# Executing Effectively from Design to Manufacturing

*"SolidWorks' support for product manufacturing"*

*June 2012*

## A CIMdata Report

# Executing Effectively from Design to Manufacturing

*"SolidWorks' support for product manufacturing"*

*June 2012*

*Produced by*
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# Executing Effectively from Design to Manufacturing

*"SolidWorks' support for product manufacturing"*

*Over the years SolidWorks has developed significant support for transitioning products from design to manufacturing. Today, many new capabilities have been built into SolidWorks to support the creation of information that is necessary when establishing efficient manufacturing processes and assuring that products can be produced profitably. While SolidWorks continues to provide geometric check functionality for plastic parts, cast parts, and sheet metal parts—it now features a new costing tool that provides automated cost estimation capabilities and SolidWorks DFMXpress, a tool that checks designs for manufacturability. In addition, many SolidWorks Gold Partners have embedded their own CAM products directly inside SolidWorks' 3D CAD environment and SolidWorks' new SolidWorks Plastics product provides plastic part designers and mold makers with detailed insight into the manufacturability of their plastic designs via plastic injection molding simulations.*

# 1. Introduction

The product design to product manufacturing transition is often characterized as one in which the design is tossed over a proverbial brick wall to the manufacturing organization, with the expectation that manufacturing will build whatever has been designed. Today, a shift in this paradigm is occurring. This shift involves changing both work processes and tools to support a much more collaborative effort where product designers and manufacturers can gain earlier insight into, and control over, both the processes and the costs associated with manufacturing products. The result, when properly supported, is that large improvements can be realized in critical areas such as reducing time to market (~30%), decreasing product design time (~10%), tool design cost reductions (~30%), and reducing product cost (~15%)[1], all major benefits of better coordinating product design and manufacturing design.

Dassault Systèmes SolidWorks has long been known as a provider of computer aided design software tools. Their own tools and those of many of their partners form a highly accepted suite that clearly caters to the needs of product design engineers. Less well understood is how much the integrated CAD/CAM workflow capabilities of their product suite and the tools provided by their partners can be used to support manufacturing engineering and planning. This paper will present some of the issues facing manufacturing companies, especially those who are small to medium sized, and how SolidWorks has provided support for these issues with manufacturing support solutions.

Product engineering organizations are primarily concerned with the design and analysis of products while manufacturing engineering is primarily responsible for developing the processes used to produce that product. CAD and CAE tools are employed to help define "what" is to be built, while manufacturing engineering tools help define "how" it is to be built.

The concept of concurrently developing both a product and the processes used to produce that product has existed for some time. However, these supposedly concurrent activities are typically treated as two distinct, serially executed product development threads. This typical current reality causes a number of unfavorable issues to occur.

Dassault Systèmes SolidWorks supported research for this paper.

# 2. Manufacturing Issues and Business Drivers

The transition from product design to manufacturing planning continues to challenge many companies. The historical divide between these two disciplines has continued into modern times due to both technical and business reasons.

[1] Based on CIMdata research.

From the business point of view, organizational divide is a major factor. Manufacturing and product engineering are often physically separated. Their physical separation places barriers to communication; both person-to-person as well as for data flow. Different limitations are imposed on design engineers and manufacturing with design engineers usually not being bound by the manufacturing processes and manufacturing engineers having to work within the constraints of what their facilities can handle (not that designers should not consider this issue, but it is often not considered as completely as it should be).

Technology differences also abound. Design and manufacturing often use completely different solutions, even for tasks that appear to be the same or very similar. For example, manufacturing engineers often do not have access to 3D CAD solutions, while this is a common capability for design engineers. CAD data translation is often required when moving information from design to manufacturing. Manufacturing also uses a whole suite of tools such as ERP and operations planning that are not common to product designers. The decision to use 2D drawings vs. 3D models in manufacturing often presents a whole set of data and data recreation problems. Finally, the wall between the two functions persists—often with poor quality data passing over it.

Several other areas impact the relationship and flow of information between design and manufacturing. Manufacturing processes can be very complex and require a lot of data that may not be documented during the design process. Companies that are using best practices capture as much information about manufacturing as practical by documenting product manufacturing information (PMI) such as geometric tolerances, reference dimensions, datum points for quality processes, surface finish, etc., in the 3D design, as opposed to only in drawings. Increased product complexity makes import and repair even more error prone, so, flexibility to import and repair data is very important. Continuing changes to engineering data prior to release to manufacturing increase the challenges to begin the development of tool paths and other manufacturing information earlier in the design process.

To alleviate the adverse impacts of these issues, manufacturers have implemented various manufacturing support solutions. They typically report substantial benefits from improved communication, process definition, and production planning.

These benefits include:

- Reduced overall new product introduction time
- Faster ramp-up of volume production
- Increased production throughput
- Reduced capital costs
- Greater utilization of facilities
- Reduced operating costs
- Improved product quality
- Reduced ongoing product support

Once products are committed to manufacturing, the cost of making changes increases dramatically as shown in the following chart. This is due to the amount of rework and disruption caused by these late changes.

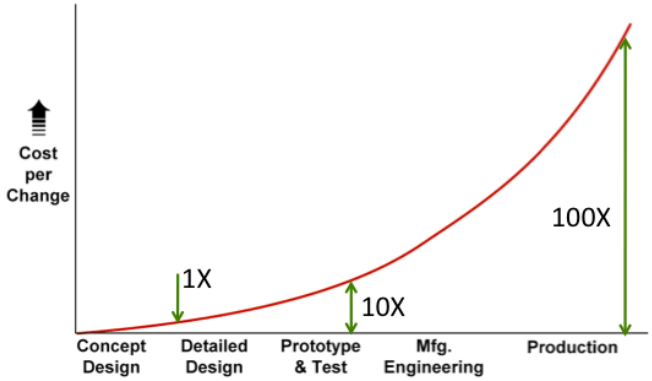


**Figure 1—Cost of Changes Rises Throughout Product Lifecycle**

Experience has shown that validating the manufacturability of designs before they get to production can dramatically reduce the initial production costs of a product as well as the costs of implementing design changes for manufacturability. In other words, designing for cost and manufacturability up front will save you time and money by eliminating the need to redesign for manufacturability and costs later on, after the product has already been released.

# 3. SolidWorks' Approach to Supporting Manufacturing

SolidWorks supports manufacturing in a number of areas as described below. This support is provided directly via the SolidWorks solution suite as well as through partner solutions, especially those from SolidWorks Gold partners. Gold partners provide products that are integrated directly inside SolidWorks. Whether a capability is built by SolidWorks or by one of its partners, they use a single user interface, and data flow paradigms that streamline activities for users. SolidWorks manufacturing capabilities are focused on design for manufacturing, design for cost, tooling design, creation of necessary file outputs required for manufacturing, and design documentation.

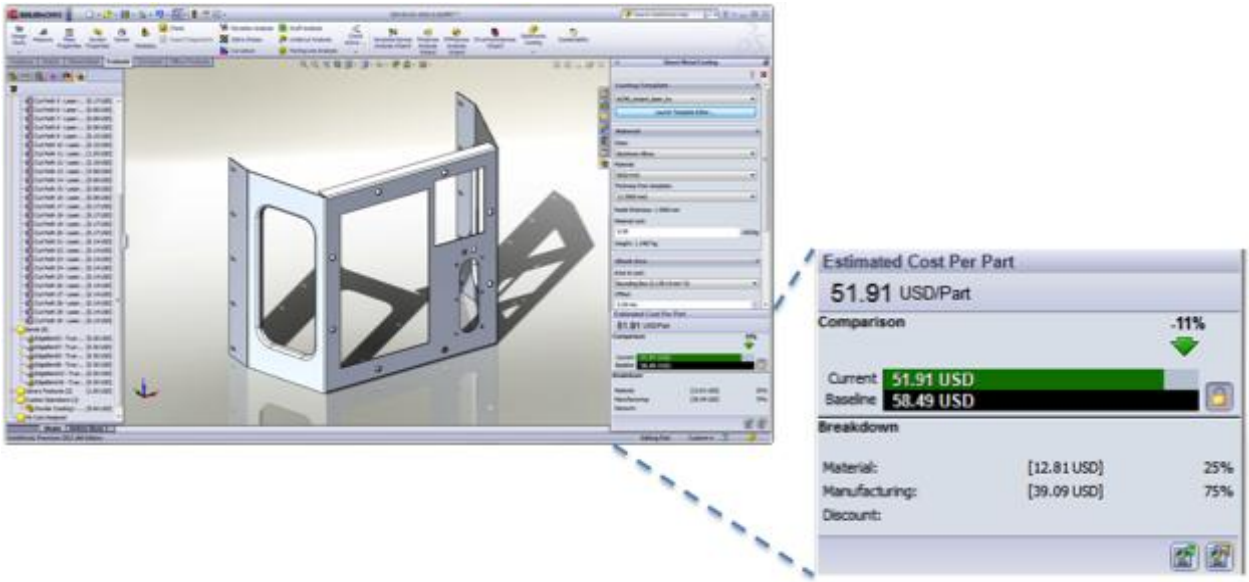


**Figure 2—SolidWorks Costing is a Cost Estimation Tool Provided Inside SolidWorks**

## Design for Manufacturability

SolidWorks provides both product and tooling design as well as analysis capabilities through its CAD product. Users can further leverage design information to produce manufacturing and assembly documentation, user manuals, service manuals, and other technical documents through the publishing capabilities of 3DVIA Composer. SolidWorks' product data management (PDM) capabilities are essential to support data and process management for manufacturing. PDM also provides a framework for controlling and automating translation of design data for use in manufacturing systems. SolidWorks also has tools that support event-based simulation including dependencies of operations, block diagramming of tasks, and creating task-timing interrelationships.

SolidWorks has developed significant support for transitioning products from design to manufacturing. The SolidWorks strategy is not only to support the design side of products and tooling, but to also provide access to manufacturing information and checks for manufacturability directly in the 3D CAD modeling environment.

SolidWorks DFMXpress provides evaluations of potential manufacturability problems during the product design phase, when they can be fixed much less expensively than when the product is sent to manufacturing. DFMXpress is fully integrated within the SolidWorks design environment. The tool analyzes a design to automatically determine what manufacturing processes will be needed to create the part. It then looks at manufacturing rules to determine if the design is in violation of any of the manufacturing rules that have been defined. If violations are identified users are warned.

DFMXpress provides manufacturing checks for drilling, milling, turning, sheet metal manufacturing, standard holes, and injection molded parts. DFMXpress helps design engineers understand if their designs may be problematic to manufacture or if their designs can be manufactured at all.

In addition to those in DFMXpress, SolidWorks offers additional checks for manufacturability. For plastic injection molded parts and mold design, SolidWorks offers a number of capabilities to check if parts will be manufacturable and advise designers about parameters that are specifically important to plastic part production. These include draft angle checking, undercut detection, plastic material checks, minimal radius, and others.

Machining processes that can be checked include drill size (to determine if the depth of the hole is too deep for the diameter of the drill) and milling tool size (to identify a tool that might have difficulty in machining deep pockets). The system flags these potential problems.

Mold filling simulation is available in SolidWorks Plastics. Product designers and tooling designers can check the manufacturability or "moldability" of injection molded parts by simulating how plastic flows during the injection molding process to predict manufacturing-related defects on parts and molds before manufacturing commences.

In the sheetmetal area, SolidWorks has a number of capabilities to help speed up manufacturing. Flat pattern development from a 3D sheetmetal design is necessary, and

is well supported in SolidWorks. In addition to that, SolidWorks allows sheetmetal designs from other CAD solutions to be imported directly, or via IGES and STEP. These designs often need to be repaired due to anomalies in how CAD tools create design geometry and how that geometry is transferred between those CAD solutions and SolidWorks. On import, SolidWorks checks geometry for these anomalies such as small holes, and helps repair them. The user can apply bend radii, K-factors, thickness, etc. SolidWorks converts recognizable geometries into bends, flanges and other sheetmetal features; then automatically generates a native SolidWorks sheetmetal part that can be flattened or folded just like any sheetmetal part designed in SolidWorks. A 1:1 scale DXF file can then be exported directly from the 3D model.

## Manufacturing Cost Analysis

SolidWorks Costing is a manufacturing cost estimation tool provided with SolidWorks. It provides assistance for producing cost estimates throughout the design phase to help designers make better design decisions based on manufacturing costs. Any time design changes occur a new cost estimate can be made immediately producing a new manufacturing cost estimate. See Figure 2 for an example of costing a sheet metal part. SolidWorks Costing is targeted at sheet metal parts and prismatic machined parts. SolidWorks states that they intend to add costing capability for additional manufacturing processes in the future.

The costing module runs in the background and takes into account changes in design models to update cost information. It is driven by customizable costing templates such as that shown in Figure 3. These templates allow manufacturing cost data such as labor rates, material costs, and manufacturing process parameters to be used to drive cost estimates. This assures that the cost parameters reflect actual company experience. SolidWorks Costing is able to handle costs associated with:

- Material price per unit weight
- Operations:
  - Processes (e.g. laser cutting, drilling, milling, etc.)
  - Setup costs (either machine setup or operation setup)
  - User definable custom operations (e.g. painting, deburring, welding, etc.)
- Discounts and markups

For designers this tool provides a "should cost" for their designs. It is important to note that the costing module uses the time to complete the machining process, labor rate, and the cost to operate the machine to determine the cost for each operation. It lets designers know which design options will cost more to manufacture; this helps them make faster design decisions based on cost to manufacture. SolidWorks Costing bases costs on the geometry of the part. For example, laser and water jet cut costs are based on the length of the cut, different materials, and different thicknesses of materials. For machining calculations such as pocket milling, face milling, and drilling, standard industry accepted material removal rate (MRR) calculations are

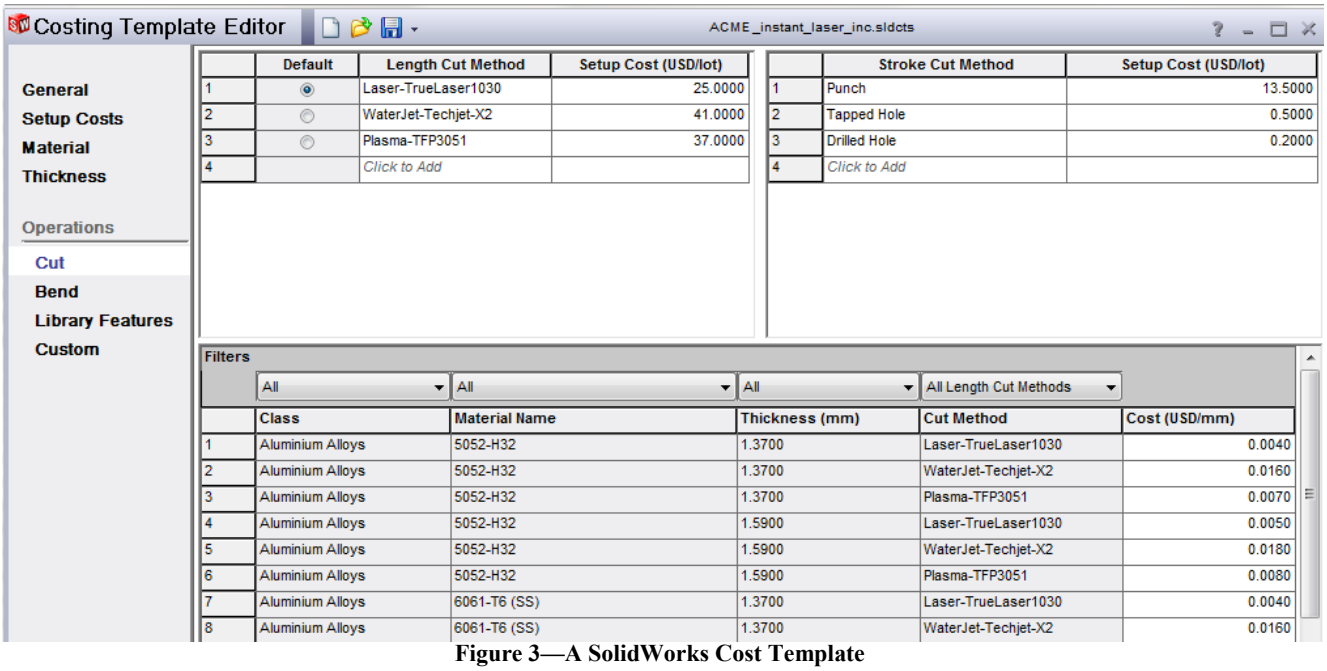


**Figure 3—A SolidWorks Cost Template**

used. The costing module can be used to estimate cost comparisons between two versions of a part and can monitor the cost variation automatically; for instance two parts that contain different features. Another example would be a material difference between an aluminum part and a stainless steel version. These comparisons can also be based on non-geometric options for a design, such as the cost of a painted part vs. a non-painted part.

Calculated costs can be stored in the SolidWorks model. These part costs can be used to roll up costs of all the parts for a particular assembly. Assemblies can be colored to graphically display the relative costs of parts (e.g. which parts are most expensive). Costs can also be included automatically and displayed in a Bill of Materials or exported to Excel.

Users can add almost anything to the costing templates. SolidWorks Costing provides custom operations to accommodate virtually any process that isn't automatically covered by SolidWorks Costing (e.g., deburring operations, anodizing, shipping charges based on part weight, etc.).

SolidWorks Costing can also cost 3D models from other CAD systems because it uses specialized "manufacturing process" recognition based on part geometry instead of relying on the design features defined in the part. This allows parts to be imported from other CAD solutions and analyzed for cost within SolidWorks.

## Integrated CAM Partners

Rounding out the manufacturing capabilities are SolidWorks' Certified Gold CAM partners who provide solutions in a number of areas that support manufacturing engineering. Before going into these, it is important to understand that the Gold partnership program is based on third-party solution providers who have created capabilities that are substantially embedded within SolidWorks. Users do not leave SolidWorks to access these Certified Gold Partner Products. The result of this is fluid data flow from SolidWorks to the embedded technology and back, without the user having to be concerned about data formatting and translation. These Gold products essentially look like part of SolidWorks and provide a user experience that is essentially the same as for SolidWorks; it is not apparent to the user that they have invoked a third-party application. The Gold partners often provide capabilities that are not directly provided by SolidWorks, such as CAM, progressive die design, electrode design, and shop floor inspection.

One of the primary areas supported by Gold partners is numerical control (NC) or CAM. The following CAM vendors all provide Gold CAM products integrated with SolidWorks:

- CNC Software, Inc. (MasterCAM® for SolidWorks®)
- Delcam plc (Delcam for SolidWorks)
- Geometric Technologies, Inc. (CAMWorks®)
- HSMWorks ApS (HSMWorks)
- MecSoft Corporation (VisualMILL for SolidWorks)
- OPEN MIND Technologies AG (hyperMILL® for SolidWorks)
- Bob CAD/CAM (BobCAM for SolidWorks)
- SolidCAM (SolidCAM)

When the CAM application is totally embedded within SolidWorks as with the above listed Certified Gold CAM Partners, no data transfer is required, and the CAM application has access to all SolidWorks data and provides an integrated CAD/CAM environment. SolidWorks can be used to create and modify geometry and perform a number of checks such as draft and minimum radius without leaving the CAM software. Native SolidWorks geometry can be read directly by the CAM application. This includes assembly and geometric data and other design information such as feature definitions, geometric dimensioning and tolerancing, surface finish symbols, notes, etc. The data is associative between SolidWorks and the CAM software—that is, when the design is modified the toolpaths can be regenerated automatically.

All SolidWorks Certified Gold CAM Partner Products are associatively linked with SolidWorks so that modifications made to a SolidWorks-generated 3D design model are recognized by the CAM application, and changes propagate automatically between the "designed" and "machined" model. These products work inside SolidWorks and operate in the same window under the same user interface as SolidWorks. Machining operations are defined, calculated, and verified without leaving the SolidWorks environment. This facilitates a fluid design-to-manufacturing process that minimizes errors and delays due to late product design changes.

# 4. Customer Experiences

At **Travertson, Inc.**, the transparent transition from product design through manufacturing is critical to controlling product quality and evolution. Travertson designs and builds high-end motorcycles like the one shown in the following picture.

**Travertson V-REX Motorcycle**

They do all of their product development within the SolidWorks environment including styling, design, manufacturing planning, and production of supporting documents such as user manuals. They use SolidWorks' partner products to support many of these activities as well. In particular, they employ SolidCAM and other partners for developing NC or CAM information. The important factor for Travertson is that the NC tools and SolidWorks design solutions are tightly integrated at both the data model level and at the user interface. This allows engineers to work fluidly between the design and the manufacturing capabilities without leaving the solution suite and without exporting and importing data. Another important consideration is that information required to communicate with people outside Travertson can be produced as a direct output of the design activity—in the form of eDrawings, SolidWorks drawings, PDFs, 3D model views, and 3D design animations. This further streamlines and shortens their product development process, thus increasing their profit and product quality.

# 5. Summary & Concluding Comments

The capabilities that SolidWorks provides for manufacturing present users with a fluid and consistent connection between product design, manufacturing design tools, and design for manufacturability capabilities. These capabilities provide a comparatively affordable manufacturing solution for mid- and small-sized companies.

According to SolidWorks, the Costing tool will continue to be improved, adding new manufacturing process capabilities in future years. These updates will make the costing capabilities applicable to a broader range of designs. SolidWorks also continues to add to its Gold partners.

Some of the key benefits CIMdata identifies for the integrated CAD/CAM solutions as supported by SolidWorks and its Gold partners are:

- Improve the ability to generate cost estimates resulting in faster and more accurate bidding, which can increase top-line sales and reduce bottom-line project cost
- Greatly reduce or eliminate CAD file transfers between the design tool and manufacturing tools, resulting in fewer errors in manufacturing and the potential for reducing rework and scrap during production
- Provide data associativity between design and manufacturing tools, so that changes made in design are automatically recognized by manufacturing applications such as CAM, resulting in automatic toolpath updates
- Allow direct access to design information (e.g., assemblies, parts, documents, and engineering changes) resulting in streamlined collaboration between design and manufacturing

Overall, CIMdata views the new design for manufacturability and manufacturing cost analysis capabilities, combined with the tightly integrated CAM capabilities in SolidWorks to be a set of tools that can have a major impact on the design and manufacture of mechanical components. These are tools that should be carefully considered by SolidWorks users and others who are evaluating new CAD solutions.

# About CIMdata

CIMdata, a leading independent worldwide firm, provides strategic management consulting to maximize an enterprise's ability to design and deliver innovative products and services through the application of Product Lifecycle Management (PLM) solutions. Since its founding nearly thirty years ago, CIMdata has delivered world-class knowledge, expertise, and best-practice methods on PLM solutions. These solutions incorporate both business processes and a wide-ranging set of PLM enabling technologies.

CIMdata works with both industrial organizations and suppliers of technologies and services seeking competitive advantage in the global economy. CIMdata helps industrial organizations establish effective PLM strategies, assists in the identification of requirements and selection of PLM technologies, helps organizations optimize their operational structure and processes to implement solutions, and assists in the deployment of these solutions. For PLM solution suppliers, CIMdata helps define business and market

strategies, delivers worldwide market information and analyses, provides education and support for internal sales and marketing teams, as well as overall support at all stages of business and product programs to make them optimally effective in their markets.

In addition to consulting, CIMdata conducts research, provides PLM-focused subscription services, and produces several commercial publications. The company also provides industry education through PLM certification programs, seminars, and conferences worldwide. CIMdata serves clients around the world from offices in North America, Europe, and Asia-Pacific.

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