DIGITAL INDUSTRIES SOFTWARE

Getting started with design for customization

Leveraging a PLM-based approach to variability management in the heavy equipment industry

Executive summary
Specialization has increased the demand for customized heavy equipment. It requires configure-to-order (CTO) and engineer-to-order (ETO) business models to meet these unique requirements cost effectively and at scale.

Heavy equipment manufacturers implement product lifecycle management (PLM) systems to provide their diverse and widely dispersed organizations with access to a single source of product and process knowledge. Once a PLM system is in place, equipment manufacturers can better manage complexity with a single, consistent definition of variability across the product lifecycle. This white paper identifies the best-practice capabilities that a PLM system should provide to manage variability in the development process and facilitate the delivery of CTO and ETO products.

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Introduction

To stay competitive and profitable, heavy equipment manufacturers must meet consumer demand for product personalization. As a result, companies with highly configurable product lines are seeking flexible, scalable platforms that can help them deliver more product variants, drive commonality and re-use and integrate with their overall product development process and business systems.

Configure-to-order

Configure-to-order (CTO) is a business process that is based on design selection at the time of order. A CTO process uses customer requirements, picked from a set of product features with predefined possible values, to select a combination of parts and assemblies to make a specific predefined, pre-engineered, pre-validated variant of a product.

For CTO, it is important that configuration-related choices are based on business considerations prior to and independent of design. They should target maximizing re-use of existing parts and components and commonality between models and variants, all while working within the boundaries of compatibility. This allows the design team to only focus on valid configurations.

Engineer-to-order

Engineer-to-order (ETO) is a business process that is based on design creation at the time of order. An ETO process uses customer requirements, often expressed as functional capabilities, and defines, engineers and creates a realistic bid or design that will satisfy those requirements from scratch at the time of the order or bid.

To support ETO, manufacturers require powerful automation tools that can dramatically speed up the engineering work. In most cases, companies combine CTO and ETO in some form. For example, if a piece of construction equipment consists of all existing parts, except one that is tailor-made, then both approaches must be integrated. Whichever one is dominant must be driving the other.

Business challenges

The heavy equipment manufacturers have a wide range of specifications their equipment must meet to get tough jobs done in a variety of challenging environments. Manufacturers that can offer these options and deliver without sacrificing product lead time, quality or profitability will have an advantage over their competition.

Some of these machines are in the field for decades and undergo repeated upgrades and retrofits to add capability or accommodate to fleet needs, such as interconnected options. The product line is responsible for making sure that both the original equipment manufacturer (OEM) configurations and the service upgrades are compatible over time. This is a massively complex and time-consuming job in engineering, and often results in field adjustments.

Ever more farms, construction companies and mines are pursuing connected and autonomous fleets, so to achieve compatibility there will be an increasing need for retrofitting field equipment. Some fixes are simple, but others require significant disassembly and replacement of components.

Another reason why configuration management is necessary and complex is related to globalization. Many heavy equipment companies are global enterprises. When they design equipment for local markets, they will obviously aim for commonality and re-use, especially for the more important components like motors, engines and drivetrains. However, the reality is that in certain industry segments, the differences between regions are significant. For example, farming in Europe is vastly different than in the United States and different than in Southeast Asia. Additionally, OEMs must also make business decisions on where to assemble and whether to ship certain parts or find a local alternative.

Delivering individualized products in a cost-effective, timely manner also requires that manufacturers be better able to leverage previous designs, capturing knowledge about how they were designed and built, and impart that knowledge effectively to all stakeholders globally. ETO manufacturers typically have complex products that must be closely aligned with detailed customer specifications while simultaneously considering engineering standards, supply chain capabilities and manufacturing constraints. Although every organization produces data and information about its products, transforming that data into an accessible knowledge base is extremely difficult.

Best-practice solutions

As you can see in table 1, CTO and ETO variability management processes help companies address a variety of fundamental business needs.

Heavy equipment manufacturers typically need to accommodate many customization requests. This generation of customers wants machines that are tailored to their specific needs. This relates to functional capabilities and operational characteristics, but possibly also to aesthetic styling including look and feel. When selling to a global market, manufacturers need to deliver variants tuned to specific local operating conditions or regulations.

Table 1. Business needs addressed by PLM-driven CTO and ETO solutions.

Fundamental business need	How a CTO/ETO addresses these needs
Respond to customer preferences	• Establishes a central repository for all product variability data like features and rules • Connects product management decisions on feature offerings directly to the engineering process with a single system for planning and execution • Uses automation to capture rules on how to engineer, design, manufacture and quote on custom jobs quickly and efficiently
Manage complexity of multi-domain systems	• Provides a single, consistent definition of variability across all domains, from product planning to execution and service • Separates configuration data from content and product structure • Offers change control for effective product features and intelligent multi-domain impact analysis
Offer product variety without driving up cost	• Drives part re-use of configured content • Prevents duplication with automated validation of uniqueness • Automates creation of fixed assemblies and buildable products from configurable products, modules, generic parts • Accelerates bid-and-order engineering processes by automatically generating engineering outputs, including bill-of-materials (BOM), 3D models and drawings
Visualize specific customer orders	• Generates 100 percent buildable end products and modules automatically • Produces real-time 3D visuals for any configuration, available to any user in the process • Streamlines visual validation of single or multiple configurations with BOM-driven visualization aligned to design

Approaches like engineer-to-order and configure-to-order are common practice but are also particularly time sensitive. These approaches need to be able to scale to accommodate the continual growth of equipment complexity from trends like electrification, automation and digitally enabled monitoring and service.

PLM-based CTO and ETO methodologies help companies become more profitable regardless of the degree of customization. By driving commonality and re-use with CTO, equipment manufacturers stand to achieve massive time and cost savings. Product planners can make business-driven decisions using their access to data across business lines and product segments as well as tools to build new configurations and validate them for compatibility. ETO allows manufacturers to leverage legacy data to set up a rules engine that couples customer requirements with the organization's capabilities. Technical content can be then automatically generated by the ETO system.

By connecting CTO and ETO processes, equipment manufacturers can efficiently deliver any sellable combination. This connects all stakeholders within an organization and adds suppliers using a common digital infrastructure. This improves collaboration and saves a massive amount of time on downstream activities such as the generation of the BOMs, computer-aided design (CAD) and simulation.

Working within a hybrid CTO/ ETO process environment

Many products have both CTO and ETO elements and fall in the gray area between these two business strategies. For example, a tractor may have configurable options for driveline and frame but may require certain subparts to be engineered to achieve the desired configuration. This is when an integrated solution should be considered with one solution driving and the other supporting.

If a product is primarily variant-driven with the top-level module uniquely configured by an order string, yet some sub-items require engineering, then a solution with the Teamcenter® Product Configurator software at its core is the proper approach. When an engineered component is required the Teamcenter Product Configurator sends a request to the Rulestream™ software ETO system (see figure 1).

Teamcenter and Rulestream are part of the Siemens Xcelerator portfolio, the comprehensive and integrated portfolio of software, hardware and services.

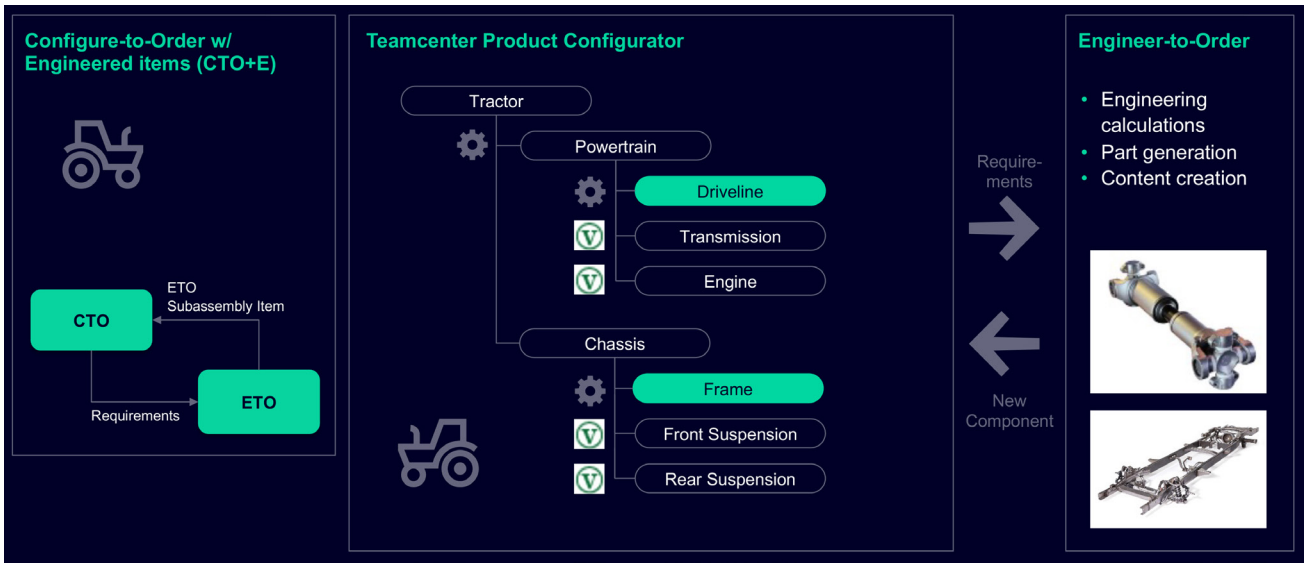

Figure 1. Hybrid CTO/ETO process with CTO as the primary solution.

With a product that's primarily engineered for every order, but has configurable options depending on the engineered product, an ETO-CTO approach would be an ideal solution. Information derived from the ETO process can be communicated to the Teamcenter Product Configurator, which can retrieve the appropriate configurations. This information is then shared and included in the product design (see figure 2).

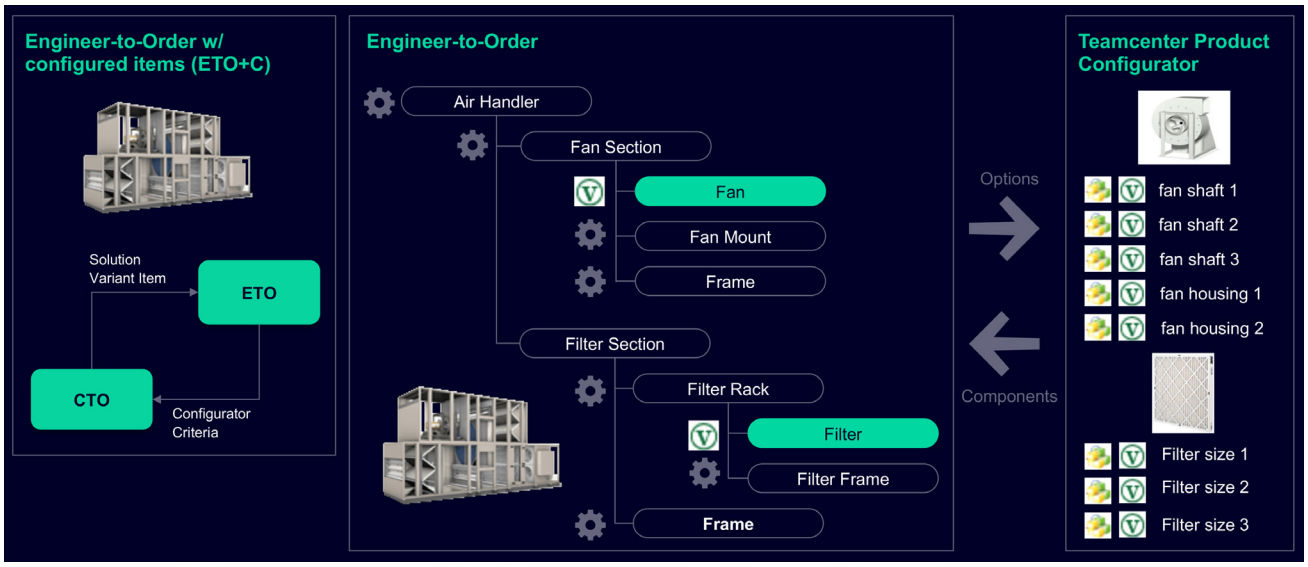

Figure 2. Hybrid CTO/ETO process with ETO as primary solution.

Key capabilities

Comprehensive variability management is critical to accelerating heavy equipment design. Users can leverage multidisciplinary configuration management to easily integrate local variants into complex designs and harness customization requirements. Table 2 gives an overview of the most important capabilities.

Table 2. Key capabilities of PLM-based CTO and ETO solutions.

Best-practice solution	Required capabilities
Engineering automation	• Automation to create part designs and documents, capture requirements • Deep integration with CAD, Microsoft Office and PLM • Support for advanced calculations
Single source of truth for product configuration	• Use product history to provide serial number level traceability and verify upgrade compatibility in all engineering domains • ETO integrations with CAD, Microsoft Word and Excel spreadsheet software • Seamlessly connect to enterprise resource planning (ERP) systems
Product line engineering	• Configuration items managed independent of product design • Global dictionary to manage product families, features and rules • Easily manage massive complexity in product line options and variants
Visualization of product configurations	• Real-time 3D visualization of any buildable product configuration • Visualization accessibility for any users at any stage across the lifecycle • No CAD expertise required to produce visualizations • Ability to visualize and validate throughout

Defining variability

Configure-to-order allows equipment manufacturers to deliver the variation customers demand while driving profitability. This solution enables a single definition of variability across domains and the lifecycle. Product options aren't tied to design data but are managed independently to be leveraged across the organization. This provides an easy-to-use common source of configuration data. Planners can define products, product lines and features they want to bring to market. Engineers can focus on valid configurations. Manufacturing can generate a bill-of-process (BOP) leveraging that same definition.

With a comprehensive engineer-to-order solution, product and process rules can be automated. With this automation, new requirements can be addressed quickly and accurately while ensuring adherence to organizational constraints. Bid and manufacturing packages can be created in minutes rather than weeks. This allows manufacturers to support customer demands for engineer-to-order products while remaining profitable.

To effectively manage and automate configured products, companies need more than a standalone engineer-to-order system and more than standalone product configuration management tools or systems. A comprehensive, integrated product configuration management solution is the key to supporting end-to-end CTO/ETO processes.

Conclusion

Many companies are realizing the benefits of product lifecycle management solutions to enable them to manage product-related processes and information across various domains. Managing all your CAD designs, organizing documents, automating key processes and visualizing your products in a single environment is becoming the standard.

It is now possible to realize that vision with the added benefits of cloud-based software as a service (SaaS), allowing companies to quickly address today's complex challenges with proven best-practice PLM solutions that drive growth and accelerate product development.

With Siemens Digital Industries Software's SaaS PLM solution, Teamcenter X, companies of all sizes can benefit from a cloud offering that gets you up and running from day one. The solution features an easy and accessible user experience, helping you to onboard teams quickly and improve time-to-value.

Architected for the cloud, Teamcenter X provides instant access for all stakeholders, wherever they are based. With web-based access and no installation, it enables them to work from any device, at home, in the office or on the shop floor. The cloud-based SaaS solution also provides greater flexibility than on-premises PLM; with no perpetual license to purchase, you have the flexibility to test new functionalities and add new users as required to scale up or down to meet your changing business needs.

With SaaS PLM you can boost information technology (IT) resiliency to better support your high-performance teams. Product development and manufacturing teams can collaborate more effectively, sharing the same environment to manage all product information and make sure market, compliance and regulatory targets are met. Take advantage of the Teamcenter X cloud-based solutions to improve business continuity and efficiency with streamlined processes and preconfigured best-practice workflows.

A key advantage of Teamcenter X is that Siemens takes care of software management and updates, simplifying deployment and eliminating unpredictable costs. Siemens ensures your software is always up to date and you benefit from the peace of mind of our industry-standard cybersecurity and privacy protections.

Teamcenter X offers the full functionality of Teamcenter with the added benefits of the cloud:

- Gain instant PLM access for all stakeholders, anytime, anywhere
- Reduce the cost of ownership with predictable operational expenses and minimal IT infrastructure
- Accelerate product development, leverage existing knowledge to support design re-use, manage change and speed cycle time
- Streamline product development and manufacturing processes with internal and external stakeholders
- Create a multi-domain BOM to visualize your entire product

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