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How to Enable the Digital Thread in Your Organization

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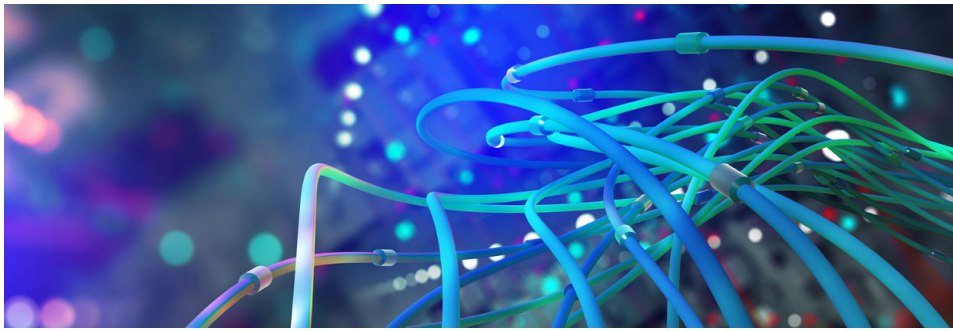
Introduction to the Digital Thread

Digital technology is transforming our physical world at an accelerated rate. With this ever-expanding digital transformation comes the requirement of a digital thread across the enterprise and product development process. This digital thread creates a closed loop between the digital and physical worlds, transforming how products are engineered, manufactured, and serviced. It serves as a single source of data truth, creating consistency, collaboration, and alignment across functions through real-time updates of connected information.

Throughout a product's lifecycle, the product designer continually interacts with a multitude of other processes. These interactions are facilitated by technologies such as IoT, AR, PLM, and CAD—with information and feedback from the actual product being sent back to improve the digital design. This digital information is used to support decision-making and processes across departments, geographies, and organizations. Having a seamless digital thread is essential to having a seamless product development process. By eliminating point solutions and ensuring a streamlined digital thread, companies can leverage data across the enterprise to operate faster, more efficiently, and with improved quality control.

From concept development to manufacturing process development, the native CAD model becomes the driving force behind the digital thread. The promise of 3D CAD, and specifically parametric modeling, is that design intent is easily captured using features and constraints, which makes it easier to define how the model should behave when something is changed. Moreover, best-in-class parametric modeling is deeply associative so that when changes occur in one part of a model, the relevant updates are automatically made to related geometry and downstream artifacts. It is through model-based definition (MBD) that all relevant data needed for manufacturing and quality control remain within a common 3D model that serves as the single source of authority that drives all engineering and downstream activities. Together, CAD and MBD form the digital foundation for product development, enabling a seamless transition of design data and information from the conceptual phase to manufacturing and beyond.



The Evolution of CAD in Product Development

CAD software began to emerge in the 1960s as a response to the growing complexity of engineering designs, with early systems focused on creating 2D representations of designs. As 3D modeling emerged in the 1970s, engineers were able to create more realistic and comprehensive representations of their designs. With the commercialization and widespread adoption of CAD, PTC's Pro/ENGINEER (now known as PTC Creo) introduced parametric modeling in 1987, allowing engineers to create relationships between parts and automate design changes. The next few decades saw growth in areas such as collaborative design, advanced simulation, cloud-based CAD solutions, and AI-driven generative design tools. With each evolution, CAD software continues to revolutionize the way products are conceived, designed, and manufactured.

For example, the shift to 3D modeling was a critical step in supporting MBD because it allowed for the creation of 3D annotated models, where dimensions, tolerances, and other manufacturing information could be directly associated with the 3D geometry. As CAD systems improved data interoperability by supporting various file formats, this ensured that MBD data could be easily shared downstream, fostering collaboration within the digital thread.

Model-Based Definition (MBD) Principles and Benefits

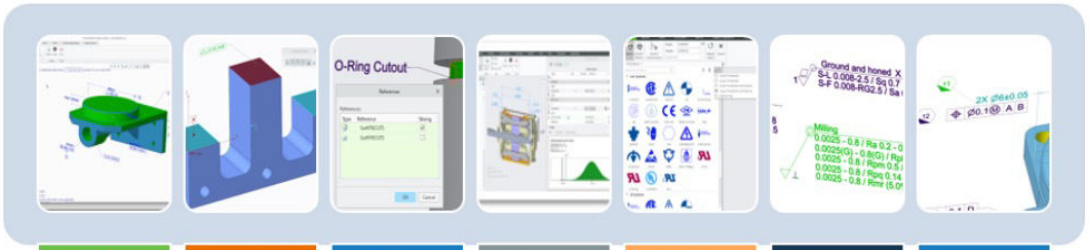
MBD is a 3D annotated CAD model and its associated data elements define the product without the need of a 2D drawing. MBD aims to eliminate the need for 2D drawings by embedding all relevant design and manufacturing information directly with the 3D model. By directly integrating all product information into the 3D model, engineers avoid the discrepancies that can emerge when working with 2D drawings. With 2D drawings there are a great deal of version control issues—making collaboration challenging and processes more error-prone.

By using the 3D model as the primary source of product information, all data remains within the model, with design intent preserved, and associativity intact. Adopting MBD offers a range of benefits that significantly enhance product design, manufacturing, and collaboration processes. MBD offers a clearer representation of the product's design and requirements. As a result, it streamlines design and manufacturing processes by eliminating the need to create and manage 2D drawings separately. This leads to faster design iterations and reduced prototyping as well as an increase of cross-functional collaboration through the same, shared 3D model.

In Creo, MBD has evolved to support full semantic definitions, allowing both humans and machines to interpret the geometric references. GD&T Advisor and EZ Tolerance are two software add on extentions that help to define the model for downstream processes. Below describes a portion of the journey that MBD has gone through within the Creo environment.

EVOLUTION OF MBD IN CREO

CREO CONTINUES TO FOCUS ON INNOVATING MBD



Creo 4	Creo 5	Creo 6	Creo 7	Creo 8	Creo 9	Creo 10
Full semantic definition to 4 annotation types Streamlined annotation workflows Improved support for ASME/ISO standards Semantic PMI with STEP AP242 GD&T Advisor	Semantic query Annotation conversion tool Improved annotation UX for failure of references	Notes modernization Improved parent/child behavior for annotations Annotation Support for advanced modeling concepts (Data Sharing features & ModelCheck for MBD)	Updated compliance to ISO 1101 & ASME Y14.5 Standards Modernized 1D Tolerance Analysis Extension (EZ tolerance analysis)	Symbol modernization Advanced surface collection methods GD&T Advisor support for assemblies and mismatched annotations manager	Surface Finish Modernization Updated ISO/ASME Surface Finish symbols Customizable Symbol Parameters Usability Improvements to GD&T Advisor & EZ Tolerance Analysis	Relate symbols & surface finish to other annotations Improved semantic behavior for general profile tolerance with GD&T Advisor Improved Stack-up definition & productivity to EZ Tolerance analysis

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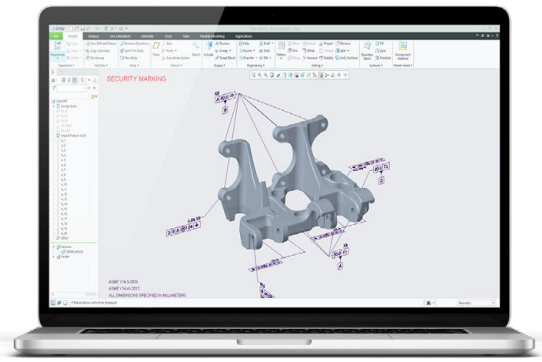
Integration of CAD and MBD in Product Development



Drawing Centric	Model Centric	Model Based Definition	Model Based Enterprise
MATURITY LEVEL 0	MATURITY LEVEL 1	MATURITY LEVEL 2	MATURITY LEVEL 3
2D Drawing is the Master	**2D Drawing** is the Master	**3D Model** is the Master	**Fully Loaded 3D Model** is the Master
• 3D Model is not verified • 3D Model is not configuration controlled • 2D Drawings are the Master • 2D Drawings are primary deliverables for internal and external customers	• 3D Model is verified • 3D Model may be configuration controlled • 2D Drawings continues to be the authority	• Design intent captured in 3D annotated model • 3D Model validated and configuration controlled • Technical Data Package (TDP) generated from these 3D models used for limited downstream consumption	• Fully loaded, 3D Models with associated artifact completely define the Product • Configuration management, automatic creation of "rich" TDP's, archival procedures in place • Rich TDP's directly used by all downstream users

CAD and MBD work together to enable the digital thread. With 3D modeling as the foundation for both, CAD serves as the primary tool for creating 3D models of products or parts while MBD serves as the starting point for embedding all product information. MBD takes advantage of CAD's annotation capabilities by incorporating the annotations into the 3D model. This integration ensures that annotations are associated with specific model surfaces. MBD also relies on the parametric and associative nature of CAD models. Changes made to the 3D model automatically update associated annotations and dimensions, ensuring data consistency and accuracy throughout the digital thread.

The digital thread remains seamless and persistent throughout the enterprise because of the tight integration process between CAD and MBD as an organization goes through the maturity matrix.

CAD software often includes digital annotation tools such as Geometric Dimensioning and Tolerancing (GD&T) capabilities to create annotations that align with industry standards. GD&T and other annotation tools enable precise and standardized representation of product information within the 3D model. Data interoperability is also critical to the flow of MBD data between CAD solutions as it ensures an integration with a digital thread framework.

LIXIL: A Digital Thread Case Study

Across a variety of different industries, CAD and MBD have been integrated into the product development cycle. With brands such as American Standard and Grohe, LIXIL is a leading manufacturer of kitchen and bath products, including fittings, ceramics, and bathing fixtures. Driven by ever-changing consumer needs, American Standard needed to address these requests as quickly and efficiently as possible. With different segments, industries and regions spread across the company, getting all team members aligned on a particular product development process concurrently, especially in the industrial design stage, was a time-consuming problem.

Because there wasn't a consistent, native CAD file that was being leveraged across the enterprise, some of American Standard's segments were at a disadvantage. When American Standard detected a late-stage, high-defect issue, the root cause analysis determined that a design modification was necessary to remedy the issue. In some parts of the company, to address this issue, engineers would need to go back to the industrial design team, open the file in a different platform, replicate the change, and then bring it back to R&D—losing out on valuable time-to-market.

Instead, American Standard connected with the Creo-using industrial designer and worked on the solution together. In this case, within an hour, design engineers were able to examine the data from manufacturing, identify the issue, determine a design solution in the latest released file stored in Windchill, PTC's out-of-the-box product lifecycle management (PLM) software. As a result, the solution was able to be put into an Engineering Change Request (ECR) so that a change notice could be processed almost instantly. With this one native CAD file being pushed throughout the business, change requests, change notices, and even the tooling modifications can be updated very quickly. In this situation, once the design engineers had the data, the design solution took one day. In other parts of the business, it takes weeks.

That's powerful— American Standard drives faster time-to-market and catches late-stage errors because they are working concurrently and agilely within the same file. This is the deciding factor in what keeps a customer happy or not. Through this Model-Based Product Development (MBPD) approach, American Standard has been able to reduce the time-to-market by a full two months, providing an important competitive advantage.

Challenges and Best Practices in Implementing the Digital Thread

Implementing the digital thread with CAD and MBD can offer significant benefits in product development and manufacturing. However, there are several common challenges and obstacles that organizations may face when trying to establish an effective digital thread:

Many organizations have legacy CAD systems and data incompatible formats. Integrating these systems with MBD tools can be challenging, requiring data conversion and migration processes. UNITE Technology and Creo Legacy Migration Extension (LMX) can help with this challenge by supporting data migration, CAD consolidation, and multi-CAD collaboration.

The growing skills gap may hinder employees from effectively using CAD and MBD tools. Training and upskilling efforts may be required to ensure that the workforce can leverage these technologies. Accelerate user skills development with Creo LEARN Online.

Inconsistent data formats, naming conventions, and standards across different CAD systems and departments can hinder data interoperability and cause data integration issues. Easily integrate and work with data from other CAD solutions with Creo Collaboration Extensions.

Sharing CAD and MBD data across departments and with external stakeholders raises concerns about data security and IP protection. Having data access controls and security measures in place is critical to combatting this. With Creo AR Design Share, easily create and securely share AR experiences.

Challenges and Best Practices in Implementing the Digital Thread

Engineers are also resistant to change. Engineers that are accustomed to traditional 2D CAD processes can be a significant obstacle. Having change management strategies and a digital thread champion at the executive level is necessary to overcoming this resistance.

Certain industries also follow certain standards. Industries with strict regulatory requirements must ensure that their digital thread implementation complies with relevant standards. GD&T Advisor can help with this challenge by applying consistent and standard compliant GD&T for all of the MBD engineers in the organization.

Maintaining high data quality is crucial as it prevents inaccurate and incomplete CAD and MBD data errors from moving downstream. By leveraging MBD in Creo Parametric, engineers can establish a single source of truth for design, manufacturing and process information.

Finally, integrating CAD and MBD data with a PLM system like Windchill is vital for a robust digital thread, but achieving seamless integration, especially when working with different solutions can be a challenging task.

Addressing these challenges and obstacles requires careful planning, a commitment to change, investment in technology and training and ongoing monitoring of digital thread processes. Organizations that can successfully overcome these challenges end up reaping the benefits of improved efficiency, reduced errors, and enhanced collaboration in the product development cycle.

Bosch: A Digital Thread Case Study

Bosch, a leading global supplier of diverse technology and services, needed to figure out a way to develop and produce products and parts faster. Addressing the challenges of collaboration, closed-looped quality, and concurrent engineering starts with building a strong PLM foundation. After identifying missing or weak aspects of the architecture, Bosch realized that they needed to develop a digital product definition. For example, in pilot project areas like power tools, they introduced the digital master and combined it with the functional view. Bosch then sees the functions and the elements connect to other functions later on.

In another instance in electronic circuit board production, a correlation was discovered between the yield and a failure picture that they had with respect to the design. They used the digital model-based representation of the circuit design and the failure feedback they got from the production line to create a correlation and learn about the limitations affected by specific design elements. Having the ability to collect and connect product data is key. This connection also includes products, machines, and their sensors, giving a complete product description. It creates a model-based enterprise that links engineering, production, supply chain and service teams through a comprehensive PLM program and the digital thread.

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Conclusion

As digital technology advances and reshapes the physical world, CAD and MBD tools play a vital role in maintaining a seamless digital thread in the product development cycle. To meet evolving customer expectations for speed and quality, organizations are adapting efficient processes that harness the power of CAD and MBD effectively. Without streamlined CAD and MBD processes, organizations are losing out on prime opportunities to enhance collaboration, advance product creation and minimize errors. The promise of CAD and MBD has been years in the making, and there has never been a better time to leverage the 3D model and the digital thread.

THE CREO ADVANTAGE:

Creo is the 3D CAD solution that helps you accelerate product innovation to build better products faster. Easy-to-learn Creo uses a model-based approach to seamlessly take you from the earliest phases of product design to manufacturing and beyond. Combining powerful, proven functionality with new technologies including generative design, real-time simulation, advanced manufacturing, IIoT and augmented reality, Creo helps you iterate faster, reduce costs and improve product quality. Creo is also available as a SaaS product, providing innovative cloud-based tools for real-time collaboration and streamlined license management and deployment. The world of product development moves quickly, and only Creo delivers the transformative tools you need to build competitive advantage and gain market share.

Please visit the PTC support page for the most up-to-date platform support and system requirements.

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