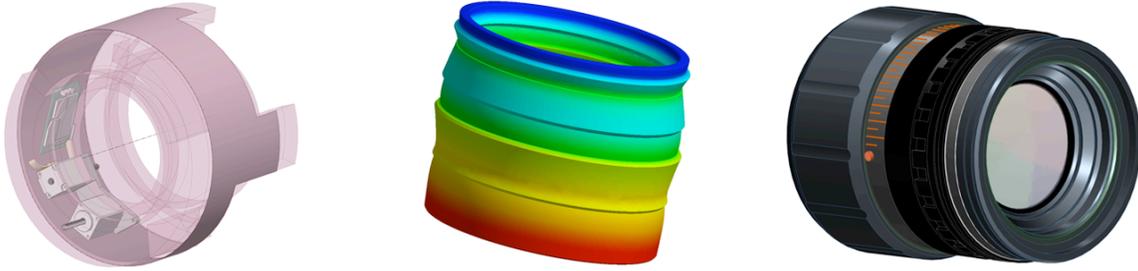
In the scenario above, it's not difficult to see that the detailed design team will encounter problems. Not one of the documents that they received would be directly reusable in the CAD system. Although the CAD system exported the 2D drawings that were the starting point for the conceptual process, the CAD models must be remodeled to have the correct new design intent. Inconsistencies among the engineering groups will appear as they develop the model. To reconcile the problems, the detailed designers must negotiate compromises among the engineering groups. The styling data is highly conceptual, requiring detailed designers to reconcile artistic guidance and engineering realities. Even worse, the design intent – the lifeblood of CAD systems – would be unknown until after the detailed design had matured, making the CAD models unable to take advantage of the full potential of the CAD system.

## Concept Models Provide a More Consistent Process

Concept models introduce predictability to the overall concept-through-CAD process by creating a common environment for engineers and stylists to collaborate on the design before it goes to CAD. In this example:

- Optical and mechanical engineers can work in the concept modeler's 2D and 3D environments to rough out the basic design.
- Product stylists and electrical and control engineers still use their preferred tools to do the bulk of the design and engineering work, but additionally they have access to coarse, but spatially accurate, 3D models of the concept to ensure the subcomponents fit into the available space.
- CAE analysts can perform analysis directly off of the concept models, suggesting modifications before the CAD teams begin creating the detailed designs.

All of the stakeholders build consensus before moving to the CAD detailed design phase, and the CAD team leverages well-defined design intent to drive feature-based models, maximizing the value of the CAD investment. When the detailed designs reach completion, CAE analysts only have to verify that the final design works as well as the concept.



*Different stakeholders in the concept design phase, including electrical and control engineers, CAE analysts, and product stylists converge on a concept model to add consistency to the detailed design process in CAD.*

## Direct Modeling Unlocks the Creation of Concept Models

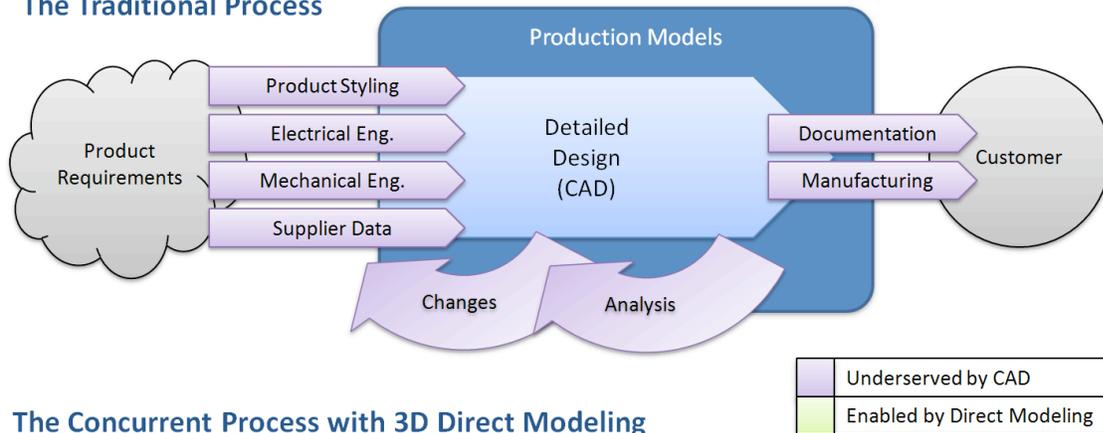
Why haven't manufacturers traditionally defined their design process around concept models? Some have, typically by training engineers in CAD or by partnering specialized designers with engineering teams. However, for concept engineering, CAD isn't necessarily the best tool for designing concept modules.

Engineers are more productive with 3D tools designed with engineering needs in mind. Until recently, few appropriate tools existed that were suitable for most engineering challenges. Engineers have long needed tools that can create models without the overhead of a CAD system; work with a wide variety of 2D and 3D source data; and are easy to learn, use, and deploy. Recent advances in computer hardware have enabled a new generation of 3D tools that finally bring solid modeling to engineers and other casual users. These "direct" or "explicit" modelers present a hands-on, no-nonsense approach to solid modeling that thrives in the conceptual design phase of a product's lifecycle.

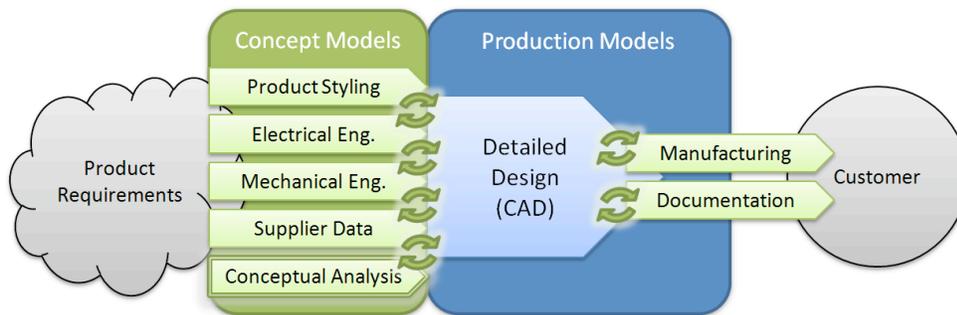
The concept of direct modeling is refreshingly straightforward: engineers are able to create and edit a model onscreen by directly pushing and pulling on the geometry, which provides hints to the modeler for how the change should interact with the surrounding aspects of the design. Direct modelers typically have no fixed concept of design intent, enabling concepts to evolve organically and opportunistically. How a model was created, or even its originating CAD system, does not change how the model can be edited. Models can be created and manipulated in any view, any document, or any cross section, fixing problems wherever they are found.

As simple as the concept may be, direct modeling does not replace CAD. CAD models should be carefully programmed by CAD experts to capture product intelligence using constraints, parent-child relationships, and other forms of design intent. At the conceptual phase, however, when the engineering team must converge on design intent and maximize product fitness, those CAD capabilities are of little use.

### The Traditional Process



### The Concurrent Process with 3D Direct Modeling



Direct modeling introduces a new paradigm in product design and development. When engineers work with concept models, iteration loops shrink, reducing time-to-market.

## Concurrency Fosters Innovation and Expedites Development Cycles

Companies become more competitive when they optimize their product development process for product innovation, development cost, and time-to-market. The best way to enable innovative thinking, reduce costs, and expedite the development cycle is to maximize concurrency. When activities occur simultaneously rather than sequentially and teams have access to each others' data, the design process can be shortened dramatically. However, if the teams working in parallel don't actively communicate, their output can diverge, causing additional rework and hampering improvement.

One of the greatest opportunities for manufacturers to accelerate time-to-market is to enter the detailed design phase with well-defined conceptual models that all stakeholders can validate in advance. Concurrency fosters an environment where engineers who have the expertise to create and change concepts can regularly collect and act on relevant design information. Engineers and other stakeholders must have access to intuitive 3D design tools that help them to collect relevant data and synthesize new concepts on-the-fly.

## Conceptual Analysis Shortens Iteration Cycles

Trends in computer-aided engineering exemplify how manufacturers are honing their design process. Traditionally, the CAD team would build fully detailed solid models prior to analysis. The analysts would then need to either remodel or simplify the CAD designs to be suitable for meshing. While less expensive than validation by testing physical prototypes, this analysis process is tedious and inefficient.

In the past decade, CAD vendors have attempted to integrate CAE into their CAD solutions to address the issue. Even if the same individual is performing CAD modeling and CAE analysis, the fundamental problem still stands: using analysis for validation requires that CAD models be reconstructed before every design iteration.

Manufacturers are discovering a different approach. With conceptual models, function can drive form. When engineers prove concept models before going to CAD, downstream validation is likely to confirm the design's integrity. Direct modelers are ideal for building concept models for CAE analysis and editing to optimize the concept with short iteration loops. With a concept model in hand, detailed designers start with accurate solid models, thereby mitigating guesswork.

## Evaluating 3D Direct Modelers to Create Concept Models

When evaluating direct modeling solutions for conceptual teams, manufacturers should consider the unique requirements of 3D tools for engineering:

- **Low total cost of ownership:** In addition to the software pricing, evaluation should include cost of training, ongoing support, IT implementation, and hardware. Engineers should be able to learn the 3D direct modeling tool on their own using quick, self-paced tutorials. The software should use simple concepts have a modern interface that make it easy to learn.
- **Fast model creation:** Conceptually simple modeling tools will drive faster model creation. Geometry creation should use straightforward concepts such as pull and move, not history-based features that can cause “regeneration” or “rebuild” failures. Consider using tools with strong 2D drafting, the ability to turn 2D drawings into 3D, and to make 2D layouts of 3D designs.
- **Straightforward model editing:** Make sure the product can open and edit data from all major CAD systems. Fill and combine tools should be available for model reuse and cleanup. The ability to make unplanned changes to assembly structure and the flexibility to store subassemblies internally and externally are advantageous.
- **Universal interoperability:** Direct modelers for engineers should have the ability to open and save diverse CAD data. The solution should be able to open CAD assemblies with the correct assembly structure and instancing, and provide the option to only open the assembly structure or lightweight graphics representations without translating entire large assemblies. Check for the ability to organize data on conceptually simple layers that are compatible with layers from common 2D and surface modeling products. Also, look for a 3D mockup environment that can graphically highlight and track changes.

- **Engineering focus:** While some traditional CAD vendors are starting to add direct modeling capabilities to their CAD systems, these capabilities increase the complexity of highly sophisticated products, preventing the expansion of use beyond CAD operators. Engineers need a streamlined 3D design solution that lets them design without the burden of an entire CAD system. All creation and modification tools should work in 3D and in any arbitrary 2D cross section. Overall, the environment should foster creativity.

From an enterprise perspective, one of the greatest advantages of direct modeling is that engineers can use it opportunistically. Unlike CAD, which must be carefully deployed, teams and individuals can take advantage of direct modeling ad-hoc. Direct modelers do not have the overhead associated with traditional CAD systems, leading many manufacturers to offer these next generation 3D tools on every engineer's desktop.

## Conclusion

Emerging 3D direct modeling tools are finally uniting the extended design team and shrinking development cycles via concurrent engineering. These tools are enabling engineers to integrate colleagues' data and evaluate the design in the context of diverse requirements. When manufacturers capture and share the extended team's creative thinking, engineers can optimize designs for cost, quality, form, fit, function, and feature-set long before the detailed design process begins.

This new product design methodology enables the CAD team to start with accurate and validated concept models, resulting in CAD designs that require fewer changes late in the design cycle. During the detailed-design process, engineers can provide valuable feedback using solid models, the common language of mechanical design. Further downstream stakeholders, such as the analysis, manufacturing, and documentation groups, gain access to higher-quality models sooner. Design concepts receive earlier approval, which drives products to market more quickly.

In today's market climate, manufacturers are well-served by evaluating their overall design process and investing in technologies that move innovative products to market more quickly and at lower cost than ever before. With direct modeling, engineering concept models are a reality.

## About the Author

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Blake Courter has been in the 3D design software business since receiving his Bachelor's degree in Mechanical Engineering from Princeton University in 1996. After holding positions in product management and business development at PTC, Blake started researching how 3D could become more accessible, ultimately co-founding SpaceClaim Corporation in 2005. At SpaceClaim, Blake is focused on helping customers to use solid modeling in new and innovative ways.

