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Model-Based Definition (MBD) – Introducing Model-Based Definition in Companies

Part 2

Executive Summary

The first part of the white-paper series on Model-Based Definition (MBD) presented technological fundamentals and business potentials of MBD – an approach where a product is fully defined by an information-enriched 3D digital model

Access to "Model-Based Definition (MBD) - Replacing Technical Drawings" - Part 1 here

Part 2 of the MBD series provides insights into the introduction of MBD in manufacturing companies.

MBD offers increased efficiency and a product development toolset for state-of-the-art manufacturing systems. These potentials are among the drivers of increasing interest around MBD. However, the introduction of MBD in a company requires a clear understanding and vision for both short-term goals and an alignment with a company's long-term digitalization and PLM strategy. Distinct MBD maturity levels provide orientation in the initial road mapping process. Briefly summarized, these maturity levels are:

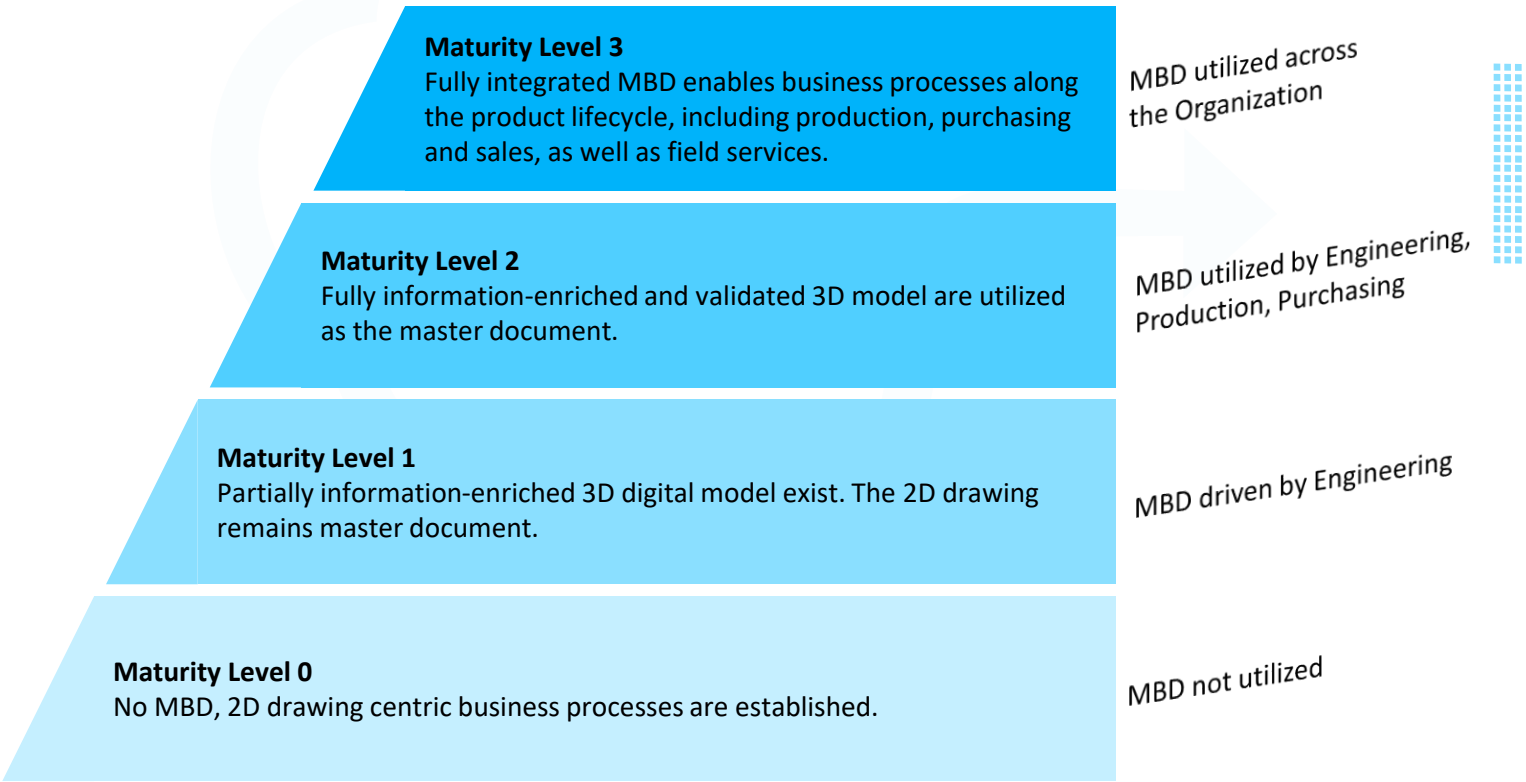


Figure 1: Top-level overview of the MBD maturity levels

While the maturity levels aid in assessing the status-quo and in the identification of areas of improvement, the implementation of MBD in companies needs to be specific to the company needs. This way, additional advantages can be unlocked on every step of implementation process. Oftentimes, a small scale pilot project in specific departments and production lines can highlight the potential of MBD while reducing disruptions along the implementation.

MBD Principles

As of today, most manufacturing companies still extensively rely on 2D drawings in product development, which contain geometric dimensions and tolerances, material specifications, manufacturing and assembly instructions, as well as other details. **MBD integrates this product-related information into the 3D digital model.** A single source of truth is created, replacing the need for additional information on technical drawings, while providing the technological foundation for complex geometries, which cannot be efficiently represented in a drawing. In turn, product developers do not need to create 2D drawings, which significantly streamlines the development process and facilitates processes of PLM, ERP and data management systems, especially for components which currently have multiple associated technical drawings. Furthermore, **MBD provides the means for automated utilization of product information,** to enable processes along the entire value chain, including efficient simulations in product development, automated manufacturing process creation and test plan creation. Looking ahead, **MBD creates the information base for digital technologies such as the digital twin,** which is of increasing importance for enabling and enhancing product's functionalities and quality. For example, MBD can enable a digital inspection of incoming goods. In such a scenario, 3D scans can be used to compare the actual geometry of components to the required geometry.

An introduction of MBD, including the impact and potentials of MBD on manufacturing companies is provided in part 1 of our white paper series.

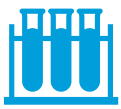
MBD leverages improved accuracy and reduced errors, enhanced communication, faster time-to-market and increased efficiency. Furthermore, it enables digital tools and services across the value chain.

While concepts of MBD have been in place for over 20 years, many companies have been hesitant to implement MBD, since MBD capabilities did not meet all requirements, thus still maintaining the need for 2D technical drawings. However, major CAD software providers have been placing a special focus on MBD, offering significantly extended functionalities such as full feature description, semantic referencing of features as well as human and machine readability. With these improved capabilities of MBD, it can now capture feature complexity to an extent which cannot be depicted in technical drawings. Neutral 3D data formats likewise support MBD functionalities to enable 3D model usage across the entire value chain and process automation based on MBD is advancing rapidly.

As a result, many organizations express interest in implementing MBD. As each company pursues highly individual goals from a distinct starting point, there is no uniform sequence of methods to unlock the potential of MBD. However, a maturity matrix, presented in the next chapter, may aid in assessing the current situation and identifying areas for improvement. The following overview further outlines the relevant steps to assess the potential of MBD for a company, analyzes the current status, and identifies the focus of the implementation with the help of the maturity matrix. Subsequently, companies gain further insights through a proof-of-concept (POC) with a small user group before deciding on the refined implementation scope.

MBD Maturity Matrix

Companies aiming to introduce MBD into their infrastructure and processes need a clear understanding of their current working methods and areas of improvement. Such awareness supports the identification of appropriate development steps. However, an effective assessment requires an appropriate comparison reference. A maturity matrix structures the various aspects of a technology and provides guidance in identifying gaps and opportunities. It consists of distinct categories, which are essential for effective technology utilization, as well as maturity levels which outline capabilities at each level. The MBD maturity matrix considers various technological aspects, such as integration of geometric information, material specifications, but likewise business and people centered categories, namely the business model and employee enablement.

	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3
Description	No MBD, 2D drawing centric business processes are established.	Partially information-enriched 3D digital model exists. The 2D drawing remains master document.	Fully information-enriched and validated 3D models are utilized as the master document.	Fully integrated MBD enables business processes along the product lifecycle, including production, purchasing and sales, as well as field services.
Integration of geometric information 	2D drawing serves as master for geometric dimensions and tolerances. 3D model aids in the creation of the drawing.	3D model is annotated with selected tolerances for improved transferability of features.	3D model contains all geometric information and is master.	A complete set of geometric information is utilized for tolerance analysis and further simulations.
Material specifications 	Material specification on 2D drawing.	3D model annotated with material type.	3D model enriched with full material properties (material grade, heat treatment, etc.).	Full integration in connected services (material lifecycle management, e.g. sustainability, recycling, storage information).
Assembly instructions 	Limited assembly instructions specified on selected drawings..	3D model annotated with basic assembly instructions (e.g. assembly order).	3D model annotated with full set of assembly instructions.	Annotated assembly instructions are machine readable for automated assembly process creation.
Manufacturing instructions 	Limited manufacturing instructions specified on selected drawings..	3D model annotated with basic manufacturing instructions (e.g. for cut or form materials).	3D model annotated with full set of manufacturing instructions.	Annotated manufacturing instructions are machine readable for automated manufacturing process creation.

	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3
Employee enablement 	No MBD awareness, working methods are centered around technical drawings.	Selected groups of employees are aware of MBD functionalities and can apply selected MBD methods.	Employees involved in product development and selected user groups along the value chain are extensively trained in MBD usage.	Utilization of MBD is a core competence for all involved user groups.
MBD related IT-services 	No related IT-services.	PLM partially supports MBD to maintain single source of truth for product specifications.	IT infrastructure supports 3D model as product master (including conversions to other formats for value chain interaction).	IT infrastructure supports full utilization of 3D model for business processes.
Value chain usage 	2D drawing is master in contracts and agreements across the value chain (suppliers and customers).	2D drawing is basis for contracts and agreements, 3D model provides specific or additional information.	3D model is master in contracts and agreements. Approved 2D drawings can be provided for specific partners.	3D model is master in contracts and agreements. 3D model is fully integrated in the legal framework.
Business models 	No related business models.	No related business models.	MBD business model centered around product development (assisted tolerance or manufacturing specifications, reuse of features).	MBD is tied to the overall business model, 3D master enables digital twin, business processes along the value chain utilize machine readable MBD.
Regulatory Compliance 	Product documentation requirements, are addressed through a set of documents, including 2D drawings.	2D drawing remains master for product compliance, information enriched 3D model supports its creation.	3D digital model provides foundation for regulatory compliance, additional documents may be required.	All documents and processes for regulatory compliance are fully derived from the 3D digital model.

MBD maturity levels can provide direction for companies striving to implement new technologies. They structure the extent of implementation and can showcase gaps to leverage the potential of technologies. However, maturity levels do not provide a sequential path for the introduction of new systems and methods. Especially obtaining the highest maturity level in all categories is not feasible for a company, if the relevant infrastructure does not support automated processes. Instead, it is often advantageous to focus on specific business processes, thus utilizing MBD more extensively in some areas than others. Consequently, an MBD maturity matrix is not a standalone tool but should be used as a sub-step of the roadmap to introduce MBD.

MBD maturity levels provide an overview of the various aspects of MBD an the degree of implementation. Combined with a status-quo analysis, they provide insights into areas of improvement

Roadmap for MBD introduction

The complete roadmap for MBD introduction is highly dependent on the company, scope of the MBD implementation, and the system architecture. It is refined within the initial scoping phase and updated after each milestone. While the roadmap is highly individual, there are recurring phases of an MBD introduction.

1. Awareness: MBD capabilities are evolving rapidly. Many former limitations of MBD, such insufficient support of neutral data formats, have been addressed in the previous years. Therefore, awareness of state-of-the-art capabilities of MBD is important for a preliminary estimation of opportunities.

2. Vision: Introduction of MBD in companies may affect the working methods of engineers in product development but likewise employees across the entire value chain. While MBD opens new opportunities to improve collaboration, productivity and quality, the MBD introduction is challenging. A clear vision for the digitalized working methods in product development and downstream departments provides the foundation for the introduction of MBD. The general vision for digitalized working methods includes major goals and opportunities of an MBD introduction.

3. Current Status: Before determining detailed usage scenarios for MBD, the current working methods and processes are examined. A status quo analysis is conducted, with the focus on major processes in product development, production, IT-services, and further related departments (e.g. logistics, quality control, purchasing). The aim is to determine how product related information is currently produced, utilized, and shared. Key users from different departments offer their perspective on daily activities, challenges, and limitations.

4. Goals: Based on the vision for MBD and the current situation, a refined set of goals is formulated. The MBD maturity matrix, more detailed usage scenarios and a risk analysis aid in specifying the extent of an MBD implementation. A timeline for different implementation stages is likewise specified.

5. Proof-of-concept (POC): The options of using MBD are tested through a proof-of-concept implementation. With limited scope, disruptions of regular work activities remain small, while further experiences with MBD can be collected. Extensive feedback is collected from the participants in the POC to determine strengths and weaknesses.

6. Further considerations: Before expansion of the MBD usage, additional limitations and requirements are analyzed. These include questions regarding the integration of MBD across the value chain, especially processes that affect suppliers or external partners. Legal aspects of MBD need to be considered as well, to ensure that the implications of MBD are reflected in contracts.

7. Implementation Decision: Options for an MBD implementation including work packages are refined based on the previous findings. Upon deciding on an implementation strategy, work packages are further detailed and implementation starts.

8. Business Process Development: New and optimized working methods and processes are defined, which ensure that MBD is utilized to the full potential. This includes the refinement of user roles to facilitate role specific information flow of product information. While all information are usually displayed on 2D technical drawings, MBD can reduce the information load for many users, as just the relevant information are depicted.

9. Employee enablement: While previous steps have focused on key users or a small user group as part of the POC, the company-wide usage of MBD requires extensive training for many employees. Therefore, a training program is defined to ensure that employees can utilize MBD functions to the full extent. Alongside, new working methods and processes are defined, ensuring role specific information flow of product information.

These steps provide a structured path to introduce MBD in companies. The approach ensures that MBD is aligned with further digitalization initiatives and is oriented on the actual working methods of employees.

The introduction of MBD does not need to place stain on an entire company. A step by step process, involving awareness, a scoping phase, and a proof-of-concept phase eases the introduction while showcasing the advantages of MBD.

Looking ahead: Taking full advantage of MBD as a Model-Based Enterprise

When implemented to its full extent, MDB enables processes and drives services across the entire enterprise. Within product development, fully defined digital models enhance the capabilities of simulations and optimization. Purchasing and sales benefit from accelerated cost estimation and improved communication. Quality engineers can directly map the measured values of components to the required ones and store component specific values in the system. Production planners can rapidly compare product requirements to production machine capabilities to identify optimized production flows. Likewise, the live connection of fully defined digital models to production machines and processes facilitates setup and prevents the usage of outdated information. Customer services and field support can likewise quickly compare the actual product condition to the master model to identify failures and provide precise feedback to design engineers regarding options for future improvement. Especially the utilization of digital twins is boosted with fully defined digital models, enabling services such as prescriptive and adaptive maintenance or distinct business models. At this level of MBD utilization, a company can be considered a model-based enterprise. While this outlook shows the extent to which tools, working methods and services across a company can be affected by MBD, the gradual step-by-step implementation offers a set of new opportunities and improvements at each stage of the implementation.

A Model-Based Enterprise describes a company, which utilizes the opportunities of MBD across all departments and for a multitude of different processes and services.

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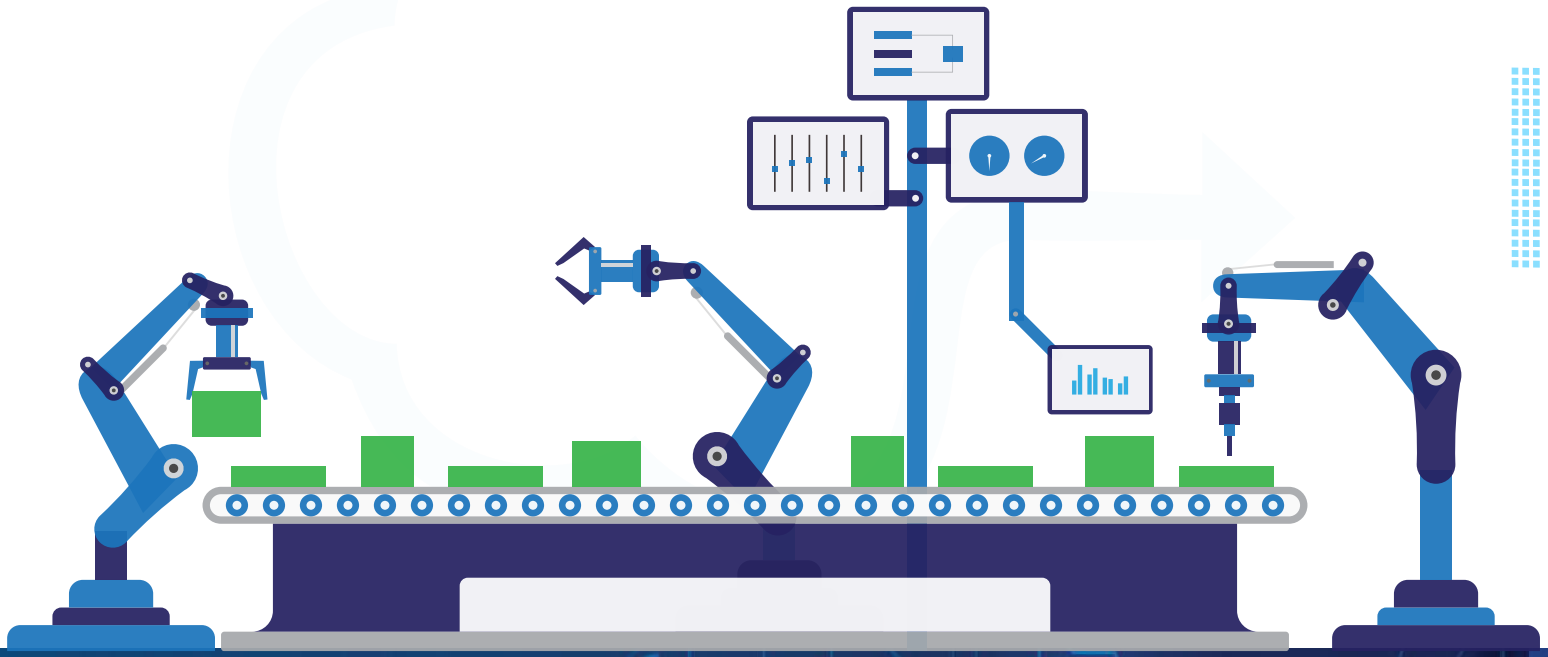

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DxP Services is an ITC Infotech specialized business unit focused on the implementation and adoption of PTC's industry-leading Windchill®, Product Lifecycle Management (PLM) software, as well as Cloud and Windchill+® SaaS offerings. Created through the acquisition of PTC's PLM implementation services division, DxP Services is the largest global PTC PLM ecosystem. The combination of PTC Heritage and ITC Infotech Power means that DxP Services is uniquely positioned to help accelerate customers' digital transformation initiatives.

Our portfolio of services augments value at every step of Modern Industrial Evolution; covering Consulting, Implementation, Deployment, and Migration. DxP Services' team of PLM Professionals are trusted advisors to our Customers during their Digital Transformation.

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