Enabling Digital Transformation through a Collaborative Approach Between Design and Manufacturing

Today's product offerings include a growing number of parts that incorporate mechanical, electronic and software components. As innovation accelerates and complexity surges, manufacturing is becoming more complicated.

Effective collaboration between those in Engineering and Manufacturing is a critical step to remaining competitive in the era of Industrie 4.0 and the Internet of Things (IoT). While product lifecycle management begins with engineers, it's a team effort:

- Product Development/Design Engineers determine what to build
- Manufacturing Engineers determine how to build it
- Production Engineers determine where and when to build it

Success hinges on Manufacturing's ability to streamline processes and stay aligned with Engineering and other downstream teams. To become fully agile, a seamless flow of information must exist between the teams designing and developing products, and the teams planning for the manufacture of the products. That means Manufacturing needs to easily access the most up-to-date product information in a timely fashion… even as it changes.

This paper explores how organizations can enable this flow by embracing a scalable, comprehensive BOM strategy enabled by the right PLM system. With this in place, they can capture, configure and manage product and process information during every step of the product lifecycle in the form of a complete digital product definition. Just as important, a part-centric approach and the right PLM system make it possible to easily propagate changes from Product Design to Product Manufacturing because of associativity. In fact, a holistic product definition that goes beyond digital drawings enables numerous advantages. It helps to effectively optimize key manufacturing processes, identify problems earlier in the manufacturing process, and enhance product quality by eliminating mistakes associated with duplicate or incomplete data.

> To support innovation and the rapidly changing information created during the product development process, organizations need visual, digital, integral and associative manufacturing capabilities.

The Growing Complexity of Product Manufacturing

At its simplest, the manufacturing process involves fabricating parts, assembling final products, and performing inspection. However, the manufacturing process is complex because it must satisfy three sets of distinct requirements: those of customers, the market, and the company.

- Customers are requesting greater product variety and capabilities, leading to more complex products. This in turn drives the need for additional planning around how a product gets manufactured.
- Market demands dramatically impact manufacturing operations. As new markets open up and companies expand their manufacturing operations to new locations and new countries, production planning must account for multiple plants, skills, machines, processes, and potentially multiple ERP systems controlling production.
- Corporate demands, like reducing manufacturing costs, faster throughput and ramp-up, and sustainability continue to be a factor for many manufacturers. Yet lowering costs while trying to open new facilities and handle new, complex products can put stress on quality.

Complicating matters is the common set of challenges many companies face when trying to establish better manufacturing planning processes.

In a typical manufacturing environment, Product Design/Engineering and Process Planning/Manufacturing operate almost independently. This can lead to disconnected teams that:

Use different systems to do their work.

Product Design/Engineering usually uses PLM systems to manage the digital product in the form of an Engineering Bill of Materials (EBOM). Process Planning/Manufacturing often relies on ERP systems for Manufacturing Bill of Material (MBOMs) along with the processes and elements associated with the physical product. This includes materials, inventory and parts and supplier sourcing.

Manage data differently.

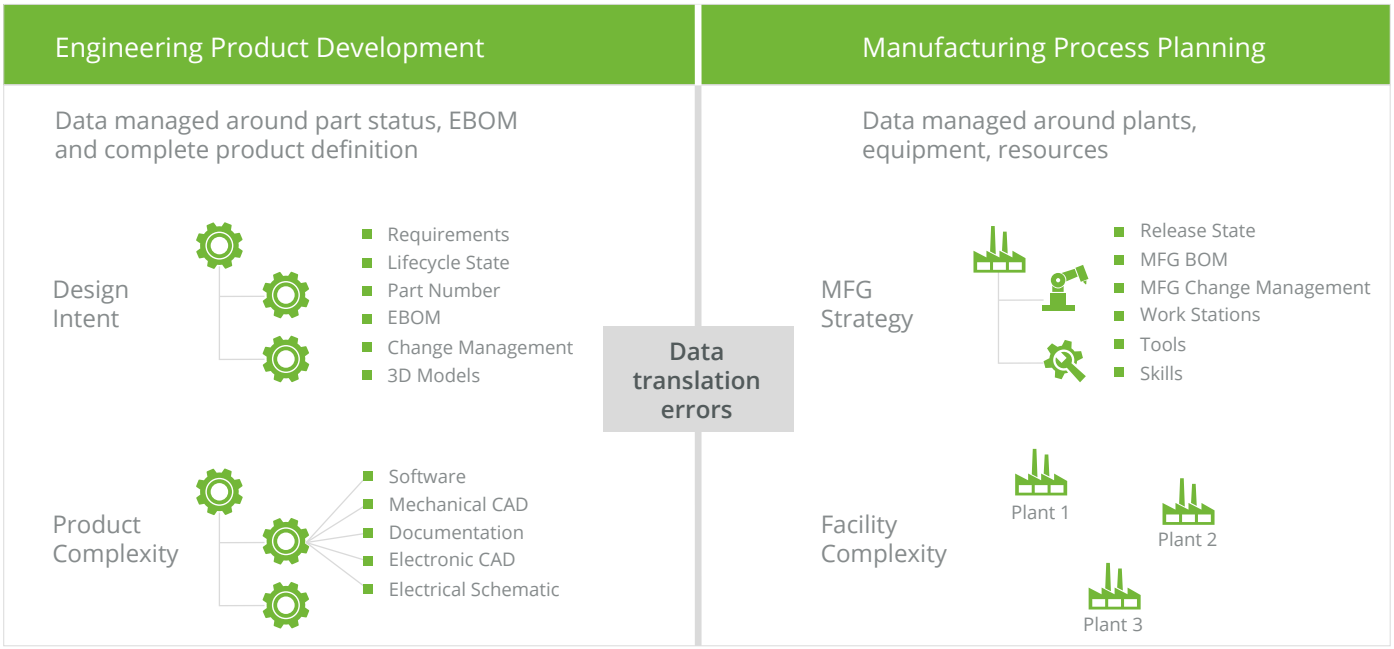
Product Design/Engineering is focused on developing the product design and on "design intent." To that end, they organize data based on product function (i.e., mechanical, engineering and software). Their product definition captures this complexity in the form of information around lifecycle state, part number, engineering bill of materials, 3D models, product structures, etc.

Manufacturing, on the other hand, is focused on the manufacturing strategy and how the product will get produced. They work with a definition of the product that includes the manufacturing release state, manufacturing BOM, workstations, tools, resources, and skills. This group also must deal with the complexity of manufacturing across multiple facilities, and different equipment, processes, and resources from plant to plant and line to line within a plant.

Rely on different data models.

Product Design/Engineering data models are set up to manage CAD and product structure information. Product design teams often spend a tremendous amount of time creating lots of valuable information including 3D models, machine steps and tool information, and model-based definitions.

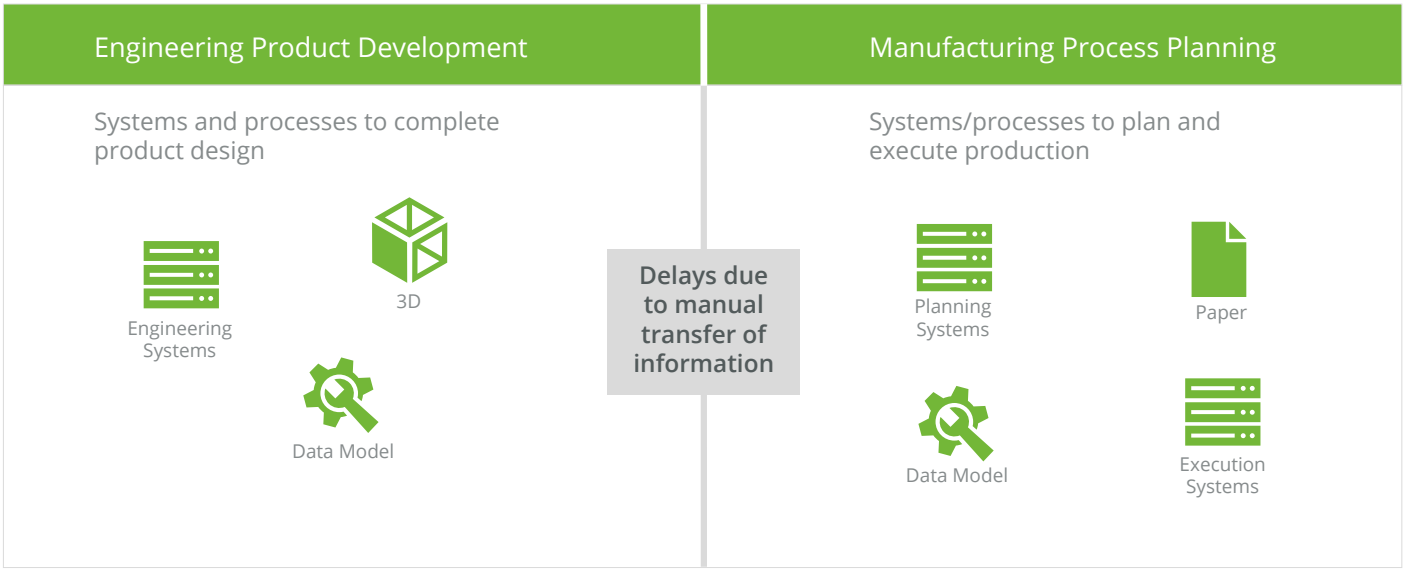
Manufacturing planning data models are set up for plant organization, workstation and tool definition, resources, and other manufacturing-related processes. Few manufacturing planning organizations are able to capitalize on all the work Engineering undertakes to produce lots of data by seamlessly incorporating that information into their production plans. Oftentimes production plans are organized in spreadsheets, requiring the manufacturing group to enter engineering data manually.



Engineering and Manufacturing have different data needs

The differences often result in a "wall" between groups. This barrier can lead to:

- Delays in dealing with product updates and changes.
- Manual updates between groups to keep information and systems in sync.
- Delays in the manufacturing planning process as Manufacturing waits until the design is finished before they can organize and translate data into the forms and systems needed for manufacturing planning.



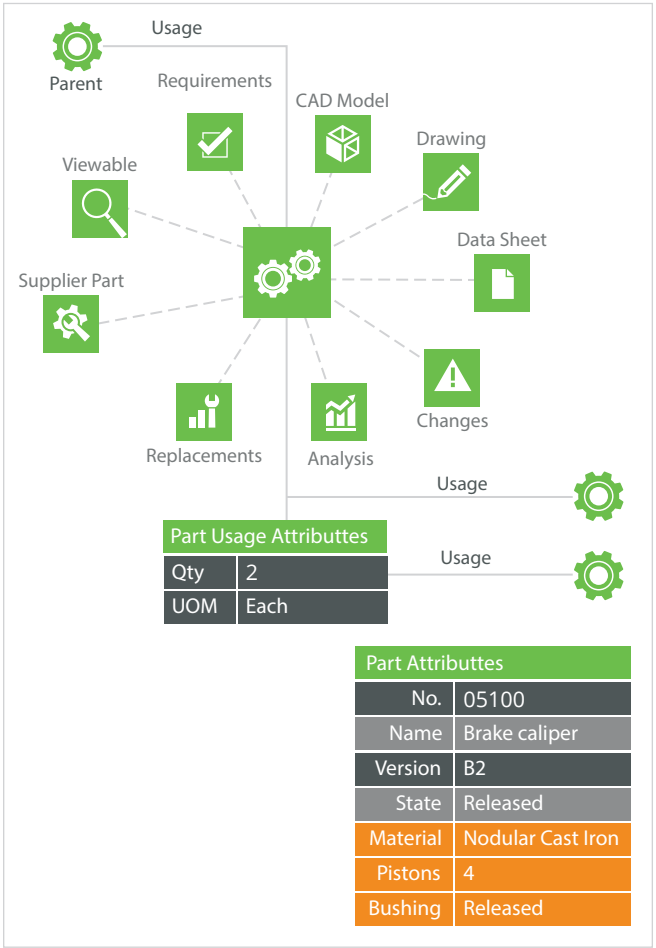
Engineering and Manufacturing rely on different systems to do their work

The problem of disconnected BOMs

Without real-time access to the most up-to-date design data, Manufacturing ends up reworking assemblies and products, duplicating efforts, expediting materials, and incurring project delays.

Embrace a Part-Centric Product Development Approach

In order to achieve a competitive advantage, organizations need Engineering and Manufacturing working together to turn virtual designs into physical products. Simply put, Manufacturing needs to be integrated into the product development process as an active participant rather than one that reacts to engineering designs. The ideal is for manufacturing processes, quality plans and work instructions to be defined and delivered digitally.



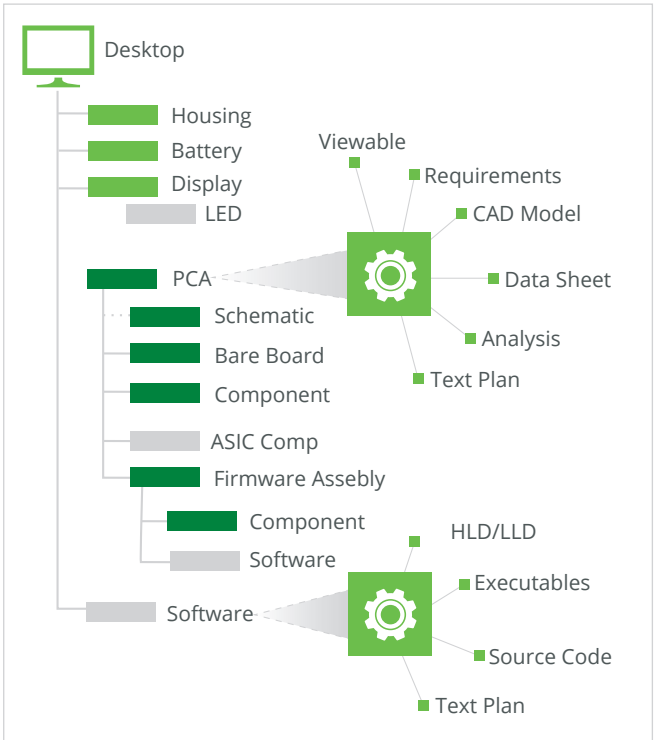
A complete product definition makes it easy to find and access all related information

Manufacturing teams must be able to access and reuse engineering data through the EBOM to create a connected but separate multiple-plant-specific MBOM and work instructions.

The first step to taking a part-centric product development approach is integrating product data, including that related to CAD and PLM, in a single repository. Another way to describe this is a multi-dimensional BOM.

Develop a multi-dimensional BOM

With a single source for CAD and PLM data, organizations can adopt a part-centric approach to BOM management by fully integrating this consolidated CAD and PLM data into a multi-dimensional BOM. This consolidation makes it much simpler to develop a multi-dimensional BOM because it minimizes the number of interfaces to manage, eliminates data latency, simplifies data structures, and more. Moreover, a single source of data truth makes it easier to consistently manage the BOM throughout the entire product lifecycle, and ensure that BOM information is accurate and timely.



The BOM contains the complete product definition

By establishing a scalable, comprehensive BOM strategy, manufacturing can optimize performance and more quickly mature their processes.

Streamline Data Sharing to Downstream Activities

The part-centric BOM also enables better part reuse and better collaboration and communication between product stakeholders. That's because everyone will be referring to the same data, regardless of product form, fit and function and stage in development. This approach – supported by single sign on and role-based access to a single data repository – even streamlines discussions and collaboration with customers and partners.

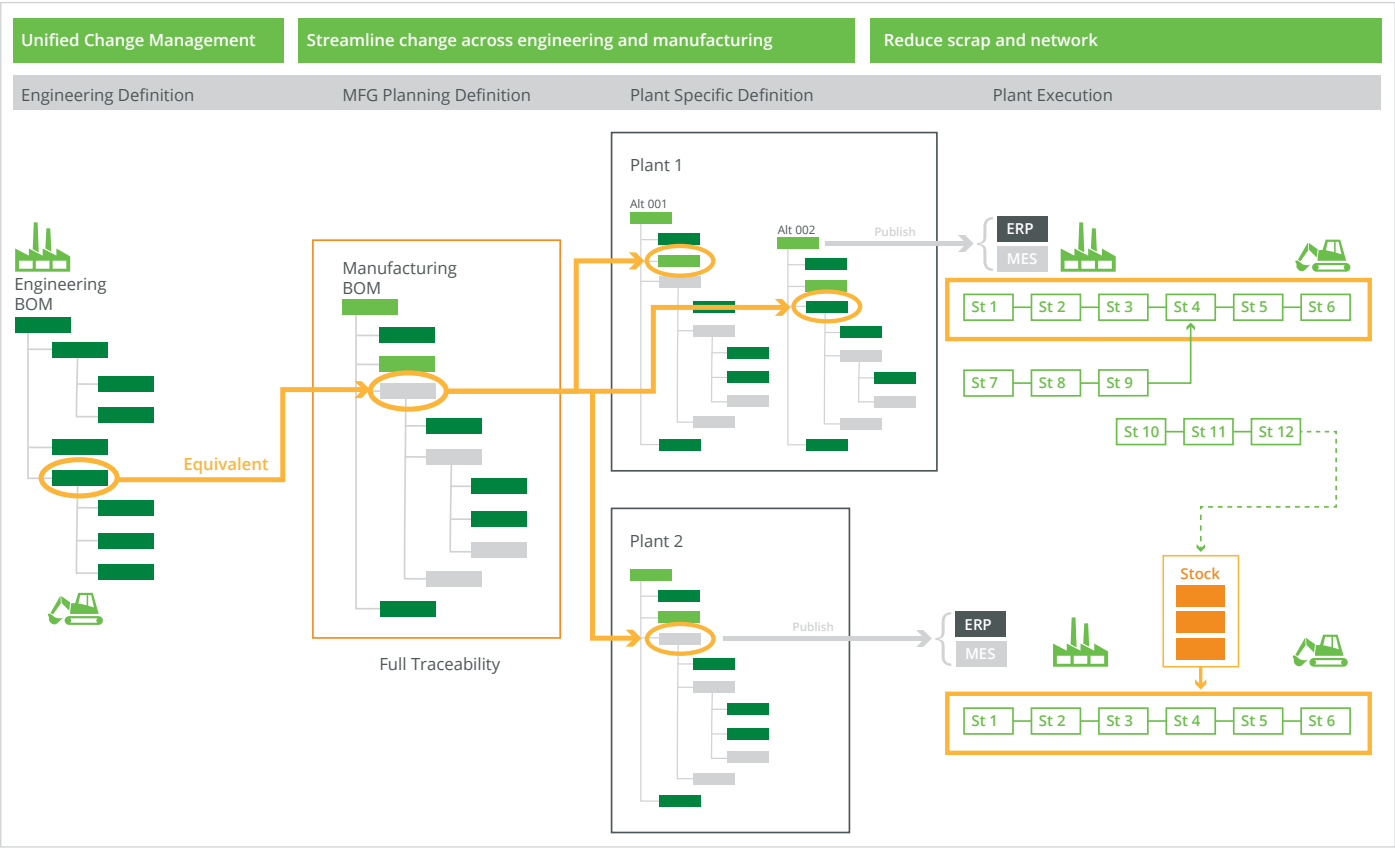
The digital product information captured in an EBOM comprises information from mechanical and electrical designs and, increasingly, the embedded software code found in today's products.

Enable concurrent design and manufacturing planning

When organizations call upon a part-centric BOM as the basis for managing the product development cycle, they can more easily ensure consistency in the information presented at each stage. Supported by a part-centric BOM management solution, companies can be certain that changes are automatically reflected across all relevant systems and presented to all relevant stakeholders. This opens access to an in-process version of the product, while eliminating the need to manually synchronize disconnected design and manufacturing elements.

Achieve digital product confidence

Holistic, part-centric digital product definitions enable full associativity so that product changes made anywhere can update deliverables everywhere. A PLM system allows the organization to identify, collect and execute changes across all disciplines in the digital product definition. The system can then feed



A digital product definition makes it easy to propagate product changes from Product Design to Manufacturing due to associativity

those changes to enterprise systems such as ERP and manufacturing execution (MES), greatly simplifying and improving the product development and manufacturing process.

Visibility into products while they are in digital form allows organizations to make decisions that most impact the cost to produce, assemble and service those products downstream. Downstream teams can more easily learn about planned changes and weigh in on the potential impact. In other words, changes at this stage come at far less cost than changes made once the product has been created or assembled.

When the EBOM, MBOM, manufacturing processes, quality plans and work instructions are all defined in a single PLM system and delivered digitally – in the form of a digital product definition – organizations benefit from:

- Higher operator efficiency due to 3D/Augmented Reality (AR) work instructions and in-process quality validation
- Faster time-to-volume production because of the ability to digitally validate manufacturing processes, and execute concurrent design and manufacturing planning
- Better product quality by defining control characteristics and validation requirements from 3D models
- Faster change propagation due to associative engineering and manufacturing change management

By connecting engineering mockups to the MBOM and work instructions, organizations can ensure design intent is seamlessly made available to the shop floor. The digitization of these manufacturing processes accelerates time-to-volume production and time to market.

How One Company is Transforming Its Manufacturing Process

While the adoption of a complete digital product definition can be truly transformative, the effort doesn't require an overwhelming and drawn-out overhaul of the organization's PLM practices. Instead, organizations can achieve this transformation in an incremental fashion, by implementing digital product definition capabilities along with process improvement based on priority and business need. Here is the journey of one company.

Solar Turbines Integrates Process Planning and Production Execution

Solar Turbines manufactures industrial gas turbines that are used for electric power generation, gas compression, and pumping. It produces anywhere from 200 to 350 units a year, each of which are extremely complex and customized. Because these turbines often operate in remote locations, like drilling platforms in the middle of the ocean, they must be extremely reliable.

Time to market is important to its customers, so Solar Turbines must design, build, test, and deliver a complex custom device in six to 18 months.

The company's EBOM defines the turbine as designed, including all items, parts, components, sub-assemblies and assemblies and is converted into an MBOM. The MBOM covers how the product is put together, including things used in the assembly process but not part of the final product.

Because of the complexity of its products, Solar Turbines automated the allocation of the MBOM parts to the process plan using PTC Windchill MPMLink, MPM software that allows manufacturing process management to be done in synch with engineering. While the company can only use each process plan once since each of its products is unique, another business could use these repeatedly.

Despite its one-time-use nature, the process plan still delivers tremendous value because of the up-front definition. When it comes time to service the turbine, perhaps ten years later, the process plan will provide complete knowledge of that particular turbine. Field service can create and transport the necessary custom part to a remote location, saving an immense amount of work and time.

Today, the instructions are on a flat screen at each workstation, with an image of the component, the assembly instructions, and all the parts. Solar Turbine is also exploring ways to go paperless on the shop floor by delivering 2D, 3D, and augmented reality work instructions to operators.

Conclusion: Take Manufacturing to New Levels

To scale operations and remain competitive in the era of Industrie 4.0 and the IoT, organizations must move beyond a drawing-centric product development process to one that focuses on the actual parts that make up products. With the right PLM strategy and system, organizations can capture, configure and manage product information during every step of the product lifecycle in the form of a complete digital product definition. This transition lays the framework for all digital transformation initiatives of the future, and is certain to be mandated by organizations of all sizes and industries." Moreover, by embracing a part-centric approach, they can enable process planning within PLM.

A complete digital product definition acts as a digital representation of a product(s) and a single source of truth to all related artifacts (in other words, CAD models, drawings, requirements, part structures, and other relevant information). This holistic product definition that goes beyond digital drawings helps to effectively optimize key business processes, enhance product quality by eliminating mistakes associated with duplicate or incomplete data, and identify problems earlier in the development process. In turn, organizations can optimize their use of a product's BOM to align engineering and manufacturing for concurrent design and manufacturing planning. Simply put, a complete digital product definition yields numerous benefits, including organizational agility, faster time to market, simplified processes, and lower costs.

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