Turn New Manufacturing Initiatives Into Real Deliverables

All the major manufacturers in Aerospace, Automotive, Defense, and Consumer Products are trying to figure out how to capture more information in 3D digital designs and make use of the digital information to speed up manufacturing.

AL STIMAC
President Florida Manufacturing League, and Shop Owner

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Contents

Executive Summary

While around for a number of years, Smart Manufacturing initiatives, drawing-less environments, the use of Product Manufacturing Information (PMI) to speed up manufacture are finally starting to produce deliverables in the mainstream marketplace and provide real world benefits for manufacturing. One leading area worth investigating is the transition to a more automated design-to-manufacturing workflow that comes from having all 3D geometry, tolerance data, and annotations in one model that can be used to automate the CNC programming process.

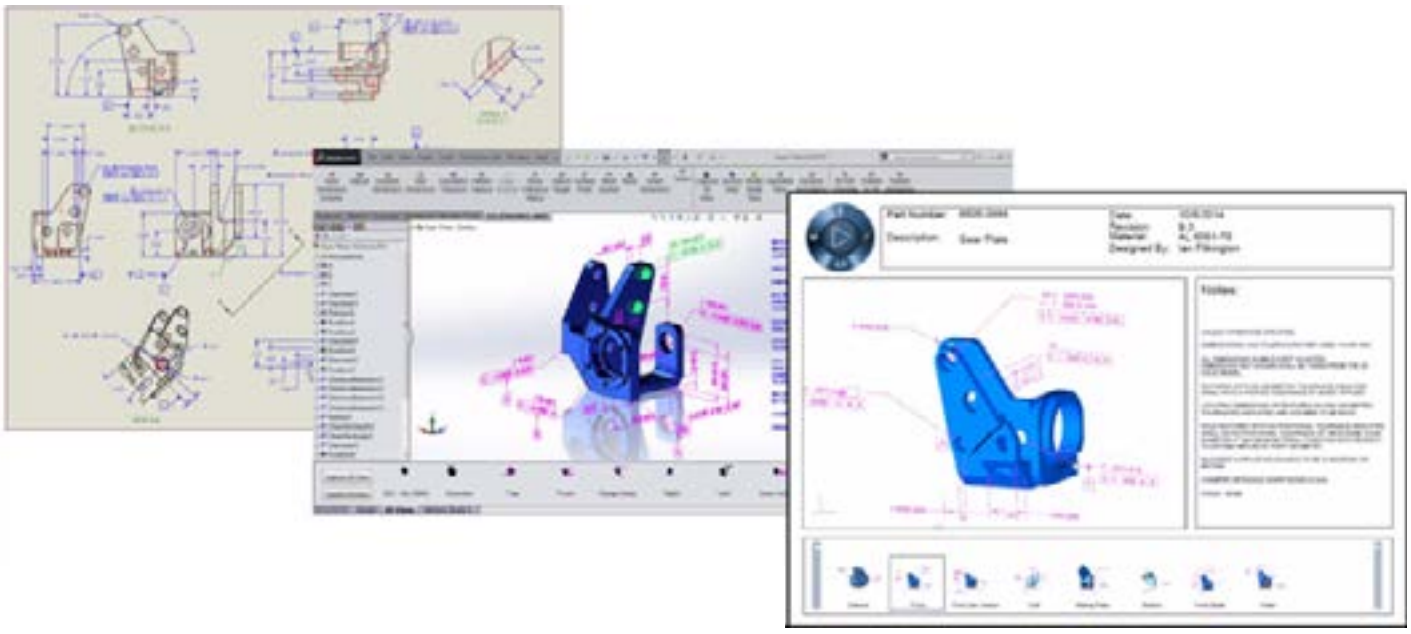
The design world is now experiencing a rapid migration from a workflow that includes the creation of a 3D model and a 2D drawing derived from the 3D model to a drawing-less workflow where all information required for manufacture is captured in the 3D model. **According to SOLIDWORKS survey data, more than 16% of companies using SOLIDWORKS have either already transitioned to a drawing-less design to manufacturing environment or are planning to do so in the near future.** This movement is being driven in part by a number of initiatives such as Smart Manufacturing, Industrie **4.0, MIL-STD-31000A** as well as various government and industry standards initiatives.

The benefits on the design side are well recognized – less documentation to manage, all the data is stored in one file and more focus can be placed on design and less on documentation. However, significant rewards can also be reaped in the manufacturing space by mainstreaming this migration with SOLIDWORKS Model Based Definition (MBD) capability. With all geometric and non-geometric information in one file and available to CAM software manufacturers to use, new opportunities for automating the CNC programming of machined parts are now possible.

The Dilemma Many Shops Face

Today, manufacturers are given several documents to use when preparing to machine a part – a 3D model and a 2D drawing. Often, the information across these separate documents is inconsistent or incomplete, and many times the part model might have to be changed or re-modeled. As an example, when tolerances from a drawing are asymmetric, the model has to be modified to adjust to a mean dimension (See Figure 1). This applies to location and size dimensions. Also, tolerances or surface finishes on a drawing that require a more elaborate machining strategy to deliver the correct result, have to be manually identified and determined. This manual intervention takes time and opens up the opportunity for mistakes if an annotation is missed and less than optimal strategies are employed.

With the introduction of PMI or MBD processes and a single 3D document that contains all manufacturing critical or non-standard tolerances, surface finishes and annotations, opportunities are presented to significantly improve and automate a design-to-manufacturing workflow. In simple terms moving from art-to-part a lot faster (See Figure 2 (MBD part)).



Transition From 2D Drawings To 3D MBD Models With PMI

What Are MBD and PMI and Why Do They Matter?

The ASME Y14.41 standard establishes the requirements to create a complete definition of a design within a 3D model, eliminating the need for a separate drawing. Together, both Model Based Design (MBD) and Product Manufacturing Information (PMI) are used to create 3D models that comply with the ASME Y14.41 standard.

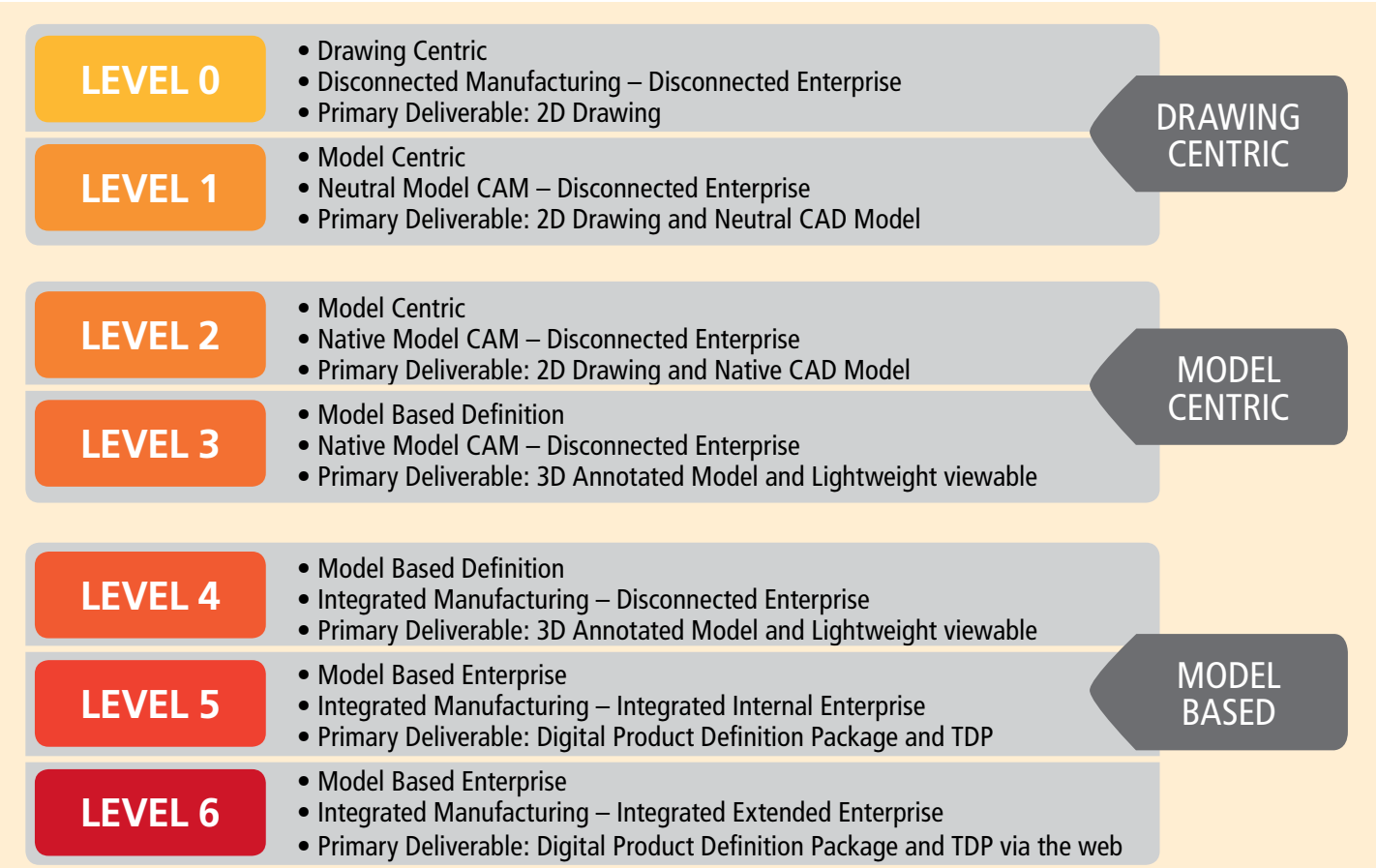
PMI conveys all of the non-geometric information in 3D CAD/CAM/CAI/CAE systems necessary for manufacturing product components or subsystems. PMI may include Geometric Dimensions & Tolerances (GD&T), 3D annotations (text) and dimensions, surface finishes, material specifications, and other non-geometric information. MBD contains PMI as defined by ASME Y14.41 that promotes clear communication with a rich 3D model from design through manufacturing. The full potential of 3D models is being realized with MBD. Although it has many possible definitions, an MBD 3D model is a combination of a design model, annotations, and attributes that fully describe a manufactured product.

The AMSE standard along with MBD is a disruptive change with a direct connection between design and manufacturing that has been building for 20+ years. The history of MBD and PMI-based design environments can be traced back to the 1980s that began with leading manufacturers such as Polaroid, Data General and others. Polaroid developed a "Critical Dimension Drawing" workflow with drawings that only contained information critical for manufacturing. 3D Wireframe, surface, or 3D solid models were made available for reference to their vendors with the critical dimension drawings. Data General was able to associate non-geometric data, such as critical tolerances, and notes to 3D wireframe models that their suppliers used for manufacturing – no drawings were provided. Beyond Polaroid and Data General, many other leading companies also developed similar internal processes that they used to communicate with suppliers and ultimately helped them stay ahead of their competition.

The efforts of the companies above along with many others have helped solidify the mainstream opportunities now available using workflows like MBD and PMI. For many years the roadblock for mainstream adoption of MBD/PMI was the complexity of implementation, as well as the lack of adequate product support. More recently, though, companies such as Boeing, Airbus, and Johnson Controls have successfully implemented MBD and a drawing-less approach. However, keep in mind that MBD and PMI are much more than just being drawing-less.

The mainstream adoption of MBD and PMI, and drawing-less manufacturing is now gaining traction rapidly and changing the face of how designs are documented. MBD is defined by a continuous digital thread of data for greatly improving business processes (planning, validation, execution) by providing a single source of information from design to manufacturing to quality inspection that enables Smart Manufacturing – a digital enterprise requiring a continuous digital thread.

To assist in the transition to MBD, the DOD Engineering Drawing Modeling Working Group (DEDMWG) developed the MBD Capability Index to assist manufacturers in setting goals to achieve the desired capabilities. Level 0 is drawing centric and is not considered model based at all; whereas Level 6 is considered to be entirely model based.



MBD Levels As Defined By the DOD Engineering Drawing Modeling Working Group (DEDMWG)

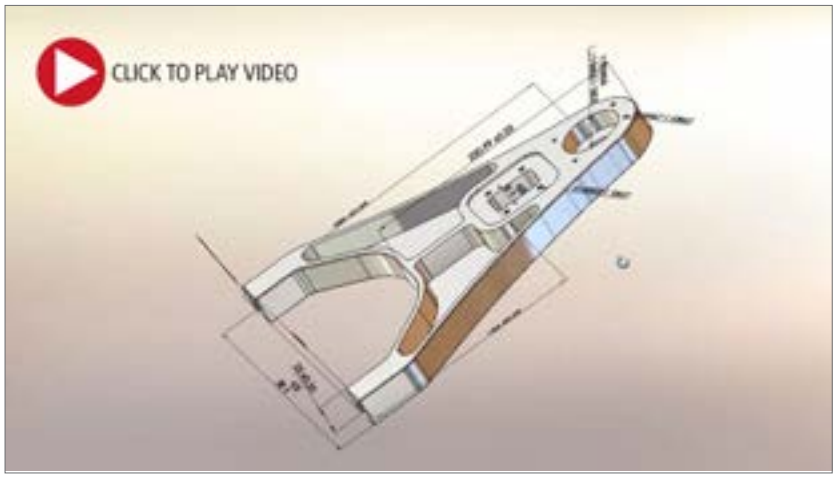
There are many practical reasons for directly using a 3D model instead of a 3D model and a 2D drawing. Major benefits include:

Engineering Benefits

- Data Associativity: Data flows from the 3D model to a drawing or other derivate documentation. Associative connections are maintained between the data sets used in production and model.
- Automation: Software can automatically process digital data sets and metadata, meaning routine tasks can be automated.
- Improved Data Exchange: Because the data sets can automatically be translated and verified, less human intervention is required for manual data exchange. Additionally, automated data exchange results in improved quality of product data sets.

Business Benefits

- Time Savings: MBD methods result in time savings of a factor of 3 for first article product development and a factor of 4 for engineering change management
- Data Reuse: MBD enables effective data reuse across a product's lifecycle, improving the efficiency of an organization.
- Value of Archived Data: Because data is accurate from beginning to end and the data has been validated to achieve a closed loop solution, archived data becomes very valuable, instead of being "possibly" useful.
- Reduced Non-Conformance Cost: MBD can eliminate non-conformance costs, which result in money spent to fix a defect once in production. Non-conformance costs are a factor of 10 higher than conformance costs. It's a no-brainer – reducing errors prior to production saves money.



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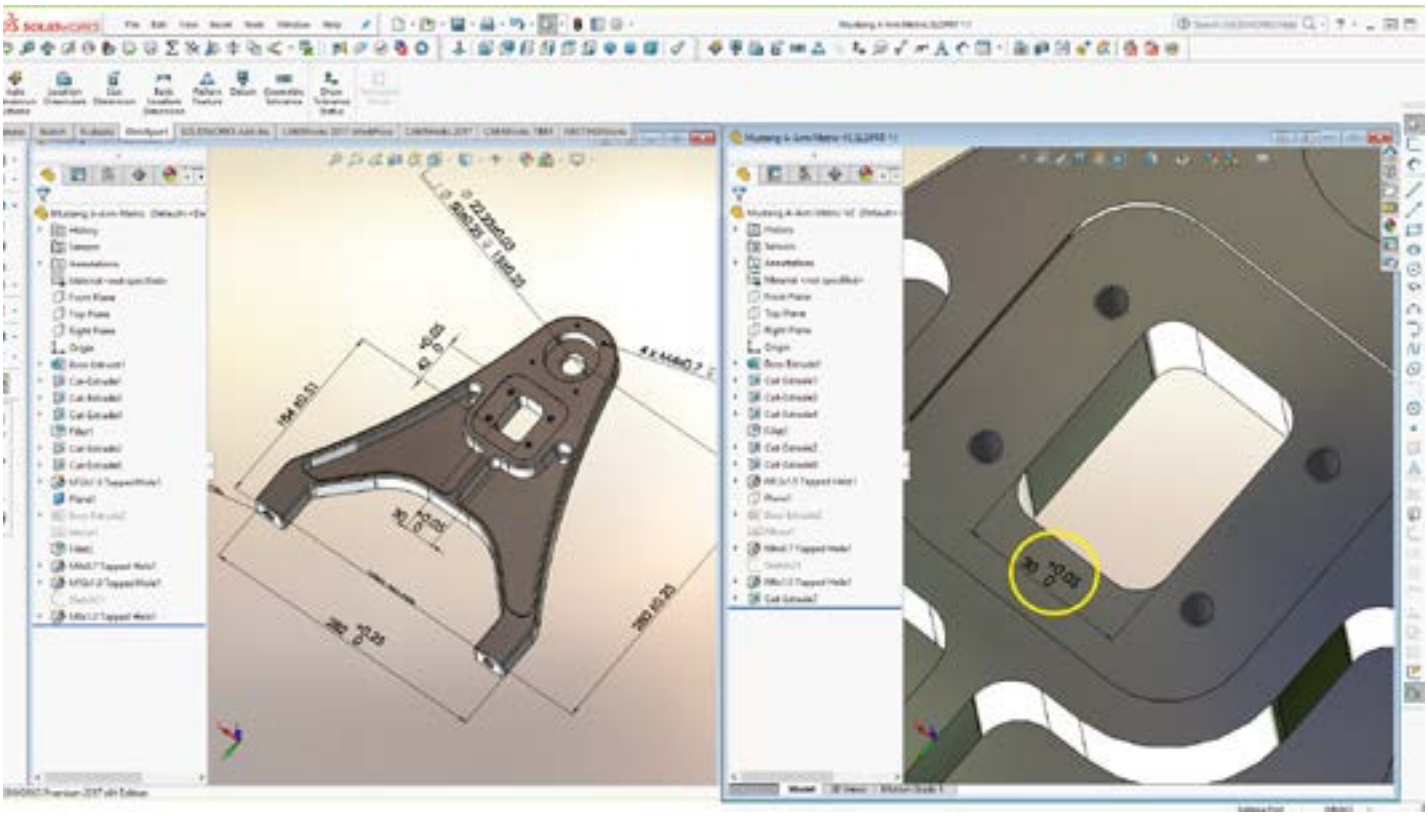
How Can This Help on the Manufacturing Side, Today?



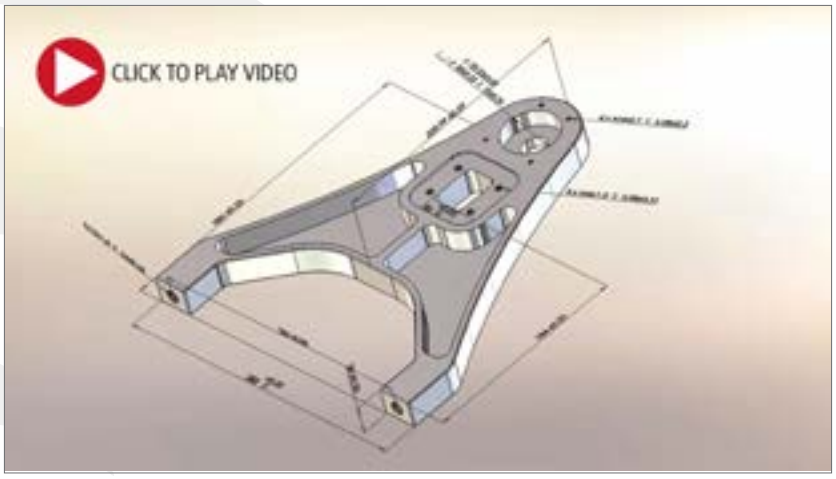
The first and most simple benefit MBD provides is that, fully dimensioned 2D drawings are no longer needed. But, the biggest benefits can be seen in current applications like CAMWorks, the first CAM software to read SOLIDWORKS MBD data and use it to automate the CNC programming process.

"CAMWorks' Tolerance-Based Machining (TBM) is a great example of a new Smart Manufacturing technology that fits in perfectly with the SOLIDWORKS Manufacturing Ecosystem of solutions" states Craig Therrien, SOLIDWORKS Product Manager. "It lets our customers use SOLIDWORKS MBD and PMI data to significantly reduce the time required for CNC programming. Other benefits include the ability to capture and automatically reuse best practices, improve quality, and reduce costs due to non-conformance."

TBM is unique to CAMWorks and can read the non-geometric information in a 3D model such as dimensions, tolerances, and surface finishes, and use them to automatically create toolpaths. TBM reads MBD & PMI information and leverages a manufacturing knowledge base to select the best machining strategies to conform to the specified tolerances and surfaces finishes.

In the past, when CNC programmers encountered features with asymmetric size or location tolerances, the model would have to be modified or in drastic cases rebuilt to mean tolerance conditions. Using TBM, CAMWorks reads asymmetric tolerances and automatically modifies the operation to machine to the mean of the tolerance, and selects appropriate machining strategies for the size and tolerance of the feature being machined. If the size of a feature or the tolerance changes, CAMWorks will automatically update the machining strategy to use the optimal tools, feeds and speeds.

For the first time, the combination of SOLIDWORKS and CAMWorks allows design and manufacturing models to become one and the same in an affordable mainstream application toolset. Using CAMWorks TBM, drawing-less manufacturing becomes a reality.



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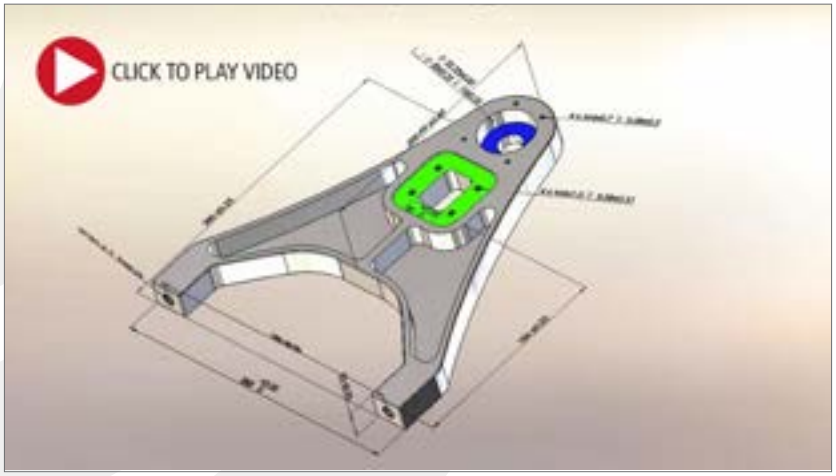

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Fully Automating the Design-to-Manufacturing Workflow

By using fully integrated CAM software that is running inside 3D CAD, 3D geometry, tolerances, annotations, surface finish, as well as the machining strategies can all work together associatively to provide a level of automation and design-to-manufacture not previously realized.

CAMWorks is an add-in for SOLIDWORKS to develop CNC programs for machining as it leverages MBD and PMI data. CAMWorks is feature-based on the front end meaning that it finds all machinable features using its industry-leading feature recognition capability and can find 20+ types of machinable features on parts, such as holes, slots, and pockets. Once the features are found, integral knowledge-based machining strategies automatically create all of the operations, including tools, speeds and feeds to machine all of the machinable features on a part.

The back-end knowledge base contains machining strategies stored in a database and it allows users to capture and automatically reuse their best practices. CAMWorks uses an extensive set of knowledge-based rules to assign machining operations to specific features. The Technology Database inside of CAMWorks contains the data for the machining processes and can be customized and optimized for any shop's methodology.

Manufacturing features are extracted from a 3D model, and 3D geometric and non-geometric data is used to generate toolpaths automatically. CAMWorks provides best case, optimized tooling per machining situation as it updates tooling throughout design and manufacturing with SOLIDWORKS, ensuring that all data is correct and synchronized through associativity.

A modern, smooth design-through-manufacturing process with a single source and continuous data stream from beginning to end is promoted. There is no chance for confusion or chance for misunderstanding because CAMWorks ensures that a model always matches the drawing because with MBD/PMI, the "drawing" is the model. There is never an issue or concern that the drawing or model includes the most current revisions thanks to the bi-directional associativity between CAMWorks and SOLIDWORKS. If a part design changes, the machining features and toolpaths update automatically to reflect the change.

Also, if a shop is provided only a traditional 3D model plus 2D drawing documentation, all is not lost. The PMI information can easily be added to the model to then be used for CNC programming by CAMWorks and provide the shop with a single reference source and record for CNC programming, while still enjoying the additional benefits provided by Smart Manufacturing.

Using MBD 3D models and CAM software that reads not only the geometry, but also the non-geometric data, minimizes programming errors and down time and maximizes throughput and quality.

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Conclusion

Connecting design-to-manufacture through one source with a fully associative and automated workflow can make significant difference. Using this new technology, you can make huge a difference with what's currently available and affordable today!

Benefits on the Design Side

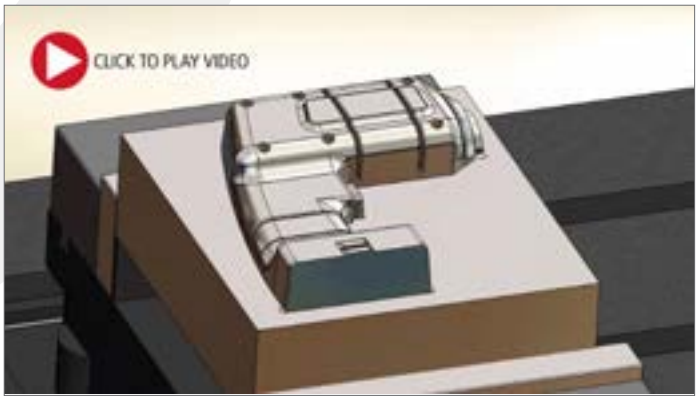
- Huge cost associated with 2D drawing creation, maintenance, and potential errors is eliminated.
- Only dimensions with tolerances different than a tolerance block need to be added and shown in the model.
- Handoff to manufacturing is much easier, because just the model is required.

Benefits on the Manufacturing Side

- One file to manage, not both 2D drawings and 3D models.
- No more inconsistencies to deal with between the drawing and model.
- CNC programming is faster, easier, and less prone to error.
- No worries about revision control. The revision of model and CNC program are synchronized and always correct. A revision of on the drawing that is newer than the part is no longer a concern.
- Determining what CNC program files go with what version of a model and drawing is a thing of the past.

Available and affordable solutions for Smart Manufacturing with MBD, PMI, and TBM from CAMWorks are helping fulfill the promise of a true design to manufacturing workflow with real benefits – faster production, more efficient process, better quality, lower costs, and higher margins.

The new Smart Manufacturing initiatives that are integral to the CAMWorks design-to-manufacturing approach save you shop floor money!



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