

The logo for Tech-Clarity, featuring the word "Tech-Clarity" in a bold, sans-serif font. "Tech-" is in white and "Clarity" is in yellow, both set against a dark blue rounded rectangular background.

Tech-Clarity

Tech-Clarity Insight: The How-to Guide for Implementing PMI

***Making Product and
Manufacturing Information a
Strategic Advantage***



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Executive Overview

With so much global competition, companies are struggling to competitively differentiate their products any way they can. Much of this differentiation will come from engineering so it is critical for engineers to focus the majority of their energy on design work that will create that differentiation. This requires streamlining the development process so that engineers are able to focus on innovation.

PMI is very important to our business and supports our overall Model Based Product Definition (MBPD) initiative.

Jeff Erno, Consulting Engineer for the CAD Tools and Product Definition Group, GE Power & Water

PMI (Product and Manufacturing Information) is a way to achieve this goal. With PMI, the need for 2D drawings is greatly reduced or eliminated altogether. Explains Jeff Erno, a Consulting Engineer for the CAD Tools and Product Definition Group at GE Power & Water, “*PMI is very important to our business and supports our overall Model Based Product Definition (MBPD) initiative.*” Adds Erno, “*It also allows us to be more productive in producing our product definition as fewer views are needed to achieve the same goal and we can build the documentation faster than with classical drawing methods.*” GE Power & Water is a provider of power generation and water technologies for utilities, independent power producers and industrial applications. PMI also enables better communication, which leads to fewer mistakes and higher quality. Andreas Pietsch, Development Body in White Manager at Daimler AG says, “*It is obvious PMI saves us money by saving documentation time.*” Pietsch continues, “*Of course there are also less mistakes because specifications are more clear.*”

It is obvious PMI saves us money by saving documentation time.

Andreas Pietsch, Development Body in White Manager, Daimler AG

Enabling better communications improves relationships with suppliers. More importantly, 3D models can make it easier for customers to work with you, which is a competitive advantage.

While PMI offers many advantages, adopting it does require some organizational changes, which can be difficult for any organization. However, with proper planning for PMI, the adoption process can be much easier. This report serves as a how-to guide to implement PMI and make it a success at your company



What Is PMI?

PMI, or Product and Manufacturing Information, embeds information into the 3D CAD model that can be used to support the manufacturing, analysis, and inspection of a product, without the need for a 2D drawing. PMI contributes to MBD (Model Based Definition), which is a complete digital definition of a product within a 3D CAD model. PMI includes information such as geometric dimensions and tolerances (GD&T), 3D annotations (text), surface finish, and material specifications.

There are a couple of terms related to PMI:

- **Paperless:** An initiative to use less paper. Instead of paper, electronic formats are used.
- **Drawingless:** Rather than 2D drawings, annotated 3D models are used.

It is important to note that these terms are not interchangeable. Going drawingless doesn't require going paperless. Views of annotated 3D models can still be printed. In addition, adopting PMI does not mean the company must go completely drawingless.

The PMI tool has to support valid ISO and ASME GD&T standards and rules for correct documentation.

Andreas Pietsch, Development Body in White Manager, Daimler AG

Over the years, standards boards have given PMI some attention. Several standards have been defined which are important to keep in mind when adopting PMI:

- **ASME Y14.41** – 3D Digital Product Definition: This standard was first released in 2003. It is a US standard for annotating 3D models. An updated version of the standard was released in 2012
- **ISO 16792** – Digital Product Definition Data Practices: Released in 2006, this is an international standard for annotation 3D models.
- **JEITA** – 3D Annotated Model Guidelines: First released in 2008 and then revised in 2014, this standard is from the Japan Electronics and Information Technologies Industries Association

In general, support for drawing standards should be an important consideration when selecting a PMI tool. Andreas Pietsch, Development Body in White Manager at automotive company Daimler AG stresses, “*The PMI tool has to support valid ISO and ASME GD&T standards and rules for correct documentation.*”

Why Consider PMI?

In today's global environment, companies are under pressure to competitively differentiate products. Many companies have found that they are left with tighter budgets and fewer engineers. Anything that frees up engineers to focus more on innovation, reduces time to market, and improves product quality should be considered to help a company be more competitive in today's market.

Daimler was seeking exactly this type of improved engineering efficiency when it began using PMI. Pietsch comments, *"We were looking into ways we could be more efficient with our 3D models. We wanted to avoid double documentation. This became our starting point with PMI."* It has worked out well for them. He adds, *"It is obvious PMI saves us money. We save documentation time doing everything in 3D."*

We needed to be faster and cheaper. We are achieving that with 3D annotations.
Matthew Johnston, Senior Design Engineer Manager, ATK

ATK, an aerospace, defense and sporting goods company, has also found PMI helped with their business goals. Matthew Johnston, Senior Design Engineer Manager at ATK says, *"We needed to be faster and cheaper. We are achieving that with 3D annotations. We are able to reduce design cycle times by not creating drawings and doing everything in the model."* There have been additional benefits too. *"We have also reduced cost by reusing the model for manufacturing and quality,"* says Johnston. These time and cost savings can then be used to make ATK even more competitive.

In addition to large companies, PMI can also be beneficial for small companies. Felix Mühlhoff, a Naval Architect at Shipdesign Mühlhoff, an independent ship design and consulting firm, shares how PMI saves time for both engineering and manufacturing. *"PMI is better because it takes less time. For one thing, it is much faster to generate PMI than 2D drawings."* Mühlhoff continues, *"It is also easier to interpret a 3D model which means it is much faster to find the right information. With the model easier to understand, communication is also much better."*

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Felix Mühlhoff, Naval Architect, Shipdesign Mühlhoff

Improved communication also means higher quality, which Pietsch from Daimler emphasizes, *"The very nature of creating a 2D drawing means information is missing. When you are working off of a 3D model rather than a sheet of paper, the specifications are clearer. This means less mistakes."*

PMI also helps companies make better decisions as Nicolas Hamilton, a CAD System Analyst at Metso explains, “*With PMI, we can make better decisions because now there is one place to find information instead of in multiple pages of drawings. We can access what we need through a single interface within the model.*” Metso is a supplier of technology, automation, and services in the mining, construction, and oil and gas industries. The company also provides advanced automation solutions for pulp, paper and power generation.

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Nicolas Hamilton, CAD System Analyst, Metso

In addition to all these benefits, there is also the soft benefit of happier employees because a tedious task has been removed from their workload. Recent [research](#) from the University of Warwick in the United Kingdom, found that happier people are 12% more productive.¹ More productive, happier employees will be able to focus more energy on value added work that contributes to more profitable products. Many share the sentiment expressed by Mühlhoff at Shipdesign Mühlhoff, “*I don’t want to make any 2D drawings if I don’t have to. It’s boring.*”

Clearly there are a variety of reasons to adopt PMI. The interesting thing is that regardless of company size or industry, companies are finding value in it.

Why Should You Consider PMI Now?

PMI standards have been around for a while, so why is now a good time to look at PMI?

If companies are not already feeling squeezed by the shortage of engineering talent, they will soon and they need to establish processes that will make the most of their engineering resources.

For one thing, engineers are overworked. An impact of the recession is that many companies have smaller work forces. In addition, as experienced engineers approach retirement age and fewer people graduate with an engineering degree, there are fewer engineers available to innovate. As stated in Tech-Clarity’s report [Developing the STEM Workforce of the Future](#), “The world’s economies face a shortage of engineers and

¹ Andrew J. Oswald, Eugenio Proto, and Daniel Sgroi, “Happiness and Productivity,” *Journal of Labor Economics*, 3rd Version: February 10, 2014.
<http://www2.warwick.ac.uk/fac/soc/economics/staff/eproto/workingpapers/happinessproductivity.pdf>

manufacturing resources trained in STEM disciplines.” The report goes on to provide some brief statistics to highlight the severity of the problem:

- The World Economic Forum indicates that there are 10 million manufacturing jobs unfilled – many of which are in areas with high levels of unemployment
- The average age of an auto controls engineer is greater than 50 and one out of 10 employees in the aerospace engineering workforce is already eligible for retirement

If companies are not already feeling squeezed by the shortage of engineering talent, they will soon and they need to establish processes that will make the most of their engineering resources.

Management is always looking for a way to help reduce the engineering workload. PMI offers a way to help with this need.

Nicolas Hamilton, CAD System Analyst, Metso

Making the most of its engineering resources was a driving factor for Metso to adopt PMI. *“Management is always looking for a way to help reduce the engineering workload. PMI offers a way to help with this need,”* comments Hamilton.

Along with a smaller engineering workforce, the demographics of the manufacturing workforce are changing. *“Managers want the faster and more effective workflow available with PMI. The problem is that the current staff is set in their ways so change becomes harder for them,”* says Felix Mühlhoff, Naval Architect. *“However, as new and younger people are hired, they will not have the experience reading 2D paper drawings and it will be hard for them. 3D will feel more familiar and PMI will be more intuitive. The use of PMI will allow them to become very productive in less time. Companies who are better positioned to tap into the resources offered by their newer staff will have the advantage.”*

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Felix Mühlhoff, Naval Architect, Shipdesign Mühlhoff

In addition to changing dynamics in the workforce, CAD tools are also evolving. The ability to embed manufacturing and quality information into the CAD model continues to grow. While embedding more information means larger models, CAD tools are also getting better at managing the performance of these large models. Hamilton shares his observations at Metso, *“There have been big changes in CAD. You can have larger and bigger models. You can also experiment more with CAD. If you have a new idea for an*

assembly sequence, you can animate it and build the idea right in the model by using PMI. The assembly can include the logic for assembly and disassembly information, plus details such as required torque.” Hamilton also commented on the future direction. “PMI is new to us, but with trends to improve ease of use, I expect it will become easier to embed even more PMI information inside CAD models. I also anticipate that eventually we will be able to take a more holistic approach to include other processes in PLM, outside of engineering.”

Hardware innovations have also made 3D data more accessible. *“New technologies such as cheap Android tablets can be used on the production floor,”* says Hamilton. *“This makes it very easy to use the 3D model outside of engineering.”*

Plan for Success

Despite the business value, there are obstacles to PMI companies should be aware of. Understanding these up front and planning for them will help companies be more successful with PMI. Erno, from GE Power & Water, commented on the reason for this. *“It is an adjustment going to 3D models. People are used to drawings and any change can be difficult,”* says Erno. *“While easier to understand, in many ways PMI is different and there has been pushback.”* Erno and his team believed in the initiative to use PMI, but found there was some work involved to educate the supply chain for them to see the value. *“The supply chain, in general, isn’t ready or ‘pulling’ for it. Instead we are pushing them to adopt it to get them to see the benefits of having data to automate their work.”* Erno adds, *“The lack of pull was very surprising.”*

To overcome cultural resistance, helping others understand the value was part of our training. This has helped with the acceptance by both our suppliers and customers.

Matthew Johnston, Senior Design Engineer Manager, ATK

Putting together a strategy to create demand can overcome this and lead to greater success with PMI. *“To overcome the cultural resistance, helping others understand the value was part of our training,”* states ATK’s Johnston. *“This has helped in the acceptance by both our suppliers and customers.”*

Identify Who Should be Involved

The initiative for PMI usually starts within engineering, but it has a positive impact across the company. With that in mind, establish a cross functional team where multiple departments are represented. Pietsch explains the breakdown of responsibilities at Daimler, *“R&D owns the PMI, but Quality is responsible for making sure their stuff is in*

there and manufacturing is involved too. We also include our suppliers.” Similarly, ATK also involves a wide range of roles. “Every department that touches our products is involved, including Program Management, Manufacturing, Design Engineering, Quality, Configuration, and Procurement,” says Johnston.

Establish a Supportive Culture First

After identifying who needs to be involved, it is helpful to establish a culture that will accept it. Given the number of departments that can benefit from PMI, it is especially important support comes from the top. *“You will need a strong manager to push the initiative. The manager should be high enough to have responsibilities across business lines,”* recommends Metso’s Hamilton. In addition to management support, the initiative needs a champion. ATK credits this critical piece and the culture they created as being invaluable to their success with PMI. *“I was the champion, but I had lots of help within my group and from my management,”* comments Johnston. *“It is important to get people excited and positive about using PMI, before they even start. We started with upper management. When the VP is talking positively about PMI and 3D Annotated Models, it got those at all levels saying good things about it and this is a must to be successful.”* Creating the “positive buzz” creates a more receptive environment where people will have a good understanding of how it will help, before they even start using it.

It is important to get people excited and positive about using PMI, before they even start.

Matthew Johnston, Senior Design Engineer Manager, ATK

Define Training Plans

Companies should consider training before beginning a PMI initiative. Training is especially important for those who are less familiar with 3D or those in manufacturing who may not be less comfortable with computers. Allowing them to see it first, play with it, and have fun interacting with the model is a great way to introduce the concept of PMI so that they are excited to use it. At Daimler, training was an important component. *“It is always hard to integrate a new process, but once they do it, they find they no longer like 2D drawings,”* shares Pietsch. *“To achieve this change in perception, training was necessary. The training involved explaining PMI, how to use it, what type of information is available, and all the process lessons we’ve learned.”*

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Andreas Pietsch, Development Body in White Manager, Daimler AG

ATK also found training very helpful. *“We held the training before we rolled out PMI. We held it for the different groups showing them how to use it, explaining what a 3D annotation is, and describing our benefits as a company,”* says Johnston. *“The training was only 1-2 hours and we ran it two or three times.”* The investment of just a few hours really paid off. *“The training will help us make a huge cultural change,”* observes Johnston. *“Once they see what you are talking about and how PMI looks, they say, ‘I like that!’ They may have been scared at first, but after learning the basics, they can look at a very complicated part and see how much easier it is to understand.”*

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Matthew Johnston, Senior Design Engineer Manager, ATK

Further strengthening their success with PMI, ATK also did cross-training to address knowledge gaps between engineering and manufacturing. *“I was part of the manufacturing and quality group when I joined the design engineering team,”* explains Johnston. *“With my experience, I was able to lead the PMI initiative because I had a thorough understanding of what the downstream departments needed.”* Looking to complement his expertise, Johnston looked for other opportunities for cross-training. *“We brought over a CNC programmer and taught him how to do PMI,”* recalls Johnston. *“Then we had a design engineer, who was our best PMI modeler, rotate into the manufacturing team. These cross-trained individuals could act as sort of a mole to advocate for PMI and be a go-to person for the others within their groups.”*

In some cases, training may not be needed, as was the case at Shipdesign Mühlhoff. *“I saw the PMI menu and was curious. I clicked on it, got a dimension, and thought it was very nice and perfect for my needs,”* recalls Mühlhoff. It is important to assess the needs of the organization and provide the support where needed.

Create Demand Among Customers & Suppliers

While eliminating or reducing the time to create 2D drawings has obvious benefits to the engineering team, customers and suppliers may need some help understanding why PMI can also be more useful than a 2D drawing. One approach is to gradually expose customers to PMI so that they can start seeing the value themselves, as was done at Shipdesign Mühlhoff. *“For customers, it can be nice for them to see the 3D model because they can see your work. It makes it easier to share information with them and there is more confidence in the design because it is more clear,”* says Mühlhoff. *“Even if the 3D model is provided as additional information with a 2D drawing supplied later, it can be a nice way to start the acceptance of PMI.”*

Our customer found that not only was the PMI model more fun to work with, but the design was also going to be faster, cheaper and better.

Matthew Johnston, Senior Design Engineer Manager, ATK

ATK worked directly with a major customer to win over their support. *“We worked very closely with a major customer to help them see how much easier it is to work with the model rather than a drawing,”* explains Johnston. *“They found that not only was the PMI model more fun to work with, but the design was also going to be faster, cheaper and better. Eventually, this led to our customer updating the contract to require 3D models as deliverables rather than 2D drawings.”*

While helping customers understand the value of PMI, making sure suppliers do too is equally important. Johnston described how ATK supported their suppliers as they adopted PMI to make it a mutually beneficial arrangement. *“When we introduced PMI to our suppliers, they bought into the value, but they requested some help,”* recalls Johnston. *“They knocked down the price in exchange for that help. We ended up working with them over the phone or traveling to their sites to support them through the adoption of PMI. It was a win-win for both of us.”*

Good communication with suppliers is key to making it work.

Jeff Erno, Consulting Engineer for the CAD Tools and Product Definition Group, GE Power & Water

GE Power and Water also worked closely with suppliers. *“Good communication with suppliers is key to making it work,”* says Erno. *“When transitioning to PMI, we had meetings with each supply chain group on process to ensure no information is lost.”* Erno also explains how GE Power and Water uses PMI with their suppliers. *“We are using PMI built into our piece part models and assemblies to better communicate to our supply chain. We think making the documentation in 3D is easier to understand by those humans who need it,”* comments Erno.

We think making the documentation in 3D is easier to understand. .

Jeff Erno, Consulting Engineer for the CAD Tools and Product Definition Group, GE Power & Water

Erno provides advice on why suppliers should find PMI beneficial and how it will save them time. *“Another major benefit is in the trust it instills in the models,”* observes Erno. *“With PMI, we are unable to manually change dimensions so the manufacturing teams can trust that the model matches the documentation. This allows the supply chain to do*

NC programming from the models directly rather than checking and/or rebuilding the models from a drawing.”

Start with a Pilot

It is important to keep the PMI initiative manageable when starting out. Making too many changes at once will quickly become overwhelming and the initiative will be more likely to fail. *“It is a little like painting a house. If you try to do it all at once, and alone, it is a much harder task. Start small, and perhaps at first avoid working in direct sunlight unless you absolutely know your stuff,”* recommends Metso’s Hamilton, alluding that a less visible project may be a good place to start. When looking for a group to start with, consider one that will be most open to adopting new processes. *“Our productization group had an easy time experimenting and adopting some of this. They also participate in EU and government research projects so they are used to seeing new things and keep an open mind about new technologies,”* says Hamilton.

Once the team or teams are selected, set up a pilot. *“We started with a pilot. We built a complete design package with PMI and used it. With that we learned a lot,”* recounts GE’s Erno. *“From there we started small. We learned even more and have adapted our processes.”* Also, with the first projects, it does not need to be an all-or-nothing approach. To help with the transition, the PMI model can still be used to create drawings, especially until there is a comfort level with the new approach. *“The first thing we did was to still provide drawings. We took the 3D views and used them as the basis to make a ‘drawing’ with some compromises, but it was still like a drawing,”* explains Erno.

We had parts in hand ready for testing in less time than it would have taken to get paper out.

Matthew Johnston, Senior Design Engineer Manager, ATK

ATK ran a series of pilots to make sure they got the process right before rolling out further. *“We ran three pilot programs, with three different design engineers, and three different machine shops. All three were very successful. We had parts in hand ready for testing in less time than it would have taken to get paper out,”* says Johnston. *“Then we were able to benefit from the great success stories we could share to support the wider roll out.”*

Capture Best Practices

After running the pilots, learn from them, and identify what works best. *“After running our three pilots, we got the three groups together and identified best practices,”* says ATK’s Johnston. *“We used this to define the standard we could use to move forward with*

the rest of the teams.” Learning from those initial projects, and using those lessons learned as a basis for the wider company initiative, will ensure greater success with PMI.

Content that was created to define best practices can then be reused to educate customers and create customer demand for it. Make sure your customer is getting extra support to instill confidence in the new program to ensure a smooth transition to PMI. *“To make sure we met our customers’ needs, we stuck to a very strict timeline and tracked weekly action items for our implementation plan. We also had the training in place and resources, such as PowerPoint’s and videos, available to show how to use it,”* shares Johnston. *“It worked and we are winning because of it.”*

Conclusion

In today’s competitive environment, companies must work hard to differentiate their products. Much of this differentiation will come from engineering. With fewer engineers, companies need to make the most of the engineering talent they have by streamlining their workload. Taking advantage of PMI is one way to accomplish this. With PMI, much of the time previously used for producing 2D drawings can instead be applied to designing better products or reducing time to market or both.

With PMI, people are able to talk more clearly about the process and requirements.

Andreas Pietsch, Development Body in White Manager, Daimler

Changes in the make-up of the engineering workforce as well as evolutions in CAD tools have made PMI an attraction option to consider. However, adopting it does require some cultural change, both internally and with suppliers and customers. Identifying those challenges and planning for them before the adoption of PMI will make the transition go far more smoothly. Companies who have addressed cultural resistance before it happens, developed training plans, and used pilot programs have reported much success with their PMI programs. *“A new process forces people to do something different and that is always hard. Once they start using PMI, they find they no longer like 2D,”* says Daimler’s Pietsch. *“With PMI, people are able to talk more clearly about the process and requirements.”* Among other benefits, companies find PMI has helped them achieve greater efficiency, lower cost, better supplier relations, and happier customers.

Recommendations

Based on industry experience and research for this report, Tech-Clarity offers the following recommendations:

- Consider PMI as a way to streamline the engineering workload and reduce the amount of non-value added work.
- Select a tool that supports valid ISO and ASME GD&T drawing standards
- Do not overlook the resistance to cultural change. Even when a change is for the better, it can still be hard.
- Provide all impacted departments a good understanding of why it will help them before they use it.
- Provide training to those who need it.
- Make sure there is a champion with management support.
- Keep in mind adopting PMI does not have to be all or nothing approach. It can be a gradual transition from 2D drawings.
- Take the time to ensure that suppliers and customers understand the value of PMI and why it will be easier for them.
- Start small with pilot programs.
- Use what is learned from pilot programs to identify and develop best practices that can be used company-wide.

About the Author

Michelle Boucher is the Vice President of Research for Engineering Software for research firm Tech-Clarity. Michelle has spent over 20 years in various roles in engineering, marketing, management, and as an analyst. She has broad experience with topics such as product design, simulation, systems engineering, mechatronics, embedded systems, PCB design, improving product performance, process improvement, and mass customization. She graduated magna cum laude with an MBA from Babson College and earned a BS in Mechanical Engineering, with distinction, from Worcester Polytechnic Institute.

Michelle began her career holding various roles as a mechanical engineer at Pratt & Whitney and KONA (now Synventive Molding Solutions). She then spent over 10 years at PTC, a leading MCAD and PLM solution provider. While at PTC, she developed a deep understanding of end user needs through roles in technical support, management, and product marketing. She worked in technical marketing at Moldflow Corporation (acquired by Autodesk), the market leader in injection molding simulation. Here she was instrumental in developing product positioning and go-to-market messages. Michelle then joined Aberdeen Group and covered product innovation, product development, and engineering processes, eventually running the Product Innovation and Engineering practice.

Michelle is an experienced researcher and author. She has benchmarked over 7000 product development professionals and published over 90 reports on product

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