THE PROMISE OF PMI:

Transforming Engineering Documentation

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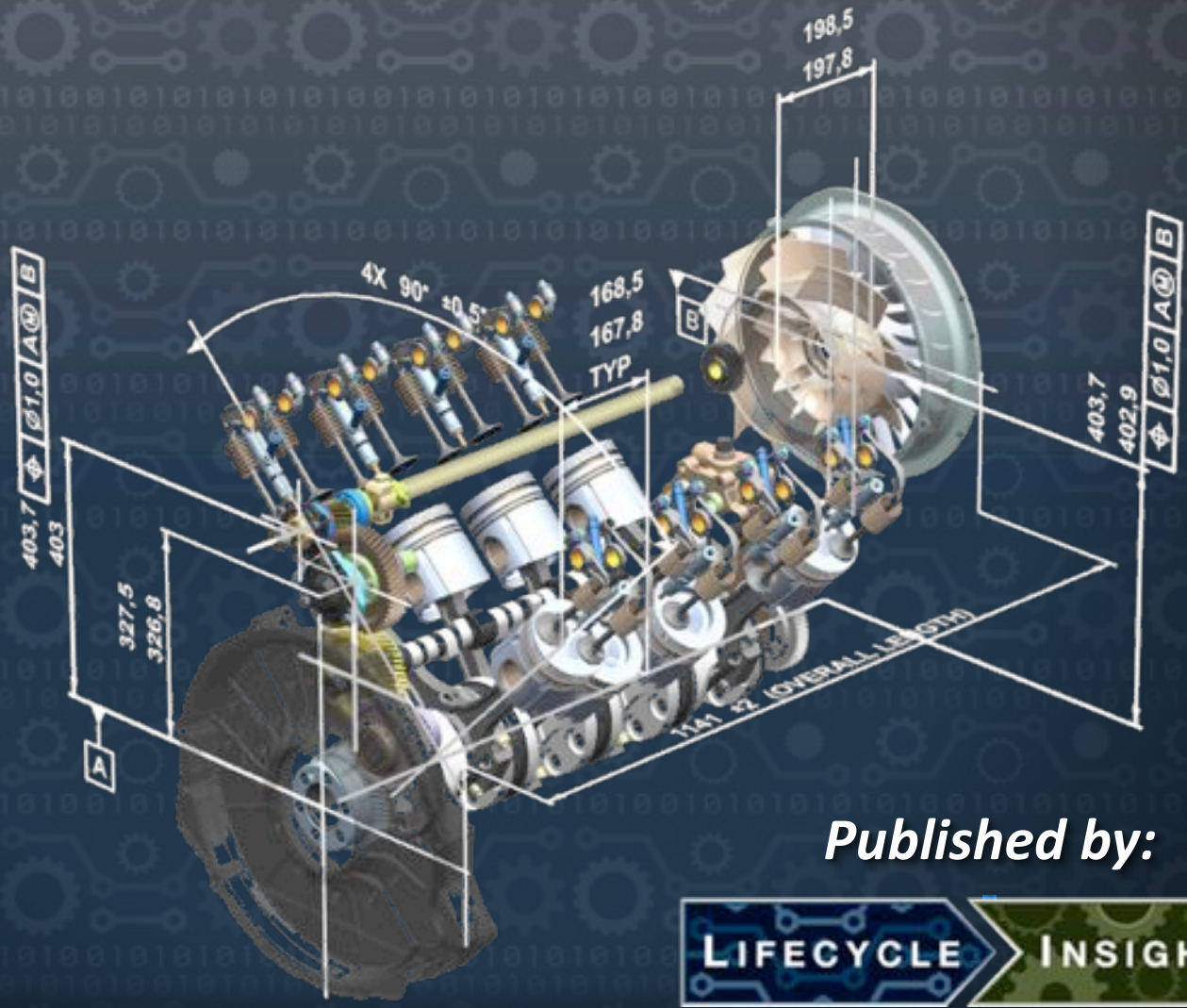

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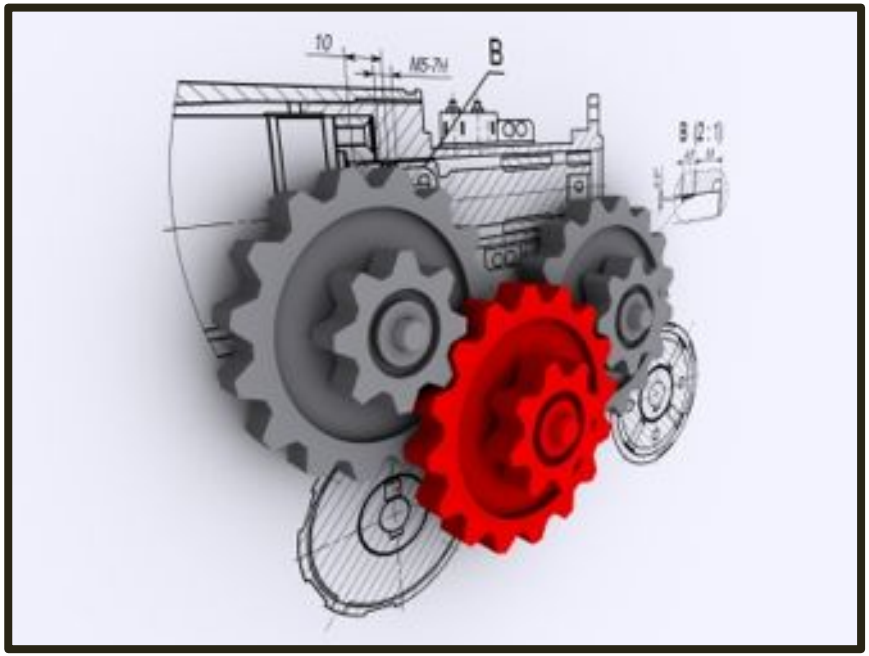
Over a decade ago, a progressive new vision for the handoff between engineering and manufacturing was defined.

It was simple, yet grand. Instead of releasing a drawing, engineering would provide a fully detailed 3D model that manufacturing would use to produce the product. The advantages were self-evident. By using an unambiguously documented 3D definition of the product, manufacturing could reduce errors and delays associated with misinterpreted drawings. Furthermore, by eliminating the effort to create 2D documentation, engineers would recoup much needed time to keep up with tight schedules.

Ten years later, the handoff between engineering and manufacturing has yet to be transformed. And there have been many missteps. It's yet to be easy enough to create annotated models or for the casual user to interrogate them. There have been misguided attempts to deploy computers to the shop floor. The most important mistake, made by too many, was to think it just about the technology and underestimate the importance of culture change.

Despite its middling progress, the opportunity to transform the handoff between engineering and manufacturing is still very real and highly beneficial. And in fact, several recent technology advances make it far more feasible. The software to create, view and interrogate such documented 3D models has been refined over the course of many releases. Ruggedized touch-enabled tablets offer a delivery platform that can realistically survive the shop floor. Yet, if we've learned anything from the past decade, it is that this effort is not just about technology. There is a cultural aspect of this change that must be planned and managed as well.

For more organizations to take advantage of that progressive yet longstanding vision, the path forward must be much clearer. This includes clarification on the terminology, the technology and how to manage such cultural change. This eBook helps with the first few steps down that path. It clearly defines the relevant terminology, describes the basics and advanced aspects of this initiative and finally explains the benefits an organization can expect.



Clearing Up Confusing Terminology

When it comes to this kind of initiative, terminology can be a real stumbling block. So before other topics are discussed, this section provides definitions for important terms.

Engineering Documentation Initiatives

Many often mistake paperless and drawingless as the same thing. While they are related to one another, they actually mean two different things.

- ***Paperless Initiatives:*** Pursuit of this initiative means the organization is delivering documentation electronically instead of on physical, hardcopy prints. Any kind of documentation, ranging from bank statements to engineering specifications, can be delivered electronically.
- ***Drawingless Initiatives:*** In this initiative, the engineering organization releases annotated 3D models instead of 2D drawings. Going drawingless doesn't necessarily require going paperless. Views of annotated 3D models can be printed onto physical hardcopies. This kind of initiative is also known as a ***Model-Based Enterprise*** initiative.

Another notable and often overlooked nuance to both of these initiatives is that neither requires a complete commitment. Hardly any organizations go completely paperless, but many are going with a less-paper approach. The same is true of drawingless efforts.

Types of Engineering Information

In these types of initiatives, 3D models are enhanced with different kinds of information. They are often defined and classified separately.

- ***Product and Manufacturing Information (PMI):*** Put simply, PMI documents any non-geometry aspect of a part, assembly or product CAD model. Specifically, it may include geometric dimensions and tolerances (GD&T), 3D annotation (text) and dimensions, surface finish, and material specifications. For more information, visit the PMI Wikipedia definition.
- ***Geometric Dimensioning and Tolerancing (GD&T):*** This kind of documentation describes the nominal and tolerance of a geometric characteristic of a CAD model such as straightness, circularity or angularity. GD&T approaches are used in drawing-based and drawingless initiatives. For more information, visit the GD&T Wikipedia definition.
- ***3D Annotations:*** This kind of documentation allows engineers to add notes that may not be related to the geometric characteristics of the part, assembly or product CAD model.

Regardless of whether an organization does or does not create formal drawings, PMI in a 3D model can be used downstream by other organizations like manufacturing, procurement and others in some manner or fashion.

Engineering Documentation Standards

For years, professional organizations published standards that defined how drawings should be documented. As some manufacturers considered the vision behind PMI, those professional organizations developed and published new standards that defined how PMI should be documented in 3D models.

- ***ASME Y14.41 3D Digital Product Definition:*** Released in August 2003, this is the American standard for annotating 3D models. For more information this standard, visit the ASME Y14.41 entry in Wikipedia or reference the standard at the ASME website.
- ***ISO 16792 Digital Product Definition Data Practices:*** Released December 2006, this is the international standard for annotating 3D models. For more information on this standard, reference the standard at the ISO website.
- ***JEITA 3D Annotated Model Guidelines:*** Released December 2008, this is the standard for annotating 3D models from the Japanese Electronics and Information Technology Industries Association.

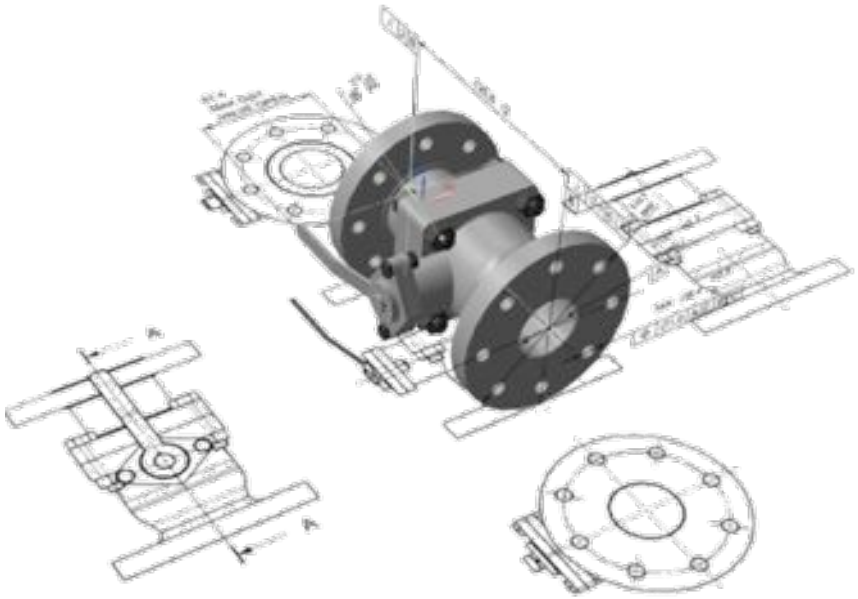
Taking the First Steps to Transform Engineering Documentation

So how does an organization get started with a PMI initiative? There are two aspects to tackle first: enabling engineers to create annotated 3D models and showing others how to view and interrogate annotated 3D models.

Authoring Engineering Documentation

Since the first incarnation of PMI, modern CAD applications have advanced to offer the ability to specify a wide-range of capabilities that leverage the information already built into the CAD model.

- ***Showing Feature Dimensions:*** The act of building a feature-based 3D model is a first step towards PMI. Dimensions are critical to defining and modifying features. Modern CAD applications make it easier than ever to reuse those dimensions as part of the model's PMI.
- ***On-Model Interactivity:*** Some years ago, CAD applications became more usable when geometry actions were placed on the model instead of in menus and dialogs. Likewise, modern CAD tools let users create and modify PMI on the model as well, making it obvious for casual users and quickly accessible for experts.
- ***Drawing Interface Similarity:*** In reality, adding PMI to a 3D model is very similar to creating a drawing. As such, the differences between the interfaces in modern CAD applications have been minimized, allowing users to use a common interface to document the design.
- ***Automated Drawing Creation:*** Likewise, if adding PMI to a 3D model is so similar to creating a drawing, why not leverage that work to help create a drawing? Modern CAD enables users to simply show the model's PMI information on drawings, automating the effort significantly.
- ***Validation of Compliance to Standards:*** Another advancement in this field is the automated checking of PMI against various 3D annotated documentation standards. Modern CAD applications assist users by acting as the digital drawing checker.



Viewing and Engineering Documentation

Of course, adding PMI to a 3D model is only half the battle. Next, the organization has to make it quick, easy and simple for everyone else, even non-technical users, to view and interrogate that documentation.

- ***Easy to Use Viewing Applications:*** 3D models viewers have existed for some time. However, early versions of these tools weren't the easiest to use, especially for casual users. Modern viewing applications let users quickly and smoothly switch between views and associated sets of PMI. They also enable them to interrogate the 3D model. In addition, these tools also allow users to also view and interrogate 2D drawings as well.
- ***Supporting Multiple Formats:*** Efforts to transform engineering documentation within a company often results in the use of a single format. However, almost every company today works within a supply chain where control over which format other organizations use is limited. Modern viewing applications allow users to open, read and interrogate 3D and PMI data in a wide variety of formats, providing flexibility to an organization's PMI efforts.
- ***Simple Apps on Ruggedized Tablets:*** Another advancement relevant to PMI initiatives is the availability of ruggedized tablets that are portable, easy to use and hardy enough to work in harsh environments. For the first time, digital drawings and annotated 3D models can be viewed and interrogated on the shop floor.

Getting the Most Out of Advanced Engineering Documentation

Long ago, when CAD applications were first used, some organizations realized a 3D model could be used for far more than just creating engineering drawings. It could be used for tolerance analyses, verification of different product configurations as well as the generation of numerically controlled (NC) code for inspection and machining sequences. Today, the use of PMI can actually extend those use cases further than the use of a 3D model. PMI information is entered once and reused in the different downstream applications.

PMI and Variational Analysis

One engineering activity enhanced with PMI is variational analyses. In this activity, engineer flexes the dimensions of the 3D model to the minimum and maximum values taking tolerances into account to identify issues like clashes, interferences and more.

PMI automates this activity because as it is added to a 3D model, tolerances are already defined. When the model needs to be flexed to a maximum or minimum, the user simply uses the tolerances in the PMI instead of adding it.

PMI and Imported Geometry

Almost every company works in a supply chain, which often necessitates the exchange of CAD data. In those cases, organizations often have to create their own engineering documentation of those models for manufacturing. The good news is that PMI can be easily added to a 3D model, regardless of source or format. That, in turn, lets the organization use the 3D model or a quickly-created drawing as the deliverable.

PMI and Product Variants

When it comes to creating engineering documentation for product variants and configurations, CAD applications have been a great boon. Users can create a single model and then define variants by excluding, including or switching parts and sub-assemblies. This master model approach allows a single model to represent many products.

Creating engineering documentation, however, isn't always straightforward. Some notes must be included for some configurations, but not for others. Some dimensions and tolerances apply to certain variants and not for others. Modern CAD applications allow users to define such logical conditions, which are applied in an automated and intelligent fashion, whether that be for PMI on 3D models or on 2D drawings.

PMI and NC Inspection and Manufacturing

Another area where PMI enhances is the creation of code that drives NC machines that inspect or machine parts and assemblies. 3D models have long been used to create such code. However, the effort often required users to select tools, speeds and feeds for a specific outcome such as surface finishes and tolerances. When PMI is embedded in 3D models, those outcomes have already been defined. Modern CAD applications use this information to automate the selection of tools, speeds and feeds. As a result, users have to spend far less time manually defining the variables to generate the NC code.

The Business Impact of PMI

This eBook has covered a number of technical issues related to PMI. And while its use seems advantageous, all proponents of such an effort must be able to answer a critical question: what are the benefits to the organization and the business overall? The answers fall into three main categories.

Cost Reduction through Less Paper

Many organizations are pursuing a paper reduction initiative. While it is beneficial to the environment, it's also beneficial to the bottom line. Using less paper translates to spending less money on paper. As we said before, using PMI doesn't equate to eliminating paper drawings. However, it can enable an organization to use less hardcopy prints.

Increased Engineering Productivity

With the use of PMI, some redundant tasks, like entering tolerance information on a drawing and generating inspection NC code, can be eliminated. The time saved translates into more time spent on designing and engineering products.

Furthermore, entering the same information for multiple applications can be error prone. Reusing information entered correctly once can eliminate such costly problems.

Summary and Conclusion

More than a decade ago, a powerful vision to transform the handoff between engineering and manufacturing emerged. There have been many missteps in pursuing that vision, but today, the opportunity to transform the handoff between engineering and manufacturing is still very real and highly beneficial.

Terminology in this area is challenging. There are different initiatives, drawingless and paperless, different kinds of engineering information (such as PMI) and different standards for documenting 3D models. Most importantly, it is important to realize that leveraging PMI does not equate to eliminating drawings.

In the past ten years, the software applications used to author as well as view 3D models with PMI have improved by leaps and bounds. Modern applications used to create PMI are far easier to use, use similar interfaces to author drawings and validate compliance to standards. Modern applications used to view and interrogate 3D models with PMI support a variety of formats and run on ruggedized tablets that work on the shop floor.

It's not all about just authoring and viewing such 3D models. PMI embedded in 3D models enhances several other downstream activities. It can be used to automate variational analyses where worst-case scenarios are scrutinized. It can be used to author documentation for imported design data. Logical constraints can be applied to it to intelligently react to master model representations of product configurations and variants. It also automates the generation of NC code for inspection and machining operations.

With all these technical advantages, come important benefits to the business. Such efforts don't require going paperless or drawingless; but they can help the organization reduce the amount of paper used. That saves the organization money. Furthermore, authoring PMI in the 3D model can open up several other applications, like adding it to a drawing or generating NC code. As a result, multiple redundant tasks can be eliminated. That translates into more time for designing and engineering products.

In all, PMI can be leveraged for a wide variety of purposes throughout a manufacturer with hard benefits. It may be a longstanding vision, but it still offers ample opportunity for those willing to transform their engineering documentation and, perhaps, the entire design process.

For more information on PMI, paperless and drawingless initiatives, please visit the Siemens PLM's site.

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