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WHITEPAPER

Shifting from Engineer to Order Processes to Configuration Based Manufacturing

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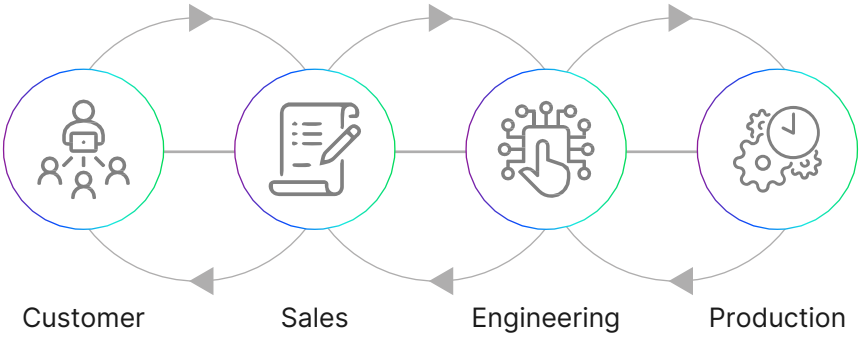
Introduction

There have been multiple production strategies to cope with industrial customers' needs, ranging from mass production to individually engineered products. These are two extremes of the spectrum of manufacturing complexity. Manufacturers face the challenge of producing the right product for every order; hence engineering every custom request is a standard practice in the industry. However, in most cases, it is a slightly modified product compared to what they produce regularly or had produced earlier. Engineer to order (ETO) manufacturers face the disadvantage of long lead times and other complexities associated with a product before it can be quoted and manufactured. This necessitates the middle ground – using modular product structures and adopting the Configure to Order (CTO) process wherever possible.

What is ETO

Engineer to order is when manufacturers design, engineer, and produce the product for each custom order. In its initial stages, the sales process is disconnected from the technical/engineering process. This leads to a multi-stage process where sales and engineering teams are interdependent for various activities leading to long opportunity-to-conversion time. It may also inhibit the sales prospect where the deal may be time sensitive or competing against other vendors. This also leads to inefficient and expensive utilization of human and technical resources and under-utilization of existing experiential knowledge. The high lead times will further continue in the order fulfillment phase where procurement needs to again work with Engineering to procure the required raw material and also have to deal with cost management given the customer requested dates

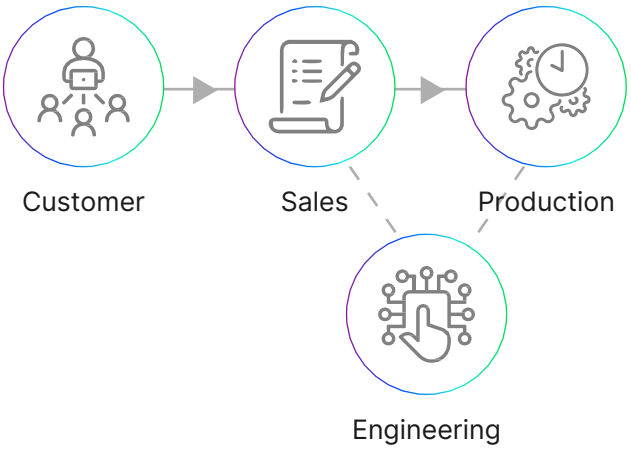
ETO Process Touchpoints



What is CTO

Configure to Order aims at composing orders from existing modules with predictable production attributes. A wide range of compositions can be built flawlessly using these modular components. The pre-defined nature of these components also comes with the necessary information to ease the whole process. This reduces the overall time throughout the different stages while reducing/eliminating various stages, dependencies, and uncertainties in the quoting and manufacturing processes. It also utilizes human and technical resources more efficiently through pre-defined frameworks, tools, and experiential knowledge. This leads to heightened, efficient and predictable collaboration.

CTO Process Touchpoints



Not a regular communication during sales/production process

Comparison of ETO and CTO

ETO	CTO
Infinite varieties	Finite varieties (configurations)
Components might have been used only in one end-product	Common components used in multiple end-products
Product Structure (BOM/Routing) are defined based on customer specification	Product structure (BOM/Routing) is available with all possible combinations that can be manufactured
Procurement must be made with low economies of scale	Procurement can be planned with high economies of scale
Maximal customer involvement	Less customer involvement
Production of components triggered by demand	Production of components can be planned by forecast
Inventory of components is huge risk	Inventory of components is less risk
Long lead time	Short lead time
Uncertain quality	Proven quality of modules
Less scope for cost-effective upgrades	Easy upgrades by interchanging modules
Higher costs when high commonalities among customer need	Lower costs when high commonalities among customer need

Modularity in Product Structure

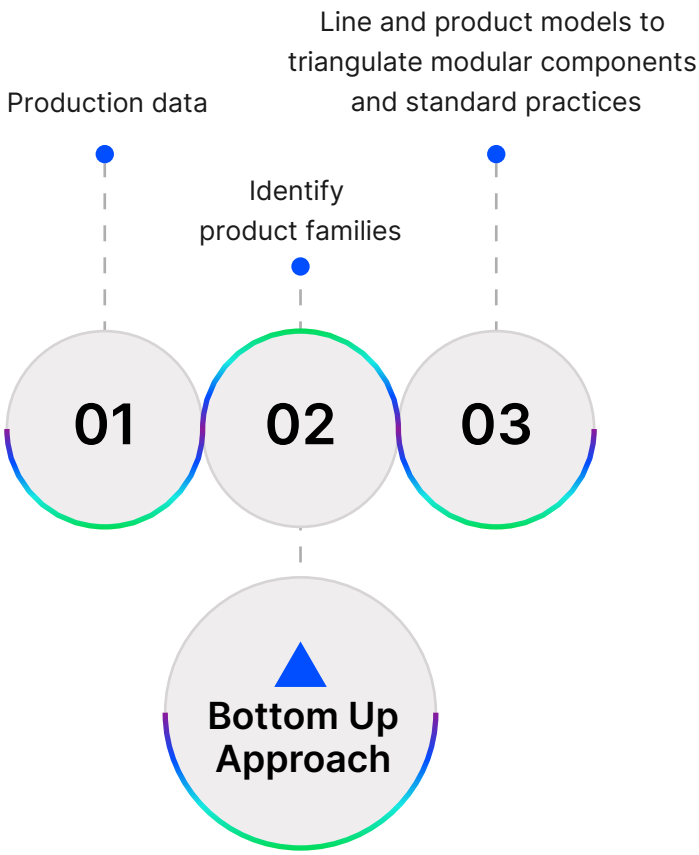
Manufacturers who have been following ETO processes would have unknowingly standardized some of the configurations, as a starting point to cater to any customer requirements. In many cases, the sub-assemblies are the same, except for some minor changes in accessories or add-on components.

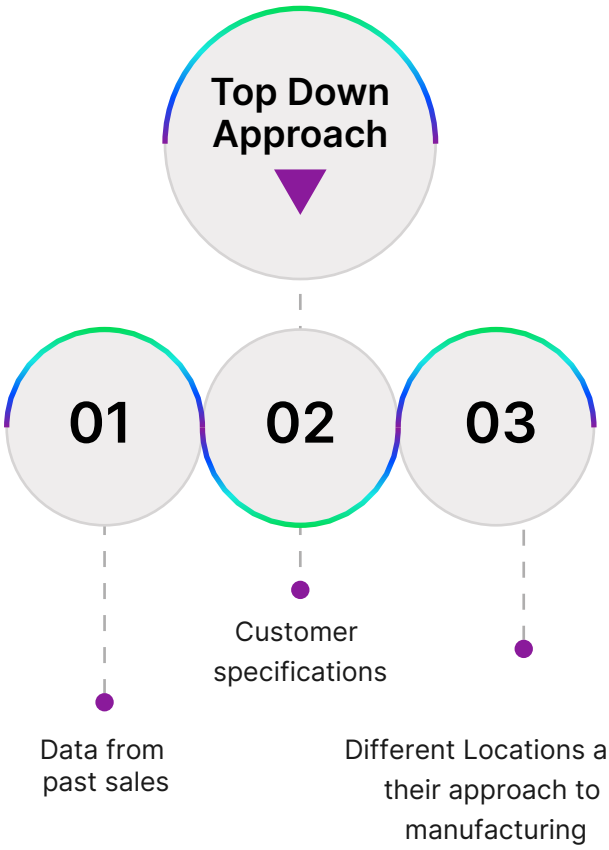
As the modular components are identified, supported configurations can be cataloged for sales by analyzing past customizations and customer requirements. Not all ETO manufacturers can define reusable/modularized physical components across projects and products. However, reusable knowledge, processes, calculations, etc., can be analyzed and standardized. Therefore, the modular concept can be adopted in a broader sense in ETO companies, e.g., a module could be defined based on common processes or engineering knowledge. With all possible modularization, about 70% of product requests can be standardized in to modular structure and its a continuous process to improve the product modularity.

Identifying Modular Structures

For a manufacturer following ETO practices, it can be challenging to adopt CTO-based manufacturing but identifying some patterns of modularity can help achieve these goals easily. Companies can look for bottom-up and top-down approaches to understand the modularity in their product structure. In the top-down approach, the manufacturer can look at data from past sales, customer specifications, different locations, and their approach to manufacturing. Similarly, in a bottom-up approach, the production data will be the starting point to identify product families, line and product models to triangulate modular components and standard practices.

This whitepaper details out in further sections on the various considerations required to enable a successful exercise of defining modular product structure.





Below are a few key steps that can be taken to come out with a modular configurable structure for the product:

- Look at past orders and start with high-moving products in your portfolio of products
- Collect the customer specifications and look for the most ordered configurations
- Identify and harmonize parts across the manufacturing locations, and in the process, look for opportunities to standardize the product design and structure
- Without this level of standardization, it is very difficult to maintain the product configurations and will diminish the value of the CTO process
- Identify distinct modules that were manufactured independently or were procured at times from external vendors
- Identify all product families
- Identify all product lines/sizes under every family sold frequently
- Look for all customizations that were added on top of the core

With the above activities, the expected results are:

- Core product structure is identified that will not change by options that can be offered
- Identified product core by size/scale of the product
- Identified independent modules, so customization on one will not impact the others
- Clear picture of product structure emerges where configurations can be supported, and engineering is still required for special cases
- Through this process, product improvement opportunities are identified and incorporated into the new product structure

Once the modular structure is identified, it can be used as the foundation to empower the quoting process. This process will require a comprehensive structuring of components, engineering practices, and manufacturing processes and dependencies to generate precise cost estimates and quotes.

Structuring the Bill of Material (BOM) for CTO

Once the modularity is identified, the next logical step is to consider various factors that need to be considered to come up with a configurable process to generate the Bill of Material. Just focusing on the bill for manufacturing is not sufficient.

Below are high-level tasks for structuring the bill of material:

Key considerations for Product Restructuring

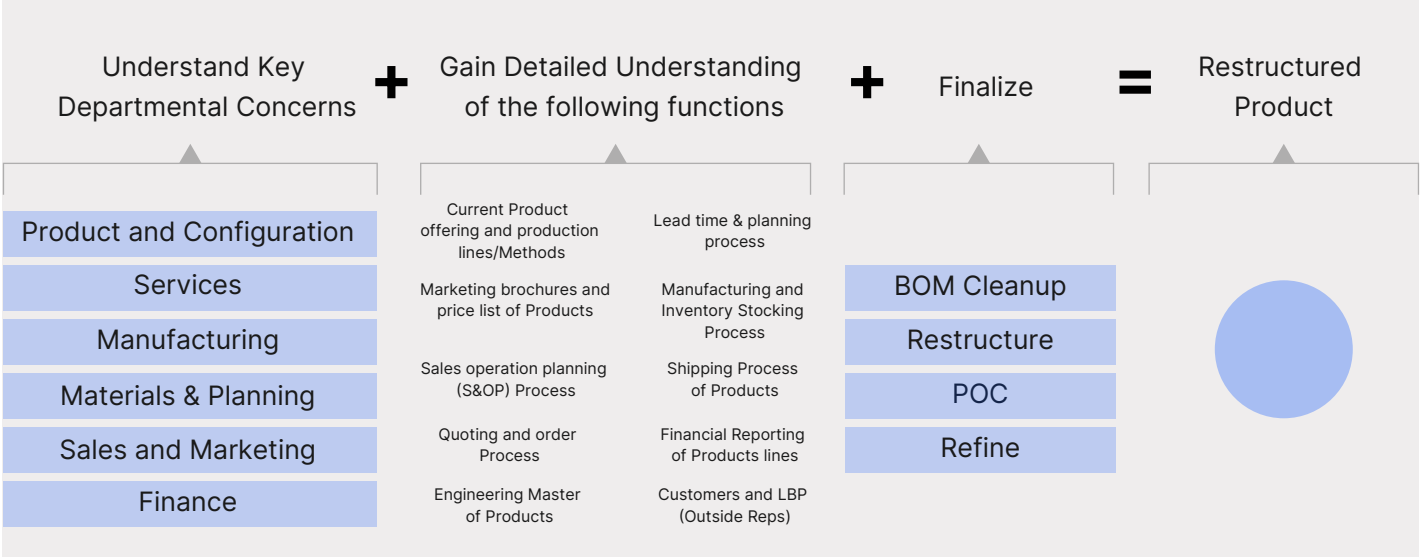
"Right upfront setup of a robust Product Model lays a strong foundation for the success of Selection and Configurator solution"

Key Principles of Product Restructuring

Impact Analysis:
Forecasting, Configuration, Quoting, Order, Planning, Manufacturing, Stock & Shipping

Detailed Reviews:
Existing number of items, item's usage (cleanup) and check feasibility for redefinition either as a configuration attribute or feature

Product Structure:
Consider all Structures viz: Phantoms, Planning Bills, Part Numbering, Specific BOM Extensions, End Items, Bulk and shop floor items



Tasks	Targets
Understand the Current Product and BOM Structure • Analyze existing product structures to understand the current BOM structure, levels of BOM, phantom, finished, sub-assembly, and purchase to finalize the correct BOM structure • For example, Some BOMs will have repetitive components leading to a huge volume of parts to accommodate various permutations and combinations	• Identify phantom or redundancy structure • Identify the key variable and fixed components • Identify common assemblies or components • Reduce the structure by reducing duplicate structure

Tasks	Targets
Understand the current product size offering and production line rates • Analyze various size offerings provided by individual products. It is also important to capture the changes in components as product sizes vary at different scales • Analyze production line rates (production per unit time at various scales). This will help decide the structure and the beginning of the product structuring • For example, some products may have a long range of size offerings, making it easy to configure but increasing the product structure. You will have to balance the configuration process with product structuring and planning	• Identify the beginning of the product structuring • Identify the number of models per product line • Identify and structure products to maximize production line rates • Identify and maximize planning for efficient utilization of shop floor planning
Understand Marketing brochures and price list of Products • Analyze how products are marketed. Need to understand at what level prices are structured, documents are published. This will help to decide the starting point for structuring the products • For example, sometimes products are structured at a high level, but pricing and marketing brochures could be at the component level and vice versa	• Identify product structure options as Configurable Model or Super Configurable models (Model within the model) • Identify the number of models to be structured • Identify the optimal size for product structure • Identify pricing structures and setups • Identify sizing outputs and results
Understand Sales operation planning (S&OP) Process: • Most important factor in deciding the product structure is S&OP process followed by the company • It is important to keep product structure in line with the SOP planning level so that planning concepts can be used to their maximum potential	• Identify the beginning of the product structuring • Structuring of products for better forecasting and consumption • Better planning Easy feeding of SOP planning to demand so that planning is accurate
Understand Quoting and order Process • Analyze quote and ordering process for product lines • The level at which products are quoted and ordered will provide details on the structuring of products • It will also help to determine the pricing, ATP, and lead time, as most of them are needed during the ordering process	• Identify the number of models per product line • Identify the pricing structure • Identify the pricing discount structure • Identify customer-facing document requirements
Engineering Master of Products: • Analyze the PLM systems/Engineering master for every product to decide on the structure as well as to decide on location-specific BOM or Common BOM • Many times same BOM is duplicated for every inventory leading to a huge volume of duplicate data • Analyze the maintenance and process for making changes to BOM	• Identify the need for common BOM or location-specific BOM • Reduce the mistakes of different versions and revisions • Reduce the maintenance of BOMs • Identify and define the ability to make quick changes • Identify the need for mass changes

Tasks	Targets
Understand the Lead times and planning process • Analyze the details of the components, their lead times, and procurement to decide the structuring of products • It will be important to identify high lead time components so that proper groupings can be done within the model structure • Analyze the current planning process to decide the product structure. It is important to understand dependent and independent demands for better structuring products	• Identify grouping of components • Identify planning attributes • Facilitate ATP planning
Understand the Shipping Process of Products • Analyze the shipping of final assembly to decide on model structure • Some sizes can be shipped assembled, and some will be shipped as components and assembled at customer location. If we have scenarios like these, it is important to factor in deciding the product structure	• Identify assembly/kit model structure • Identify the need for hybrid product structures • Identify the need for Sub Models
Understand Financial Reporting of Products lines • Analyze reporting requirements to structure the products • Look at incentive/commissioning requirements and see what level the bill has to be strucured	• Identify the number of models per product line • Identify the level for the incentives, price, cost, and profits
Understand current and Future IT framework • Analyze the complete IT framework to decide on the cost of maintenance and support • It is also important to understand the future state after products are re-structured	• Identify the number of models • Identify the cost for maintenance of re-structured products • Identify IT systems need to be updated/synced for product re-structures
Customers and External Sales Reps • Analyze customer expectation on trade documents on products • It is also important to understand the pain areas and expectation of current product structure from customer • It is also important to understand current pain area in selection and configuration process	• Identify structure easy for selection and configuration • Identify and reduce the configuration process for best customer experience

Tasks	Targets
Understand Manufacturing Process • Analyze the complete routing steps/manufacturing steps involved in final assembly • It is also important to understand Outside Processing (OSP), inter plant movement within manufacturing stage etc. • It is also important to understand the current routing steps and operations • Analyze the number of work orders (Jobs) for a given quantity	• Identify structure to map with routing steps • Identify the routing required for model structure • Identify need for option dependent routings • Identify need for OSP items in the BOM • Identify additional need for phantom structure to facilitate routings and OSPs • Identify the required number of models based on manufacturing times • Identify if quantities will be split to generate more work orders or it will be one work order for many quantities
Inventory Stocking Process • Analyze if any Make to stock/Semi finished products are made in advance to cater for fast manufacturing • Analyze scenarios where it will be built from beginning, from semi-finished product and directly shipped from the stock • It is also important to know if there are any Kanban-like systems with vendors for supplying semi-finished products	• Identify grouping within the structure • Identify the need for sub-models to cater to different manufacturing needs based on inventory • Identify if there will be any return of components from semi-finished products

A manufacturing organization would have many stakeholders, each with their own unique needs. The BoM should be able to address the concerns of all departments in a manufacturing organization.

Departmental Concern	BoM Restructuring Objectives

Sales and Marketing Concerns:
• Sales and Marketing typically want to have application-oriented sales options
  • This is often in direct conflict with manufacturing strategies. With the introduction of the product "configurator," this problem can be reasonably solved without altering the BoM too much
• Selling a hybrid product is complex and time-consuming because product configurators often do not work with hybrid products, and then going through the BoM is the only option
  • Separate models have to be configured manually to sell a hybrid system
  • Increased processing time for quotes and orders
  • Easy to introduce errors during configuration
• Difficulty to show a customer exactly what they have ordered in case of a hybrid
	• BoM structure should enable easy configuration of the product
	• Reduce processing time for quotes and orders -this again takes us back to the point - the features must make sense to the customer
	• Allow salespersons to easily show customers what has been ordered for any product in full detail. This does not necessarily translate into providing a full bill of material to the customer. The only BoM that the customer is entitled to be the service BoM
	• Sales should try to reduce non-standard orders, and one of the ways of doing this is to increase the available customer options
	  • This is a double-edged sword because an increased number of options increases the size of the BoM, which is not always favorable in the planning world

Departmental Concern	BoM Restructuring Objectives

Product and Configuration Management Concerns:
• The Product Managers own the BoM during the initial phases of the product life cycle process. They must ensure that the BoM is structured to support manufacturing and planning
  • Dramatic changes in the BoM structure in the later phases of the product life cycle process causes enormous numbers of change orders
  • Product managers must balance sales & marketing and manufacturing
• For products with cutting-edge technology and highly complex configurable design - product managers should have the option of creating special and hybrid orders. The hybrid orders typically include a design combination of two or more products
  • Special Orders can be created without vastly modifying the bill of materials
  • Hybrid orders can be created as "one-off orders"
  • Special Orders, or Hybrid Orders creation increases order processing time
  • Manual process to configure and price a hybrid system or orders with special options
  • Errors are generated due to the manual configuration of the hybrid system
	• Complete representation of the product with possible options
	• Balance between Sales & Marketing and Manufacturing
	• Least modeling effort for configurator
	• Easily configurable pricing and easy Gross Margin Analysis
	• Reduce the need for manually creating a hybrid system
	• Reduce duplication of rules and modeling errors
	• Reduce the need to maintain multiple BoMs for similar options (like multiple positions can use the same options, so we use the same BoM one time with multiple instantiations)
	• Model needs to be flexible enough to adapt to future business

Materials /Planning Concerns:
• The BoM Change process should be manageable - changes to long lead time items should be requested outside the lead time
  • Inside lead time request is a very standard practice in the industry with tremendous expediting cost
• Large forecast BoMs (for example - combined technologies) increase the complexity of planning
  • More discrete forecast BoMs are preferred
  • Planning percentages at multiple levels is extremely difficult to maintain
• At low volumes, it is extremely difficult to synchronize material delivery with Manufacturing needs using % based forecasting methods
• If new material differs significantly from what is already offered, a separate BOM should be considered
	Enable effective end item slotting process
	• Accurate product cycle times to drive factory schedule
	• No change orders within lead time, so planners have to be part of workflow upfront
	• Product linearity using supply planning - sometimes phantom items are added to achieve this
	Provide granularity of forecast at product, option, and kit level
	• The BoM and its content act as a foundation for the S&OP process and single forecast process
	Minimize manual intervention to execute demand and supply planning for low volume options/products
	• Master Scheduling with the minimum number of items
	• Purchasing from fewer vendors
	• Outsourced suppliers should get a usable BoM with drawings
	Prevent dilution of forecasts on options and minimizes material excess for lower volume options Minimize customer specific BOM variants Enable effective communication of product variations and forecasts to supply chain

Departmental Concern	BoM Restructuring Objectives

Manufacturing Concerns:
 	
• Large super BoMs will be harder to maintain - more complicated change process and more collaboration with other groups necessary
  • Model and routing complexity increases as the number of options increases
  • Hybrid Products design adds additional model and routing complexity
  • Complex reference designators, restrictions, dependencies, etc.
  • increased opportunity for configured BOM errors
  • increased opportunity for design/compatibility issues
• Shopfloor and planning needs more granularity, but this leads to more indented BoMs which means
  • More ECOs to review; this will require multiple product lines involved during approval process
  • Producing a usable BoM report with all the attributes is not always easy. Typically such reports are limited to certain BoM levels. BoM explosion takes a considerable amount of systems resources
• Engineering BoM, if separate from manufacturing BoM, often must be synchronized with the manufacturing BoM, which is not always automated. All design changes flow from design to manufacturing, but all manufacturing changes and design defects must flow the other way around. Such feedback mechanism must be built into the engineering change process
• More options reduce the number of non-standard orders, so there is always a tradeoff
	Provide granularity at product, option, and kit level
	
	• Aligned with design organizations for accountability
	• Enables fast ECO processing (manufacturing changes)
	
	Enable 3D product modeling (support Design For manufacturing - DFM) Minimize configurator logic and reference designator complexity
	
	• Minimize configuration error
	• Minimize manual configuration
	
	Reduce opportunity of design compatibility issues for hybrids
	
	Link manufacturing parts to SO characteristics
	
	Provide simple user interface for viewing/linking parts to characteristics
	
	Enable simplified routings for manufacturing process Manufacturing and Engineering need signoff of BOM structure proposal for new products

Services Concern
 	
• Require equipment-specific information and also a generic product specific service BoM
  • During the design phase of the product
  • Identification of all parts required for service and maintenance (contract)
  • Identification of all spares (to be sold as spares)
  • Link spares to labor and work methods
  • Process Performance attributes after changing spares
  • The “As Installed” BOM contains updated information
• Parts may be different by the customer from the “as designed” service BOM
	• The service BoM should incorporate all information required to do the job right the first time at the customer site, wherever possible
	  • If the work procedure on a specific assembly contains a detailed part list, then a detailed task list is required for that assembly’s procedure
	  • This way, parts can be ordered against the specific equipment, and usage can be tracked against that equipment
	• Planned tool maintenance procedures on each level of the equipment should be included in the installed base and then integrated into the task lists or service templates used by the maintenance team
	  • These procedures should include the manpower requirements (# of technicians to do the job, Qualifications required, the expected duration of the job, the procedure steps, documentation, tools & parts required.)

	• If a product has been in the field for a period (Eg: 2 or more years) and is in an as maintained state, a customer requests an identical shipment, the as maintained BoM can be copied back to be reused for sales and manufacturing purposes. • A Customer Engineer in the field should be able to see all indented levels of the manufacturing BoM • Able to link Bill of Material components to drawing vaults • Sometimes, system software needs to be part of the BoM (mechanism required to handle upgrades and patches) • Serialization. For any part that has a serial number, that serial number must be tracked on that part throughout the life of the part. (Benefits: OEM warranty recovery, litigation failure analysis, QA records.)

Every Engineering company has developed their products over a period of time and it needs a fresh outlook on what can be turned configurable vs what needs engineering team's involvement. The above guidelines and steps can be used for starting your journey into Configure To Order space.

SLK's Solutions and Services

SLK has a vast experience and is uniquely placed in this space for handling large programs involving ETO & CTO processes. We also bring the right balance between experienced engineering domain consultants and strong technical developers.

SLK has built tools and guidelines over the period of time to enable ETO manufacturers assess their current systems and chart out the roadmap towards quick and reliable CTO adoption. Along with the analysis, SLK also identifies the right fitting tool for the business to accomplish seamless configuration process.

As a step forward, SLK's commerce and UX practices can take the user experience to next level. Our solutions enable omnichannel product configuration experience for customers and internal users alike, incorporating many tools for guided selling, 3D product visualization, AR and many more.

About Us

SLK is a global technology services provider focused on bringing AI, intelligent automation, and analytics together to create leading-edge technology solutions for our customers through a culture of partnership, led by an evolutionary mindset. For over 20 years, we've helped organizations across diverse industries - insurance providers, financial service organizations, investment management companies, and manufacturers - reimagine their business and solve their present and future needs. Being A Great Place To Work Certified, we encourage an approach of constructively challenging the status quo in all that we do to enable peak business performance for our customers and for ourselves, through disruptive technologies, applied innovation, and purposeful automation. Find out how we help leading organizations reimagine their business at https://www.slksoftware.com/