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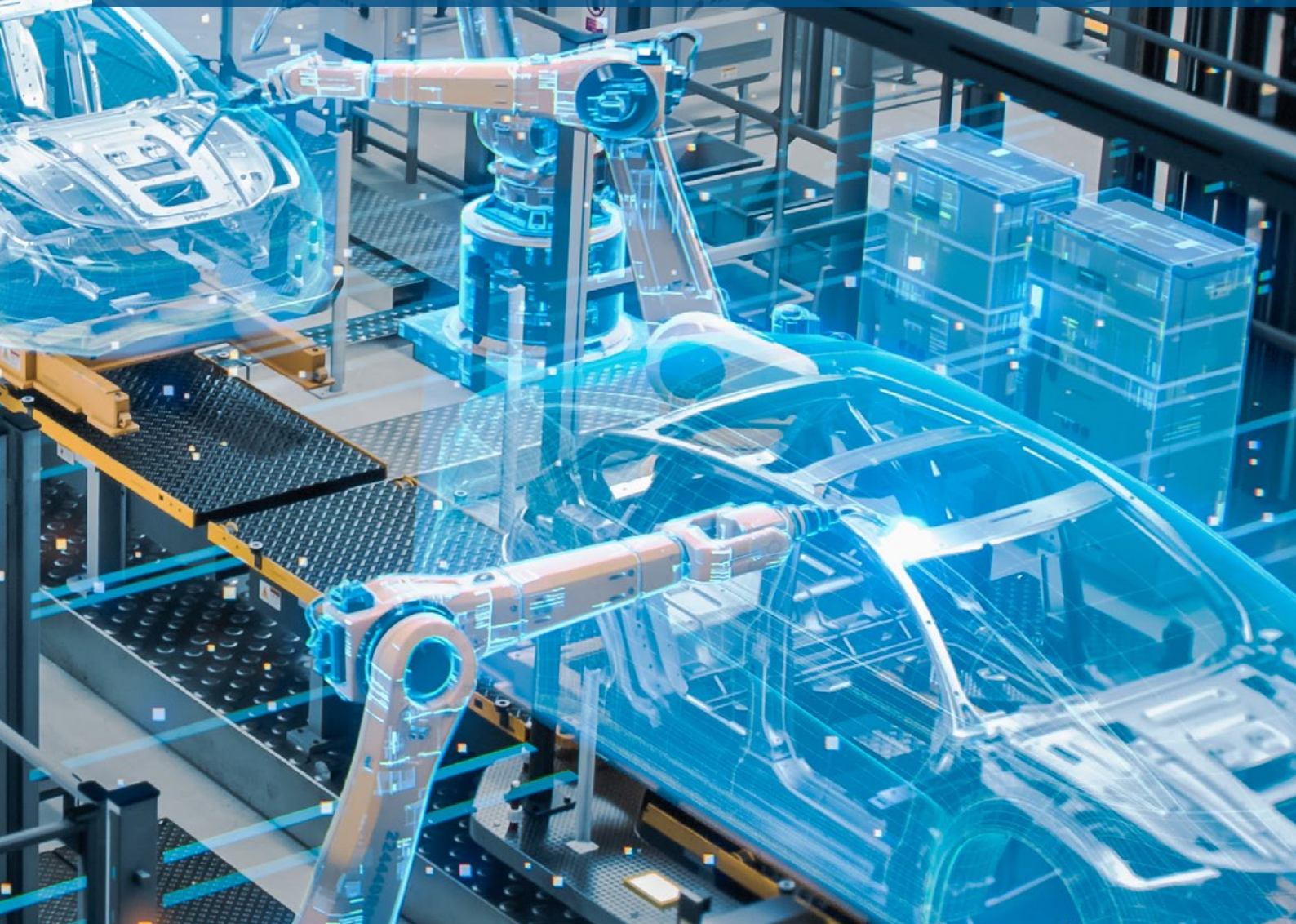
WHITEPAPER

END-TO-END DIGITALIZATION BETWEEN PRODUCT DEVELOPMENT AND PRODUCTION

In order to make production processes more flexible and control them more efficiently, IT systems for manufacturing process planning must be seamlessly integrated into the digital information flows between the PDM/PLM and ERP worlds. This white paper explains how the digital thread can be spun from product development through manufacturing process planning to production.



Production planners caught between two stools

End-to-end digitalization between product development and production forms the basis for making production processes more flexible, ramping up production lines faster and controlling the entire production process more intelligently. This requires better integration of manufacturing process management (MPM) and production planning and control (PPC) in the digital information flows of product development and production. Production planners act as an interface or, perhaps more accurately, as a mediator between both domains. But in terms of IT, they are usually caught between the two stools of the PDM/PLM world, which specifies WHAT is to be produced, and the ERP world, which specifies WHEN. With MPM and PPS, however, it is primarily a matter of HOW.

In business dictionaries, production planning and control is generally understood to be responsible for ensuring the cost-effective design and smooth running of production processes. Production planners determine what products are to be manufactured in what quantities during the planning period, what initial and intermediate products have to be produced or procured for this purpose and what lot sizes are needed, when this is to take place and what personnel and machine capacities are required. They also decide what production orders are to be released when and in what sequence they are to be processed.

Among other things, production planners transform the basic product structure of the engineering bill of materials (EBOM) into the manufacturing bill of materials (MBOM) containing the work specifications. The MBOM then serves as the basis for the work plans and production orders. But this is still largely a manual process because the information from the other domains is not available to them in a digital form. As a result, changes are difficult to track and involve a great deal of time and effort.

Unlike product development and production, where PDM/PLM and ERP systems have been established for many years and are nowadays often relatively well integrated, the end-to-end digitalization of planning and control activities has been treated like an afterthought. In industries such as mechanical and plant engineering or shipbuilding, MPM processes are supported by IT tools, but not end-to-end and not integrated with other enterprise applications. Data and documents are stored in Excel, mail programs and/or tools developed in house. But many companies have now recognized the need for action and are introducing appropriate solutions. Some PDM/PLM vendors are therefore trying to meet this need with integrated MPM modules.

In this white paper, the authors explain why companies do not necessarily have to opt for a monolithic approach or for the use of PLM or ERP systems. Depending on their requirements, they can use a separate solution such as an MES system for PPS or MPM. The OpenPDM integration platform allows such a system to be integrated in the existing IT landscape to such an extent that BOMs and other manufacturing information can be exchanged easily and synchronized in the event of changes.

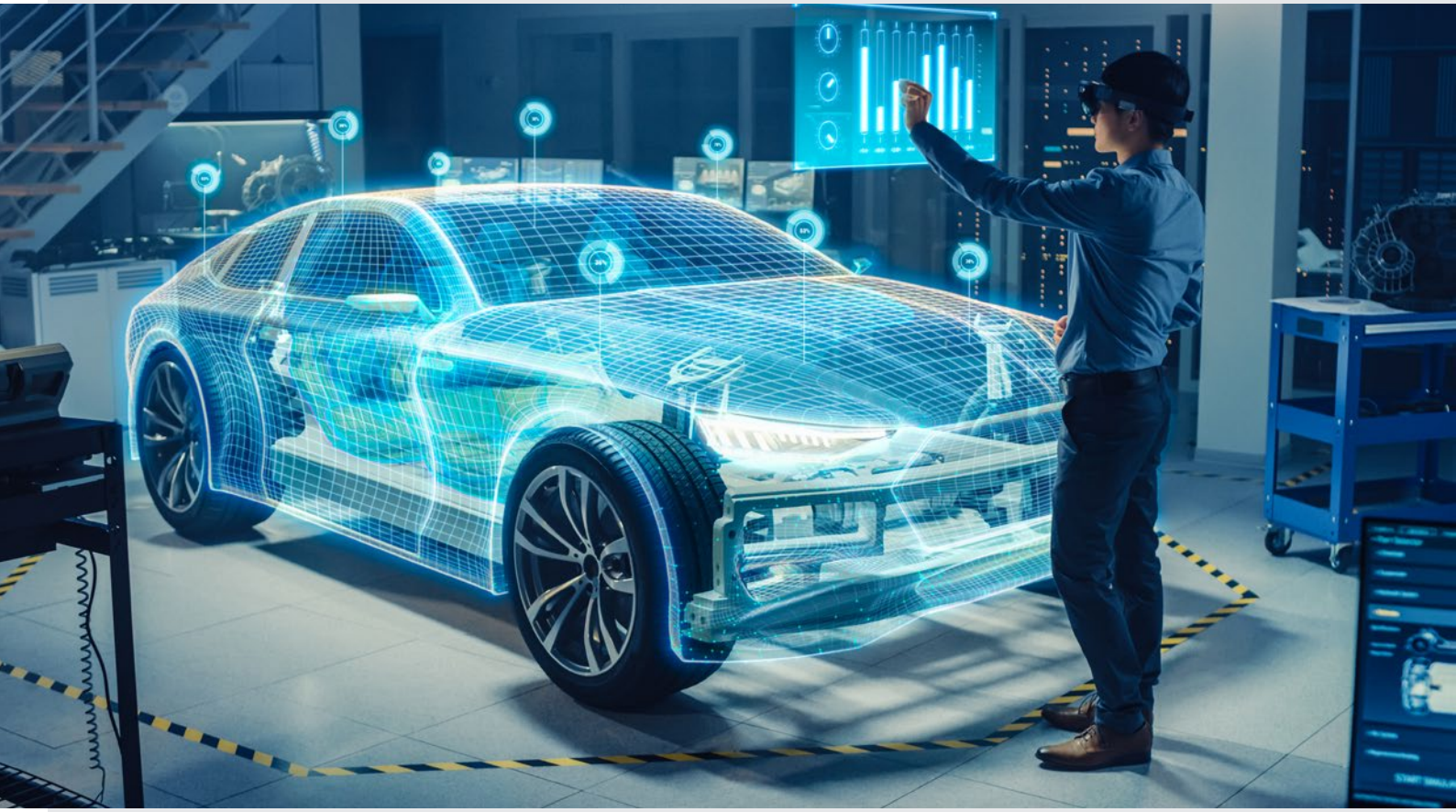
More sophisticated MPM processes

Production planners work with a variety of different tools that are not integrated or only integrated in a rudimentary sense, and which do not provide end-to-end support for the MPM process. In many companies, they still derive the MBOM from the EBOM in a manual transfer and translation process, which is very labor-intensive, especially when changes are made, and limits their ability to respond to new product requirements or customer requests. From the perspective of those responsible for the process, the lack of dovetailing between product development and production hinders the efficient design of processes and a flexible response to necessary changes.

Users in the fields of PPS and MPM are increasingly calling for tools specific to their requirements and that support all processes from end to end. Their requirements, as well as the company's demands for a federated and adaptable IT architecture, speak against the use of a monolithic solution from a single vendor. All the more so as data must be kept synchronized between different tools:

- CAD documents and bills of materials (EBOMs) from a PDM system that acts as the central engineering database
- Information from the ERP system, the central resource and materials management system for procurement, purchasing, production and logistics, in which manufacturing and procurement orders are issued
- The MPP application, in which the various engineering and production bills of materials are prepared, processes and tools are simulated, and the tool and jig data is prepared for transfer to the catalog systems in production

From the perspective of the production planners, requirements are becoming more demanding to the extent that production processes need to be made more flexible. Currently, many companies combine series production of easily configurable products (CTO or "configure to order" process) with make-to-order production of customized products (ETO or "engineering to order" process). Production planners therefore have to plan and control two different product lines.



Production planning in series manufacturing

The basic objective in series production is to manufacture a large quantity of products as efficiently as possible. Production planning starts with the first prototype from the design engineering department before the production order is issued and refines work plans, processes and tools and, if necessary, the layout of the production line until everything is ready for series production.

To form the basis for the MBOM of each product variant, production planners receive a concrete product configuration in the form of a 100-percent EBOM from the product development department, whereas developers usually map their variants in a 150-percent EBOM. Because MBOMs are broken down to the level of individual parts, planners find it difficult to assess the impact of changes in the EBOM on the MBOMs of different variants without studying the change notifications.

When creating the MBOM, production planners create the assemblies that follow the production process and assign the corresponding components to them. They also add materials, colors, screws and other information to it that was not defined in the engineering model. The MBOM forms the basis for materials control and process planning. Process planners define the manufacturing and assembly methods to be used and optimize them using simulation tools for ergonomics and work time analyses. They also commission the design and construction of the necessary tools and operating equipment.

When changes are made to the EBOM as a result of further development or optimizations of the product, production and process planners must adapt their work plans and designs, as must toolmakers and jig builders. Any new assembly concept is likely to result in changes to methods and jigs. If they are to be able to evaluate and implement these changes as easily as possible without having to start from scratch each time, those involved need to know where the EBOM has changed. Currently, they will find the information about changes in the engineering change request and will usually transfer it manually to the MPM or ERP system.

End-to-end digitalization from design engineering to production, process planning and the construction of tools and jigs would save the design engineer from having to create additional documents to explain the changes and the production planner from manually transferring the information to MPM, a process that is susceptible to errors. Furthermore, it would avoid downstream errors in process planning and jig design resulting from incomplete or incorrect data synchronization. To achieve this, any change to the EBOM would have to be automatically transferred to MPM and synchronized with the MBOM after approval by the design engineering department.

Production planning in make-to-order operations

In make-to-order manufacturing of custom products, meeting the delivery date is the top priority. Production planning usually has to start before the design is complete in order to meet the contractually guaranteed delivery date. It is divided into two phases: rough planning, based on the project plan and without detailed information from design engineering, and detailed planning, which begins after the order is issued and determines the production orders and their timing within the production process. In this respect, it coincides with production control. Production is usually structured flexibly in order to be able to cover the expected range of potential customer requirements.

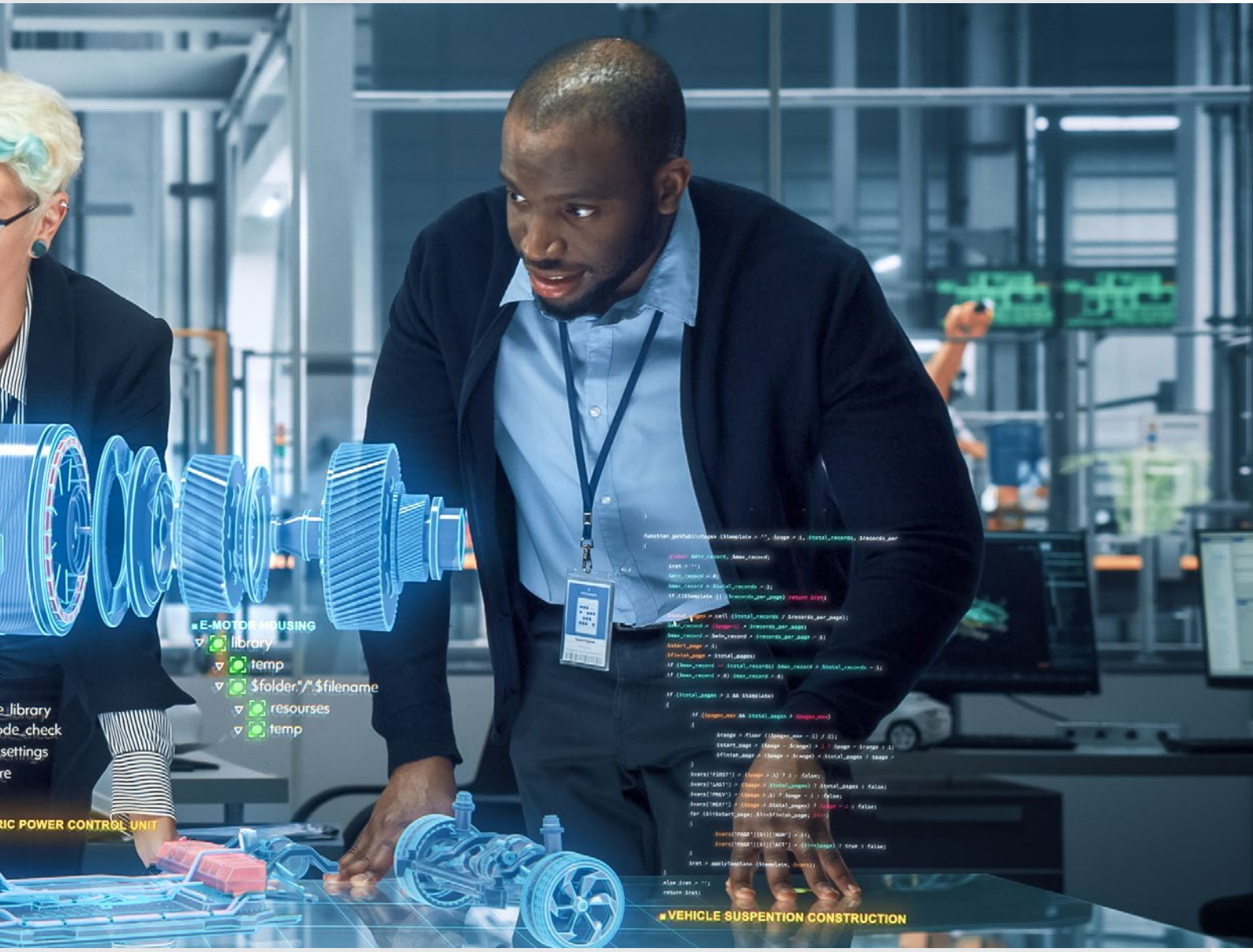
Unlike series manufacturing, production planners in make-to-order production do not normally scrutinize the factory layout or the basic manufacturing and assembly processes. Process planning is strategically organized independently of the orders. This makes it easier to convert the EBOM into the MBOM, because planners can rely on predefined process logic. On the other hand, they need additional information from the EBOM in order to be able to calculate the outlay on the basis of the specified production processes and methods.

Production planning receives updates to the EBOM from design engineering on an ongoing basis, but these cannot be manually reflected in MPM or the MBOM with an acceptable amount of time and effort. The MBOM is geared to the required production stations and is put into a chronological sequence (e.g., production cycles) by defining production orders. Detailed scheduling enables adjustments to be made to the

MBOM in order to be able to react flexibly in production and, for example, to change production sequences in order to meet delivery deadlines. The production plan, i.e. the production orders and work plans, is derived directly from the detailed MBOM.

Nowadays, the production planner regularly creates a new production plan, i.e. usually on a weekly basis, and adjusts the work already done in production instead of changing the production orders that have already been defined. If the changes to the EBOM were synchronized with the production planner's MPM system, the production planner could actively decide whether a production order and associated work plan can still be changed or whether correcting the changed design requires more effort. At the same time, this would provide greater transparency with regard to adherence to schedules.

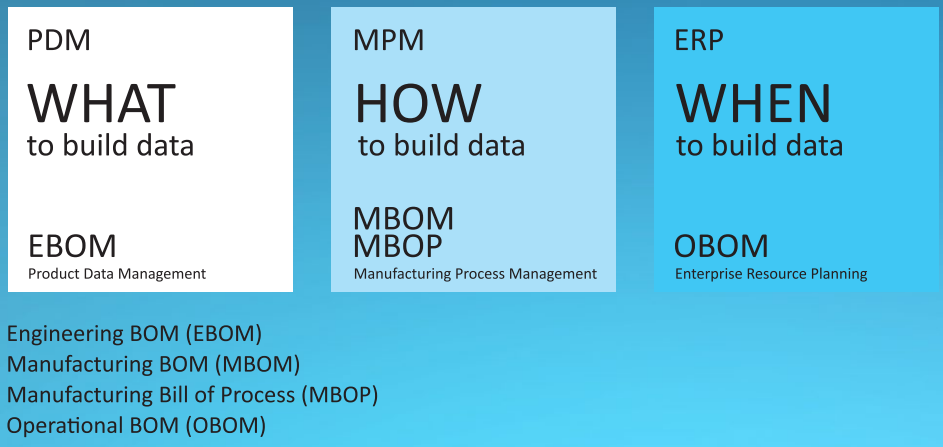
Ideally, end-to-end digitalization would also involve control systems such as MES systems in order to provide production planners with feedback from production on the status of production orders that have already been created. This information could be passed as an additional attribute of a structural element in the MBOM or of the parts.



Integration of production planning in the world of PDM/PLM and ERP

As outlined earlier, end-to-end digitalization from design engineering to product planning through to resource management, including production planning, is indispensable. In the following, we will show how production planning can be integrated in the digital thread of the entire product lifecycle using optimally matched tools. In this context, it is in no way necessary or sensible for production planning to be limited to systems that are already being used in companies. Instead, in order to maximize the potential of production planning, the best-of-breed approach should be used to integrate software that is fully tailored to requirements in the existing system landscape.

Production planning consumes information that is already available from product data management (PDM) such as bills of materials (EBOMs) or CAD information describing the WHAT. Production planners use this information to create MBOMs and manufacturing bills of processes (MBOPs), which define the HOW. In turn, these form the basis for the WHEN in subsequent production, which is specified by the operational bill of materials (OBOM) and by procurement – supported by the ERP system.



Engineering BOM (EBOM)
Manufacturing BOM (MBOM)
Manufacturing Bill of Process (MBOP)
Operational BOM (OBOM)

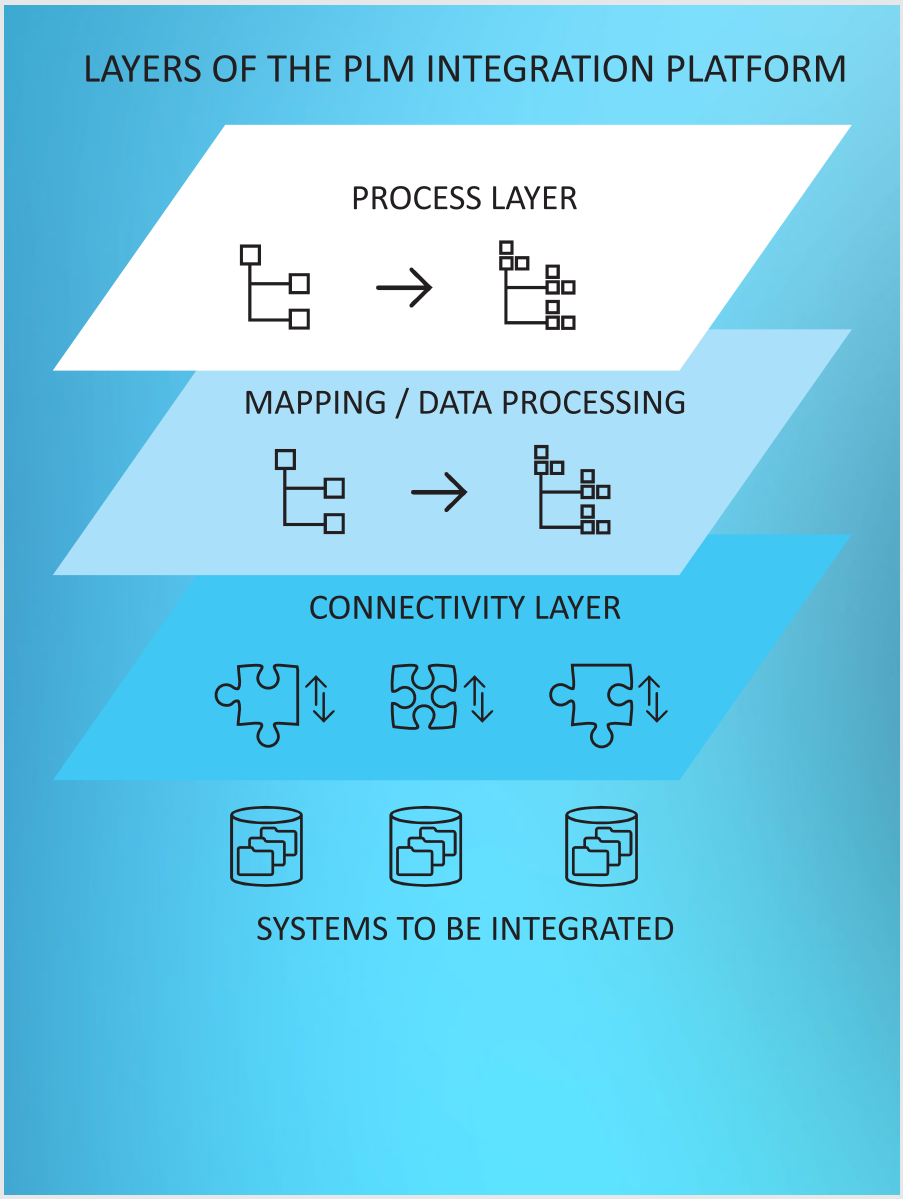
To ensure end-to-end digitalization, production planning must be integrated in the process and information flows at two points: On the one hand as a consumer of information from the world of PDM, and on the other hand as a producer of information for the world of ERP. It is necessary that the information does not only flow in one direction. Instead, change processes in the direction of product development must also be supported to promote continuous improvement.

The foundation for production planning with an MPM system is formed by the results from design engineering or the current status of the PDM information. To do their work, production planners need product information such as the metadata and structural data of a component alongside the geometric information. PLM integration platforms such as OpenPDM are available to allow this information to be exchanged between the different PLM domains and keep it consistent.

OpenPDM supports the transfer of information between PDM, MPP and ERP systems at different layers. At the lowest layer, the software enables access to the connected systems via connectors that can read and write product-specific information in compliance with the PLM paradigm. These connectors make use of concepts such as the part master, revisions and the lifecycle status and are able to use a method call to easily read and write both 150-percent and 100-percent BOMs, so that no product information is lost.

At the second layer, OpenPDM supports the seamless integration of production planning in the enterprise digital thread by mapping data schemas between the applications involved. Special data models ensure optimum processing of the information in specialized applications such as PDM or MPM systems. Therefore, when moving product information from the PDM domain to the MPM domain, the PDM information must be transferred to the MPM data model consistently and without loss. The OpenPDM mapping service supports integration with predefined and customizable mappings.

At the topmost layer, OpenPDM supports integration using an intuitive process engine that defines the triggers and workflows. PLM is a well-defined methodology for creating and managing products. Its key elements are version information and lifecycle information. This information describes the status of the product data and thus forms the basis for any collaboration. Consequently, it is also used as the basis for setting triggers to initiate an exchange of information within the framework of the integration between the PDM and MPM domains.



On the one hand, the process layer controls the actual exchange of data and, on the other, links cross-system processes such as change management, in which case the information is exchanged by synchronizing the EBOM information between the PDM and MPM systems. As a rule, the EBOM and all its structural information is passed during the initial transfer. If the design of a product is geared towards production, the structure of the EBOM can serve as an ideal starting point when creating the MBOM. Since the production planners inevitably change the structure of the MBOM, only the part information and geometries are exchanged and updated during subsequent synchronization processes. This allows the EBOM and MBOM to be maintained in two different systems while still ensuring that the parts information is up-to-date at all times. In the same way, OpenPDM synchronizes information between the MPM and ERP systems to provide end-to-end support for control and planning processes.

Cross-system synchronization of change processes

As part of the processes typically involved in make-to-order production, information is usually updated as a result of adaptations, improvements and further development of the product ordered. These changes are subsequently reflected in production planning to allow the product to be manufactured. This means that integration between the domains and systems is largely unidirectional: from product data management towards production planning.

In series production, on the other hand, the aim of the change processes is not only to improve the product but also to optimize the production steps and systems. The design of the product is optimized and these changes are transferred to production planning, whereupon production planning is adapted accordingly. Optimization in the production process may require changes to the product design to enable more efficient production. As a result, the integration between product data management and production planning is cyclical.

In this cycle, changes or change requests in one domain have a direct impact on other domains. Since there are clear responsibilities with regard to the ownership of information in an end-to-end PLM process, the domains may only change the data over which they have sovereign ownership. However, the changes must be communicated and coordinated transparently across domain boundaries. This is achieved with cross-domain change management, and this is also handled by the process functions of the integration platform.

All modern software systems offer the option of managing changes and linking them internally to the relevant information. If the changes affect information that lies outside the system, this information must be linked using the integration platform. To do this, OpenPDM extracts all the information relevant to a change, together with the product data linked to it, from the system that triggers the change and uses this information to create new change objects in the systems of the affected domains. The information remains linked to the change that triggered the process.

This means that each planner has all the relevant information about a change that affects them available in their system environment. They do not have to obtain additional information from other systems to process the change. It goes without saying that lifecycle information about the change itself is also synchronized between the systems, so that everyone involved is always informed about the status of the changes in other systems and domains.

The OpenPDM integration platform thus makes it possible to provide production planning with up-to-date and consistent product information. This means that production planners can always access up-to-date information for their day-to-day work and decisions in their MPM system without having to laboriously obtain it by mail or in Excel spreadsheets, as was previously the case. Necessary changes are also recorded and processed with system support and synchronized between the participants without any loss of information.

Summary

Production planners work with a variety of different tools that are not integrated or only integrated in a rudimentary sense. From the perspective of those responsible for the process, the lack of dovetailing between product development and production hinders the efficient design of processes and a flexible response to necessary changes. The demands being made on production planners are becoming more challenging to the extent that production processes need to be made more flexible. Currently, many companies combine series production of easily configurable products with make-to-order production of customized products.

If both CTO and ETO processes are to be made more flexible and controlled more efficiently, MPM and PPS have to be seamlessly integrated in the digital information flows between product development and production. This does not mean that companies inevitably have to use existing PDM/PLM and ERP systems for planning and control tasks. Depending on requirements, production planners can also use a separate solution such as an MES system. However, they must be able to exchange bills of materials and other manufacturing information with PDM/PLM and ERP systems without loss and keep them synchronized throughout the process.

PROSTEP's OpenPDM integration platform enables companies to integrate their existing PDM/PLM and ERP solutions with MPM systems to ensure end-to-end digitalization from product development to production planning through to production, thus achieving a closed information loop. The platform not only enables read and write access to the connected systems, but also mapping of the different data schemas. This in particular simplifies synchronization between the EBOM and MBOM. It also has a powerful process engine to automate the exchange processes and control cross-system processes such as change management.

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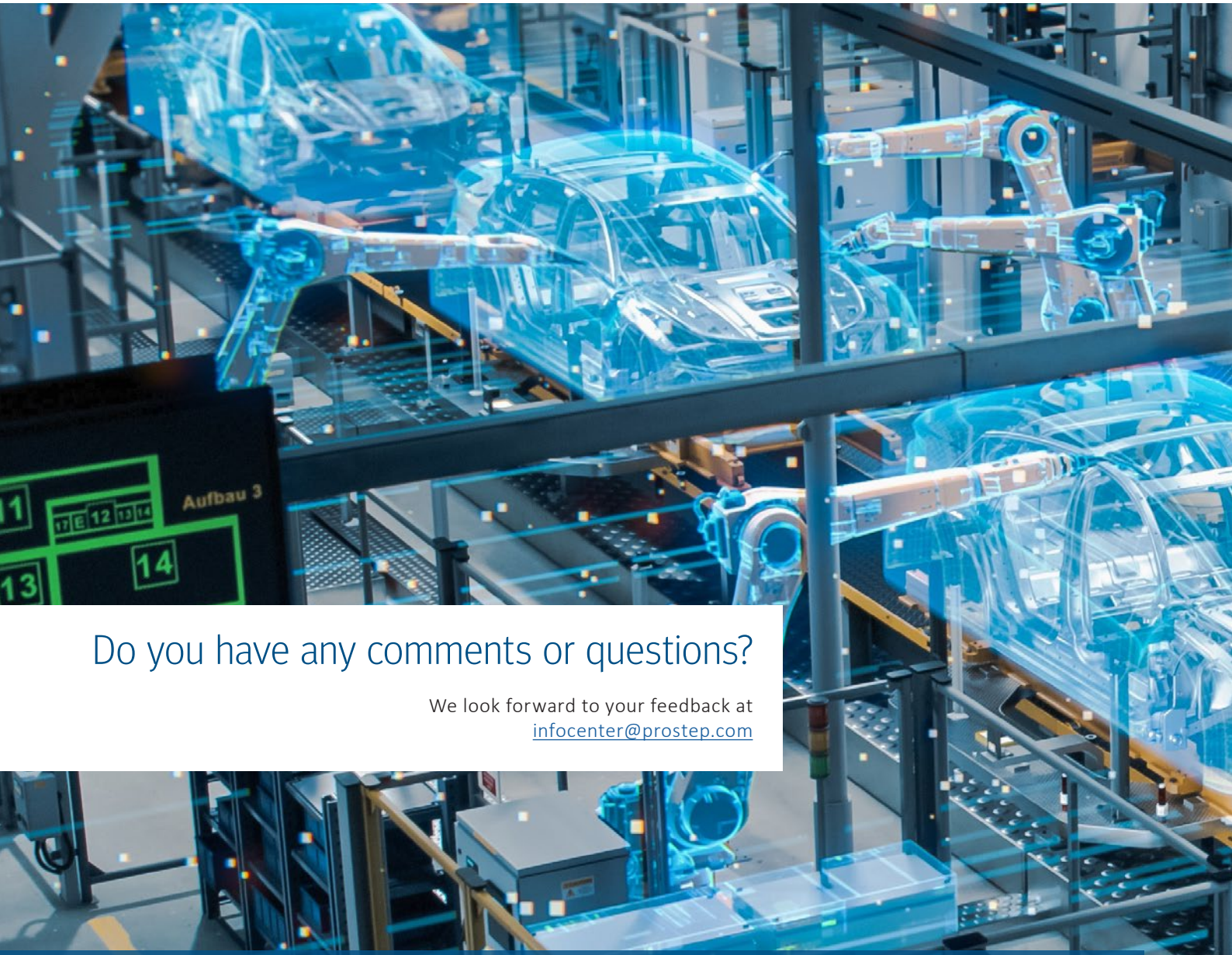

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