A Manufacturer's Guide to Maximizing the Productivity Gains of 3D Mechanical Design

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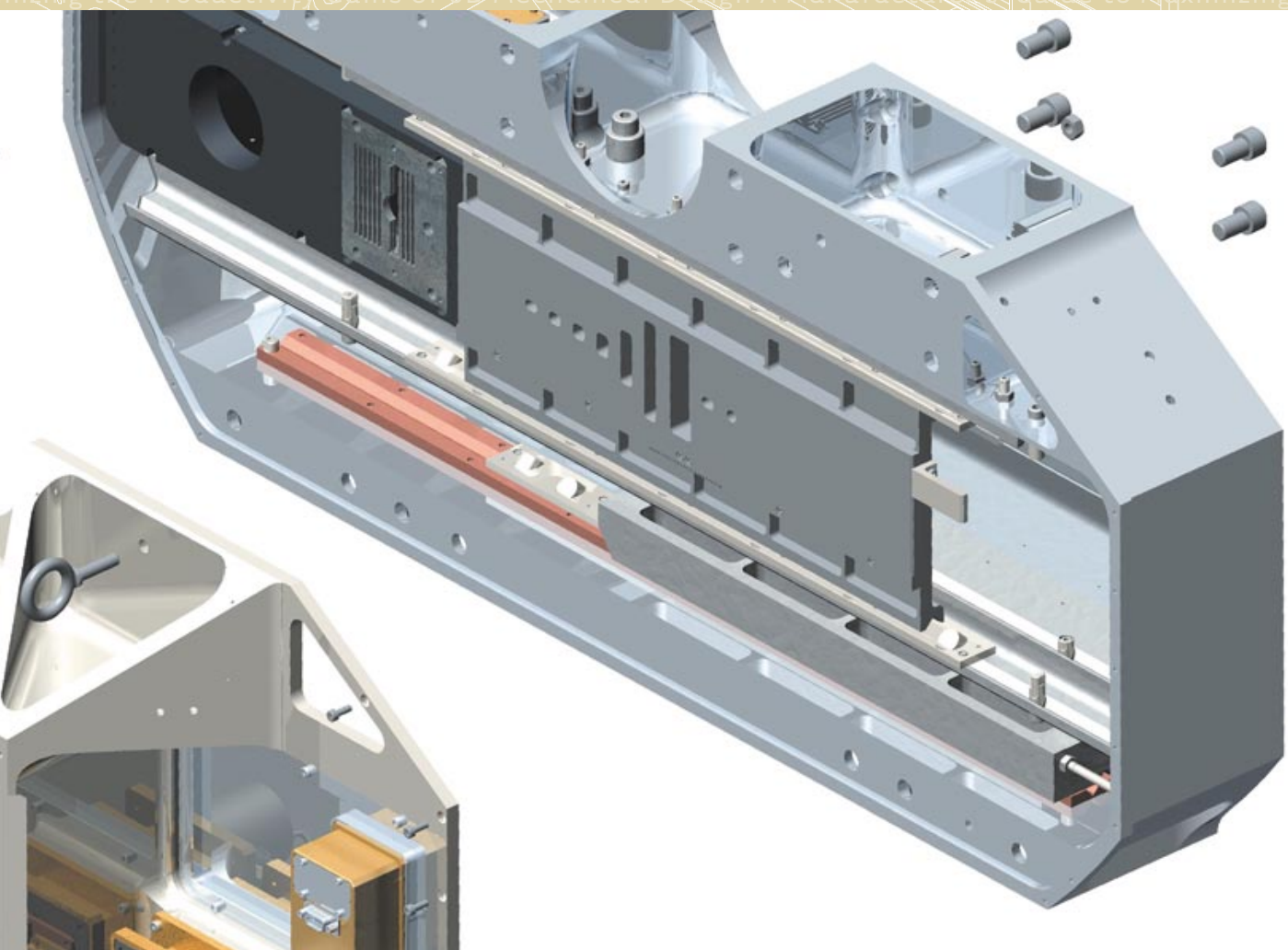
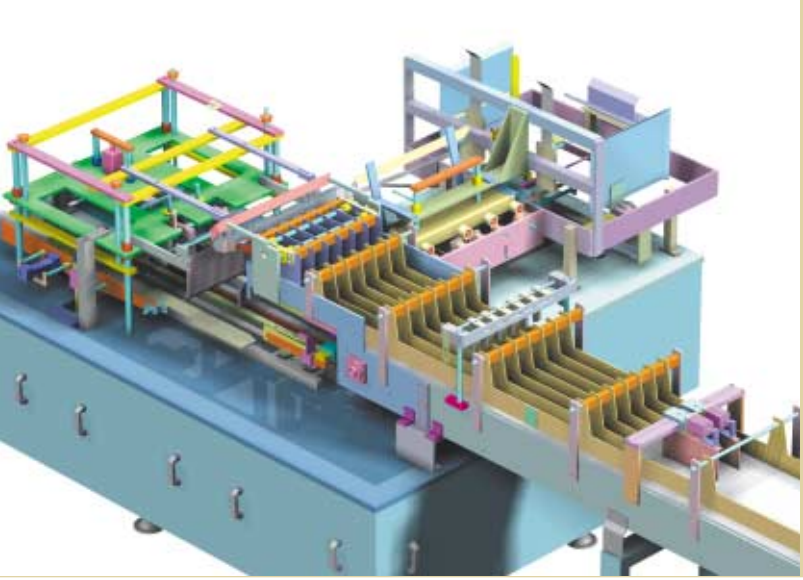




Using SolidWorks® software, packaging machinery manufacturer Yu Hou Industry Company, Ltd. has shortened its design cycle by 40% and increased market share by 20% while designing larger, more complicated assemblies.

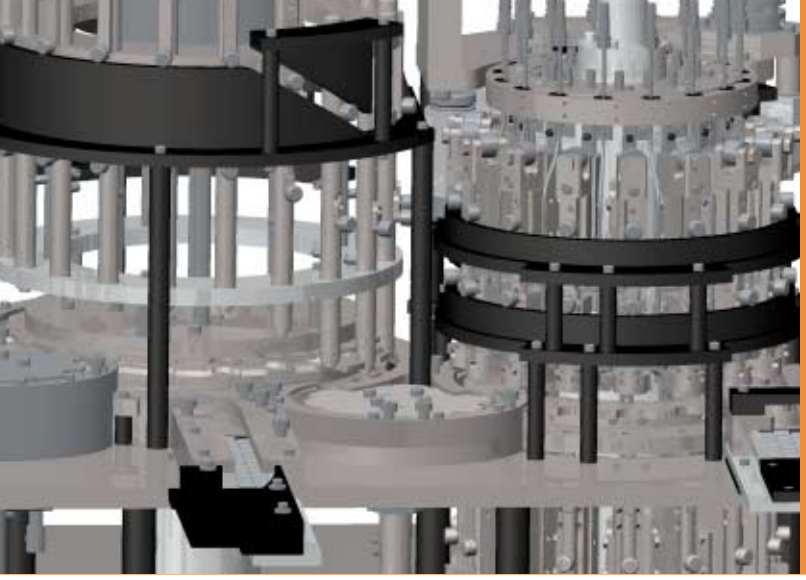
Why 3D Solids and Why Now?

Faced with the challenge of improving product design and development processes in recent years, a growing number of manufacturers have concluded that migration from 2D computer-aided design (CAD) to 3D solid modeling systems is essential to remaining competitive. While 2D CAD techniques support many product design and manufacturing processes, rapid advances in desktop computing hardware and powerful, affordable, and easy-to-use solid modeling software have created unprecedented opportunities to improve quality and accelerate time-to-market for manufactured products.

Now that early adopters of solid modeling software have successfully completed the move from 2D to 3D CAD, manufacturers that have yet to begin the transition are likely to do so soon. In fact, the majority of respondents to a recent survey of 20,000 CAD users indicated that they believed most manufacturing organizations would be using 3D solid modeling software for mechanical design within the next two years.

Why are so many companies migrating from 2D CAD to 3D solid modeling for mechanical design? Clearly, the productivity gains made possible by solid modeling software can dramatically increase a manufacturer's competitiveness. Solid modeling shortens design cycles, streamlines manufacturing processes, and accelerates product introductions by improving the flow of product design information and communication throughout an organization, as well as among its suppliers and customers. On the financial side, faster time-to-market and higher quality products translate into increased revenue, while reduced design costs provide larger profit margins. On the technical side, engineers benefit from improved handling and visualization of design data, leading to greater design innovation, validation, and confidence.

The ultimate objective in migrating to 3D is to accelerate the rate at which information is processed through the product development organization. By implementing a solid modeling system that supports the entire product development process, manufacturers can reap the full benefits of 3D mechanical design. This guide is designed to aid manufacturers in the decision-making process to maximize benefits and enable a smooth transition from 2D to 3D CAD.



"Using SolidWorks we can design the machine in solids, visualize parts and assemblies, and conduct interference checking and collision detection, all in less than one hour."

Jim Daffron, Engineering Manager,
Haumiller Engineering Company

Resolving 2D Challenges in 3D

The current generation of affordable 3D CAD software provides important benefits that help to eliminate obstacles that otherwise extend design cycles and increase engineering and manufacturing costs. By resolving the common challenges of using 2D tools, solid modeling provides the productivity gains and quality improvements manufacturers need to succeed in competitive markets.

Communicating Design Intent

CAD data is basically a geometrical representation of an engineer's imagination, capturing the engineer's creativity and design intent. With 2D drawings, engineers and manufacturing personnel have to interpret or visualize a flat 2D drawing as a 3D part or assembly. At times, interpreting 2D drawings results in a loss or misinterpretation of the engineer's original design intent, leading to delays and rework. With solid modeling software, design intent is maintained and effectively communicated through the actual 3D representation of the part or assembly, leaving little possibility for misinterpretation.

With SolidWorks, 3D solids accurately communicate design intent, minimizing errors due to misinterpretation.

Assessing Fit and Tolerance Problems

Engineers who design assemblies and subassemblies cannot assess fit and tolerance problems in 2D. Using a 2D layout drawing that shows product components, subassembly interfaces, and working envelopes, engineers are unable to fully visualize the 3D fit, interface, and function of assembly components. Often, this results in fit and tolerance problems that go undetected until late in the design cycle, when they become more costly and time-consuming to correct. With solid modeling software, an engineer can assess and address fit and tolerance problems during the initial stage of design.

Bucyrus International, Inc.

is a global leader in the manufacture of shovels, drills, and draglines for the surface mining industry. Designed using SolidWorks software, the Bucyrus® 795B Electric Mining Shovel with Hydraulic Crowd has more than 60,000 unique parts.

Handling Large, Complex Assemblies

When a product design requires large, complex assemblies involving thousands of moving parts, 2D design techniques become labor-intensive and time-consuming. Managing the numerous production-level drawings alone can be tedious. With solid modeling software, managing the accuracy and completeness of assembly production drawings becomes a less costly and more manageable process.

Minimizing Reliance on Physical Prototyping

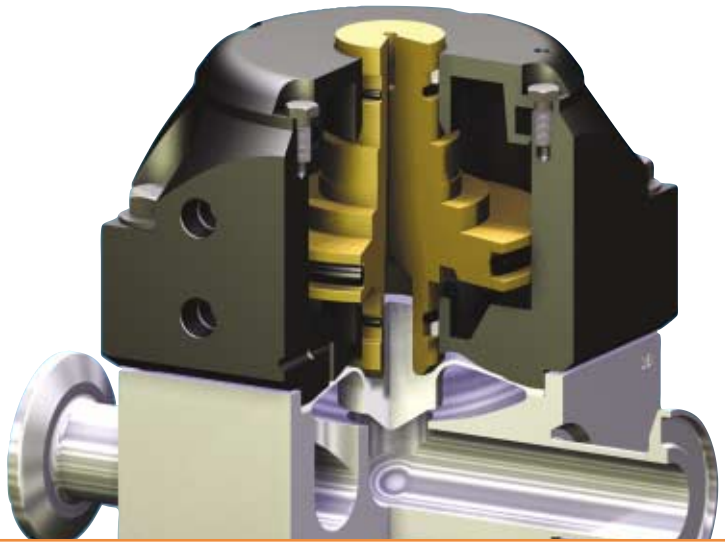
Product development teams that use 2D CAD often rely on prototype development to visualize the performance of an assembly. This is how they detect parts that collide or interfere with one another and ensure that all components have adequate clearances. With solid modeling software, the same task can be accomplished on the computer, saving both time and significant prototype development costs.

Eliminating Lengthy Error-checking

With 2D, most assembly designs require a lengthy, labor-intensive drawing error check, which is itself prone to error. Checkers spend countless hours checking fit and tolerance dimensions between drawings. This process can become even more complicated when drafters use different dimensioning parameters for parts from the same assembly. The error-checking process takes additional time when redlined drawings are sent back to the designer for corrections, then returned to the checker for final approval. With solid modeling software, it is easier to check drawings because the designer addresses fit and tolerance problems in the model as part of assembly design.

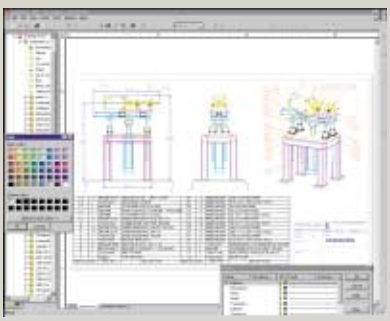
Creating Instant Drawings

Creating different views and drawings for a product design in 2D can be inefficient. Typically, creating isometric or exploded assembly views in 2D requires additional work because a designer has to recreate or redraw the design line by line. The same situation applies to detail and section views. Drawing creation can add substantial time and cost to a design, especially when the task involves intricate parts or complex assemblies. Most solid modelers create these views automatically from the solid model.



"Perhaps the greatest strategic benefit of solid modeling is the leverage it provides in performing downstream functions."

Andrew Dougherty, Manager of Product and Technology Development, Swagelok Company



SolidWorks automatically creates production-level drawings (any combination of views) from a model, such as this assembly with a bill of materials included. Additional views can be added easily.

Making Quick, Easy Design Changes

Making a design change in 2D can be tedious. Most designs require more than one 2D orthogonal view and a variety of auxiliary views. A single design change to a part often impacts multiple views of a drawing, forcing a designer to make changes to each view. This creates the need for another round of drawing checking, consuming more time. With solid modeling systems, once a design change is made to the solid model, it automatically changes all related drawings and associated views.

Configuring Derivative Products or Product Families

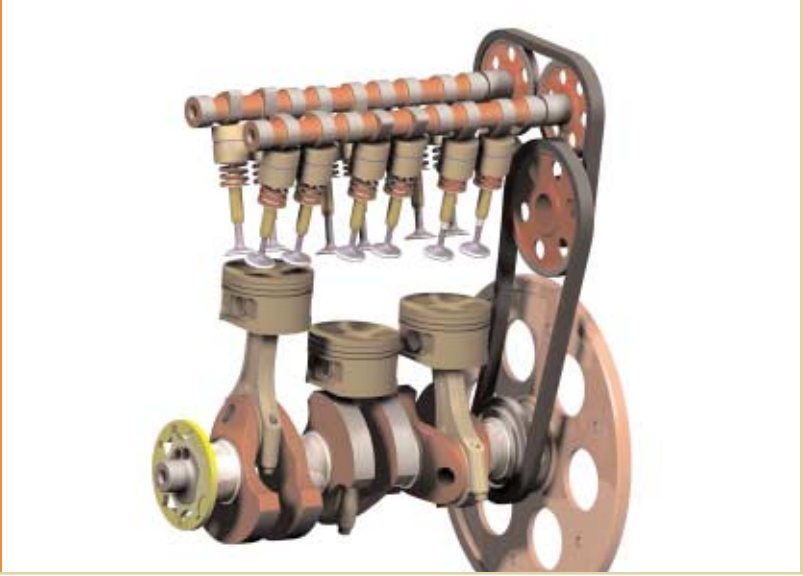
Using 2D, it is virtually impossible to develop varied configurations of products, assemblies, or product families efficiently. Many companies manufacture product families with varying sizes, dimensions, weights, and capacities. In 2D, each individual assembly must be redrawn from scratch, incurring additional costs. 3D CAD systems, on the other hand, enable a designer to generate families of part and assembly configurations from a single part or assembly quickly and easily.

Reusing CAD Data Downstream

Following the generation of engineering drawings, 2D data has little value in downstream engineering and manufacturing functions, such as stress analysis, tooling creation, and numerical control programming. These processes require 3D design data, which must be recreated from the 2D data, resulting in additional time and costs. With 3D CAD, the original solid model can be used for all downstream functions.

Reducing Analysis Time

Because 2D designs have to be recreated in 3D to take advantage of finite element analysis (FEA), many manufacturers refrain from performing detailed design analysis, choosing instead to overdesign parts. Design analysis can help designers optimize designs, reducing material usage and associated costs. When



Steve Prentice Design Limited

uses SolidWorks software to generate solids from underdefined sketches, create parts within assemblies, and edit designs in different configurations. According to Prentice, "It's like sketching with solid metal."

Using SolidWorks, configurations of products, assemblies, and product families can be created and managed from the original design, such as the multiple bolt patterns shown here for a snowboard binding.

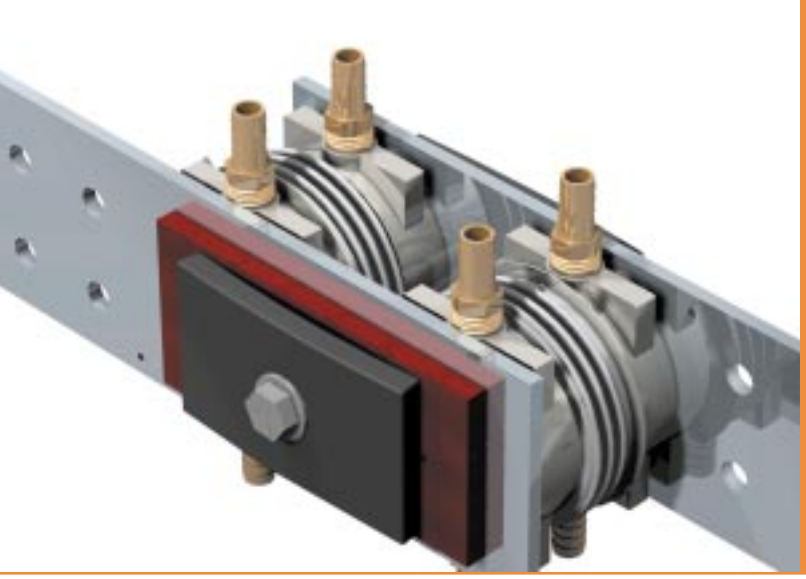
manufacturers seek the benefits of design analysis, turnaround times are extended by the need to build a 3D model of the design, which is necessary for generating a finite element mesh. With 3D CAD, design analysis can be performed on the original solid model, reducing analysis time. Many FEA applications are integrated directly inside the 3D system.

Shortening Manufacturing Cycles

With 2D, after the initial design phase, every design and manufacturing process is needlessly extended. All of these processes – analysis, prototyping, stereolithography, manufacturing, fabrication, and assembly, to name a few – require 3D solid geometry. Thus, with 2D, additional time is required throughout the manufacturing cycle to manage, manipulate, and recreate design data. Using 3D CAD, the original solid model supports all of these functions, accelerating the manufacturing cycle and reducing time-to-market.

Improving Support for Documentation, Publication, and Marketing Processes

While 2D drawings can support some documentation, publication, and marketing needs, in most cases these functions require customized isometric and exploded assembly views and 3D graphics. Creating these graphics requires additional work in the 2D system, other software designed to create technical illustrations, or a 3D graphics package. With 3D, all graphics, drawings, and exploded assembly illustrations, whether used for documentation or over the Internet, can easily be exported from the original solid model.



"SolidWorks is a faster, more logical approach to design and development. As a result of using SolidWorks, we increased our assembly sales by about 30%."

Gonzalo Martinez, Sales Engineer,
Westcode Semiconductors

Key Considerations for Migrating to 3D

In making the decision to migrate from 2D to 3D, product development organizations face a myriad of options and different software packages to choose from. What is the right package for a particular organization? What factors should a product development team consider as part of its migration to 3D mechanical design and its evaluation of specific solid modeling systems?

While the benefits of solid modeling are well proven, the 2D-to-3D migration process varies by company and industry. The following considerations are critical to selecting a solid modeling system to meet a manufacturer's specific requirements. By considering these factors, product development organizations will select the right package for their needs and facilitate the transition from 2D to 3D.

Modeling Products with Style

Manufacturers should consider whether a solid modeling system can easily create complex models, surfaces, and shapes. Certainly, a solid modeler should handle curves, blends, fillets, and unique design features far better than 2D packages. Some 3D systems do this better than others. Also, stylizing and improving the attractiveness of products has become increasingly important. Product development organizations should compare their design needs with solid modeling software capabilities to ensure that they are equipped to meet existing requirements as well as meet future design needs.

Bidirectional Associativity and Parametric Design

Bidirectional associativity and parametric design are critical elements to consider when migrating from 2D to 3D. Bidirectional associativity guarantees that all elements of a model are associated or connected. For example, assembly models, drawings, details, and bills of materials should be associated in both directions. This means that when a change is made to any of these pieces of data, that change is automatically made in all associated files. Bidirectional associativity is a major improvement over 2D, where a single drawing change requires a manual update of all assembly models, drawings, views, details, and bills of materials.

Similarly, parametric design functionality is critically important to maximizing the benefits of 3D. In creating a model, a 3D package should store all features and dimensions as design parameters. This enables designers to make lightning-fast design changes by

KryoTech, Inc., a manufacturer of innovative cooling systems for personal computers, shortened its design cycle from one year to three months, in part by using integrated finite element analysis (FEA) inside SolidWorks software.

simply changing the value of a parameter. The model automatically updates to the new value, and all other model features and dimensions impacted by the change update accordingly. In 2D, all design changes must be made manually.

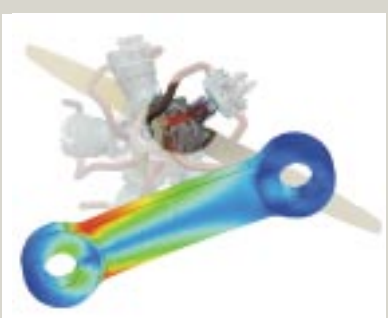
By considering whether 3D packages are both bidirectionally associative and parametric, manufacturers can eliminate tedious error-checking and guarantee that nothing will be missed when a design change is made.

Intelligent Geometry

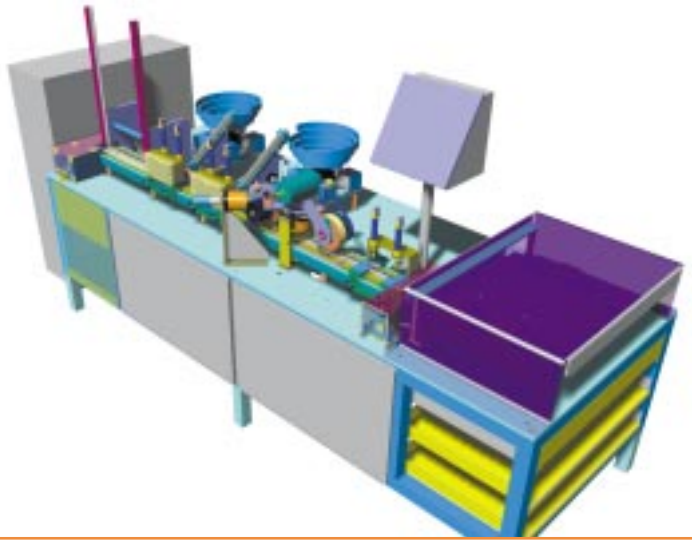
Manufacturers should consider whether solid geometry is "intelligent" enough to support other design and manufacturing functions – machining, prototyping, analysis, assembly management, and documentation – without the need for file transfers, repetitive data entry, or clumsy data "handoffs." Once a designer creates a 3D model, product development teams should be able to work with the geometry throughout the manufacturing process without intervention or the need to recreate, remodel, or redraw. In 2D, repetitive manipulation of design data is a given. In 3D, it should be completely unnecessary.

Large Assembly Capabilities

Most product design involves assemblies and subassemblies as well as individual parts. In migrating from 2D to 3D, manufacturers should evaluate their assembly design needs and the large assembly capabilities of different 3D packages. Does the 3D system support assemblies involving thousands of parts? How does the package manage assemblies? Does it support collaboration on an assembly by many designers? Does the 3D system include built-in tools for assembly design evaluation, such as interference checking and collision detection? These are important considerations for realizing the productivity gains of 3D in assembly design.



The SolidWorks Solution Partner Program is the strongest in the industry, offering a broad range of best-in-class, single-window integrated add-on solutions that help save time and improve product quality.



"With SolidWorks, we can change parameters of completed projects to meet specifications of new customers, compressing months of redesign time into a few days."

Richard Higgins, Vice President of Engineering,
Matrix Automation Group, Inc.

Integrated Add-On Solutions

Another important consideration for accelerating the processing of design information through a manufacturing organization is the availability of additional integrated solutions. This represents a step above intelligent geometry (using common data for separate functions). Integrated add-on solutions, such as analysis, machining, and product data management, not only work on the same data as the 3D CAD system but within the CAD system, using a common, fully integrated user interface. Manufacturers should consider the degree of add-on solution integration, as well as the number and reputations of the solution partners.

Legacy Data Management

Many product development organizations delay the migration to 3D solid modeling because of concerns over large amounts of legacy 2D data, which designers frequently access to design new products. Legacy data can exist in a variety of data formats, including 2D and 3D CAD files. When migrating to 3D, manufacturers should consider how they will access and utilize legacy data, and look for a solid modeler with data translation formats and built-in productivity tools for converting 2D and other forms of legacy data to 3D solid models.

Visualization and Virtual Prototyping

The ability to visualize a 3D model or assembly on the computer is the next best thing to holding the finished product in your hand. Attempting to visualize 2D drawings in 3D is difficult if not impossible, which is why there is such a heavy reliance on physical prototyping in 2D design environments. In migrating to 3D, manufacturers should consider a solid modeler's visualization, design evaluation, and animation capabilities, and the impact these have on prototyping needs and costs. In addition to minimizing physical prototyping, 3D visualization and animation capabilities can support functions outside the design cycle, such as sales, marketing, and customer service.

Automatically create high-quality exploded views of products to support documentation, installation, and marketing needs.

Hartness International,

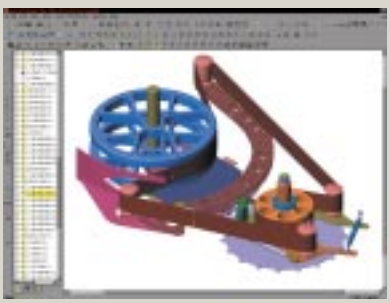
a manufacturer of custom packaging machinery, chose SolidWorks software for its easy-to-use, intuitive, 3D modeling capabilities. Designers can quickly explore part and assembly alternatives in real time to optimize machinery performance.

Ease of Use – Training Demands

A solid modeling system should be easier to use and require less training than a 2D package. A well-designed solid modeler should be intuitive enough for an engineer to pick up quickly. How easy is it to reuse design data or automate repetitive tasks? Does the modeler require fewer steps and dialog boxes? Can the designer access design properties and parameters easily? Does the interface enable the user to assess the status of the design or the steps taken from a single window? Does the modeler provide an open API for customizing certain functions? A designer should be able to use a solid modeler following a day or two of training and should become proficient with the software in weeks instead of months.

Integration with Desktop Productivity Tools

Solid modeling systems should be integrated with and support the use of desktop productivity tools. Model and drawing images should be easy to bring into Microsoft® Office documents and PowerPoint® presentations. Design data should be easily exported directly into an Excel spreadsheet. 3D CAD is a tool. The more versatile the tool is, the more productive its user will be.



"We had formal training for two days and started making parts on the third. Two months later, the machine was delivered on time!"

Olivier Duterte,
Product Manager,
Hartness International

"The SolidWorks data translated perfectly every time, capturing the complex curvilinear shapes used frequently by our team."

Miles Keller, President/Designer,
Carbon Design, Inc.

Return on Investment (ROI)

Although a comprehensive ROI assessment prior to 3D deployment can aid in successful planning, simple calculations based on easily quantified metrics can also provide useful insights. Here's an example:

New Product Development Cost Savings	
— Product design team size (designers/drafters)	4
— Average salary per team member (incl. overhead)	$75,000/yr.
— Reduction in development time	24%
→ New product development cost savings	$72,000/yr.
Engineering Change Orders (ECOs) Cost Savings	
— Engineering change orders completed	250/yr.
— Time needed to make changes for a typical ECO	2.0 hrs.
— Reduction in number of ECOs	60%
— Reduction in time needed for one ECO	80%
→ Engineering change orders (ECOs) cost savings	$17,250/yr.
Reduced Prototype Fabrication Costs	
— Design projects undertaken	12/yr.
— Prototypes fabricated during a typical project	2/project
— Average prototype fabrication cost	$3,000
— Reduction in prototypes	40%
→ Reduced prototype fabrication costs	$28,800/yr.
Reduced Manufacturing Scrap Costs	
— Annual cost of scrap in manufacturing	$60,000/yr.
— Percent of scrap attributable to design errors	10%
— Percent of scrap eliminated via CAM integration	15%
→ Reduced manufacturing scrap costs	$15,000/yr.
Improved Time-to-Market	
— New products introduced annually	6/yr.
— Average revenue per product	$300,000/yr.
— Average gross profit margin for new products	30%
— Typical product development process	7.0 months
→ Profit impact of improved time-to-market	$75,600/yr.

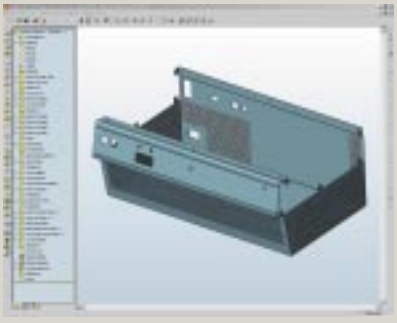
Company Strength, User Base, Vision

In migrating to 3D, manufacturers should assess the CAD vendor's size, position in the industry, commitment to customer support, and vision for the future. The company should be financially secure and strong enough to continue aggressive research and development. The 3D CAD software should be used widely and be proven in a manufacturer's industry. The number of seats of software sold and in use is another factor to consider. A focus on mechanical design by the vendor provides a greater likelihood of long-term success. Evaluating a CAD vendor is as important as evaluating a solid modeling system.

Customer and Vendor Interaction

In moving to 3D, manufacturers should consider whether a 3D CAD system supports and enhances communication with vendors and customers. Does the package allow for import and export of common data formats, such as DWG, DXF™, IGES®, STL, and STEP? Is the solid modeler compatible with other CAD systems? Does the software include web-based communication tools for facilitating interaction with vendors and customers?

With offices located in both West and Middle Slovakia, industrial design firm Bendis & Kierulf uses eDrawings Professional software to collaborate daily via the Internet with each other and with clients in Western Europe.



Specialized functionality, such as built-in SolidWorks sheetmetal features, can be an important consideration for manufacturers that are migrating to 3D. SolidWorks also offers modules for piping and mold base assembly.

Specialized Capabilities

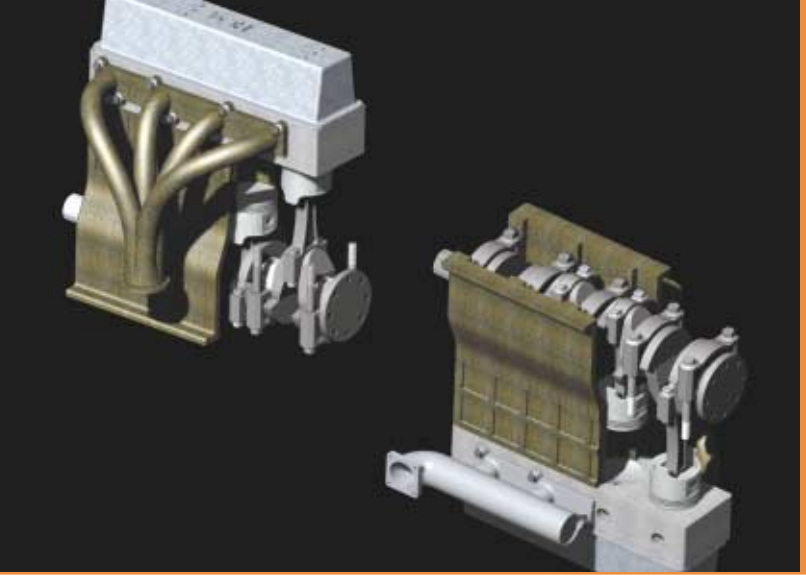
In addition to base mechanical solid modeling functionality, manufacturers should consider whether the 3D CAD package offers special features that support specific needs. The software should include sheetmetal, piping, or mold creation features that are automated to a higher level than the base capabilities. The software should include specialized capabilities that enable productivity gains.

Assembly Flexibility and Automation

While most 3D CAD systems improve the handling of large, complex assemblies, manufacturers should also consider whether the system enables automatic configuration of assembly variations quickly and easily. Manufacturers that produce families of parts and products with varying sizes, dimensions, weights, and capacities can benefit greatly from the flexibility to configure products automatically from an original design. Instead of designing variations of an assembly individually, manufacturers should look for solid modeling systems that can produce these derivative products or product families automatically.

Effective Web Communication Tools

The Internet has changed the way much of the world does business, and exploiting the web from a design perspective is an important consideration for companies moving to solid modeling software. Manufacturers should consider whether or not a 3D CAD package provides web-based communication tools for easily sharing design data with vendors and customers and collaborating with colleagues and partners. The software should provide a means for efficiently emailing design data or easily creating web sites containing solid models. This consideration is especially important for design groups that are separated geographically.



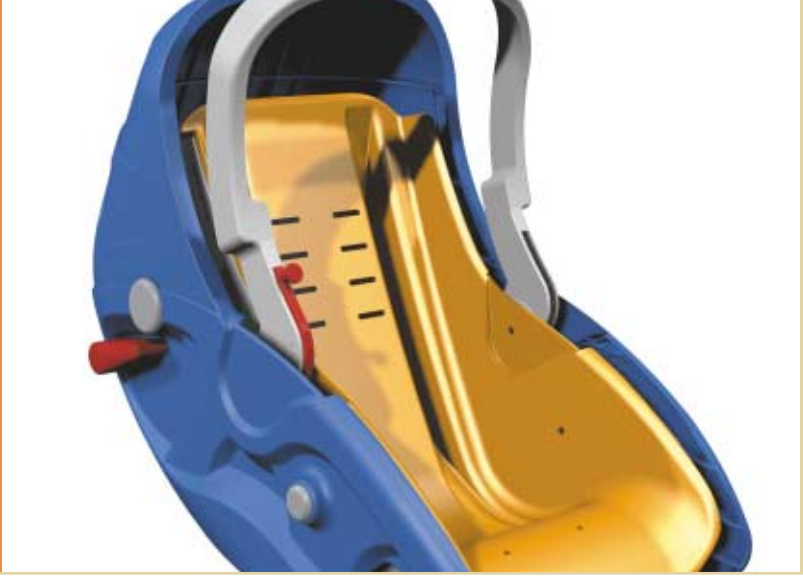
"SolidWorks enables us to design products quickly and to use the same data as proof of concept for analysis, prototyping, machining, and sales materials."

Ted Christiansen, P.E., Owner/Operator,
Christiansen Engineering

Evaluating Solid Modeling Software

The following checklist is designed to provide basic criteria for evaluating solid modeling systems, so you can identify the functionality and capabilities you need.

CRITERIA:	CONSIDERATIONS:
Ability to stylize designs	○ Does the software handle advanced surfaces, curves, blends, fillets, and unique design features well? ○ Can the software create complex models, surfaces, and shapes?
Ability to handle large, complex assemblies	○ How many customers are using the software to design assemblies consisting of 50,000 unique parts or more? ○ Can you perform collision detection and interference checking for parts in an assembly? ○ Does the software offer the ability to mirror assemblies and subassemblies?
Ease of making design changes	○ Does the software allow you to easily modify or create variations of a design or do you need to start over each time?
Configuration management	○ Does the software allow you to develop part and assembly configurations? ○ Can you store multiple configurations of a part or assembly in a single file? ○ Does the software allow you to use tables to create configurations? ○ How easy is the table editing process?
Parametric functions	○ Are the parametric functions powerful and easy to use? ○ Does the software provide bidirectional associativity among parts, assemblies, drawings, details, and bills of materials?
Intelligent geometry	○ Does the software produce 3D data that can be used throughout the product development process? ○ Can design data be used for machining, prototyping, analysis, assembly management, and documentation? ○ Does the software offer the ability to automatically size and add multiple fasteners?
Ease-of-use and required training	○ What type of training is required and how long will it take to become proficient? ○ How many users are in production with the software?



Xportation Safety Concepts, Inc., a developer of innovative safety systems, uses SolidWorks modeling capabilities to create complex surfaces and shapes required for the design of its airbag-safe infant seat for use in the front seat of automobiles.

CRITERIA:	CONSIDERATIONS:
Integration of add-on analysis, animation, and other design tools	○ Are best-in-class add-on solutions available? ○ Are the tools integrated into the software, that is, can you use them within the same program window? ○ Are the tools sold with the software as a package? ○ How easy are those tools to use? ○ Is the software compatible with desktop productivity tools such as Microsoft® Office?
Value	○ What is the cost of ownership and return on investment?
Ease of sharing designs	○ Can you easily share legacy and native models with other users? ○ Can you easily share your models with non-users? ○ Can you display your 3D models on a web page or send electronic copies of drawings that can be easily reviewed without purchasing separate markup tools?
Available languages	○ Is the software and documentation available in a full range of languages?
Established user base	○ Is the software widely used in your industry? ○ Do your customers and suppliers use this software? ○ Are students entering the workforce widely trained in the use of the software?
Export of rapid prototyping files	○ Does the software export parts and assemblies as .STL and other rapid prototyping and computer numerical control (CNC) file formats? ○ How easy and accurate are those exports?
Compatibility with legacy data and other CAD programs	○ Can the software import 2D legacy data? ○ Does the software have tools for converting 2D data into 3D models? ○ Does the software have the ability to read and write the CAD data formats used by your suppliers and customers?
Post-sale response to your needs	○ Does the vendor have a network of resellers that provide solid modeling expertise? ○ Do the developer and the reseller have a record of supplying strong customer support after the purchase?

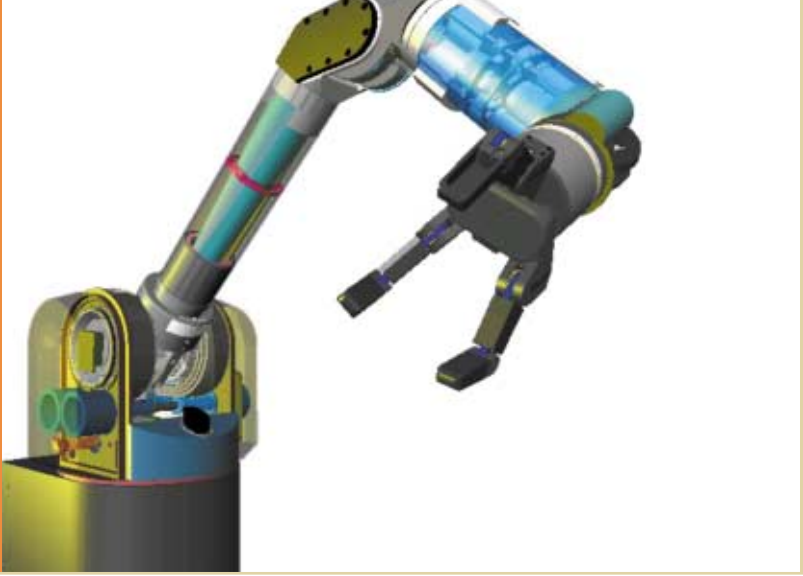
"Weight and center of gravity calculations enabled us to design a much lighter and stronger product than the competition. Actual weight was within ten pounds — not bad for a 3,000-pound product!"

David Smith, President,
Professional Components, Ltd.

Comparison of Modeling Features

3D CAD systems provide better modeling capabilities and productivity features than 2D approaches. The following chart shows the primary differences between these two types of product design technologies.

CHARACTERISTIC	2D DRAWING	SOLID MODELING SOFTWARE
Drawing automation: • View creation • Section creation • Dimensioning • Bills of materials • Update all views to reflect dimension change	N/A	●
Visualization & rotation of design	○	●
Drawing creation	●	●
Creation of families of parts and varying assembly configurations	N/A	●
Collision/interference detection	N/A	●
Assembly motion modeling, animation	N/A	●
3D photorealistic rendering of design	N/A	●
Capture design intent in meaningful relationships between dimensions and geometries	N/A	●

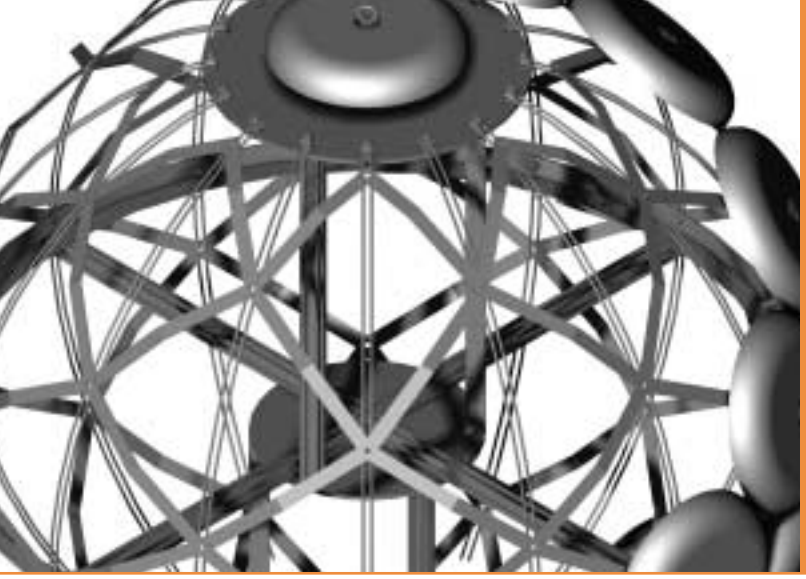


Barrett Technology, Inc.,

a developer of high-performance robotic systems, uses SolidWorks software to investigate multiple design alternatives and optimize designs. Using SolidWorks, Barrett has reduced design cycles by four and manufacturing costs by 50%.

CHARACTERISTIC	2D DRAWING	SOLID MODELING SOFTWARE
Mass properties calculations:	N/A	●
• Mass		●
• Volume		●
• Surface area		●
• Center of mass		●
• Moments of inertia		●
Ability to perform 3D finite element and other kinds of analysis	N/A	●
Ability to generate 3D CNC machine paths, rapid prototyping files	N/A	●
Drawing accuracy	○	●

Available:	●
Limited:	○
Not Applicable:	N/A



"The most important benefit is bringing products to market faster and designing more products in the same amount of time. That's why we moved to SolidWorks."

Ullrich Clemens, Engineering Manager,
HIGHVOLT Prüftechnik, Dresden GmbH

Going 3D — the Time is Now!

Migrating from a 2D CAD system to a 3D solid modeling environment is an important step for manufacturers. Many companies, including the SolidWorks customers referenced throughout this guide, have already made this transition, reaping business, engineering, and productivity benefits.

Today's rapid advances in computer hardware and software technology create an ideal opportunity for manufacturers to migrate from 2D to 3D CAD. As explained throughout this guide, the basic steps for moving to 3D involve:

- Understanding how 3D can resolve many challenges in 2D
- Considering the critical issues for making a smooth transition to a solid modeling environment
- Evaluating 3D design tools thoroughly based on capability and need

By following these steps, manufacturing organizations can maximize the benefits of 3D mechanical design. In the process, most manufacturers realize increased sales and revenue and an improved competitive position in the marketplace.

To find out more about how SolidWorks customers have benefited from "Going 3D," see the customer case studies published on the SolidWorks web site (www.solidworks.com).