Tool for deciding upon and supporting the transition from ETO to CTO for capital goods manufacturers

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Tool for deciding upon and supporting the transition from ETO to CTO for capital goods manufacturers

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I. ABSTRACT

This master thesis presents a framework that can help project oriented engineer-to-order (ETO) capital goods manufacturers in deciding to transform to a (hybrid) configure-to-order (CTO) order fulfilment strategy or not. It includes systematic guidelines for deciding which parts to standardize and for which parts to allow customer specific variants. An operational implementation suggestion is included.

The problem stated by the manufacturing manager of a capital goods manufacturer is the presence of a large number of unique items to be produced and the small batch sizes. A deterministic analysis is done on the product and demand characteristics. This analysis confirmed the stated problem of the manufacturing manager.

Getting further back in the supply chain, the causes for this diversity of items were investigated. The ease of choosing to engineer new customer specific “specials”, the lack of good communication between the departments and the ERP system that doesn’t properly allow for batching are found as the main causes.

This research is done at Vanderlande Industries B.V., where the recent way of working is project oriented and standardization initiatives are there, but loosely managed. The application of the developed framework at Vanderlande keeps in mind the existing resources in order to keep the transformational cost as low as possible.

Finally, an extended implementation plan is given in the last part of this thesis, giving the management of Vanderlande practical handles when the company wants to implement the plan in the complex organization of Vanderlande.

II. ACKNOWLEDGEMENTS

This report is the result of my master graduation project as the final phase of the master program Operations Management and Logistics at Eindhoven University of Technology (TU/e).

The graduation project was carried out from September 2014 until February 2015 at Vanderlande Industries B.V.
I want to thank my mentor and first supervisor from the TU/e, dr.ir. H.P.G. van Ooijen. He supported me in the decision to go on exchange semester in South Korea, but also made clear the consequences for the master thesis project; for example that the literature review could be started best after my return when I had time to focus on orientation on the company and problem statement.
During the development of the project, van Ooijen gave directions on where to focus on and placed critical side notes at the various concept versions. I really appreciate van Ooijen's management style of letting me act independently and being quickly available when support was needed.

I want to thank dr. M.J. Reindorp, my second supervisor from the TU/e, for giving objective feedback on the report and his questions on the core principles of the research. This enabled me to step back and look at my research through the eyes of an outsider.

I would like to thank Hans van Pelt, my supervisor at Vanderlande, for reserving time next to his busy job as manufacturing manager. He helped me to shape my research question at the start of the project. In the beginning I was influenced by the complexity of the processes in the company and opinions of various people in the company, but Hans kept me on track. He supported me in finding the right stakeholders to get the necessary information and data. Because of the strategic approach that was taken in the research, a lot of different stakeholders of almost all functional departments are contacted.

I would like to thank all the employees of Vanderlande for their collaboration and their openness. I would have liked to thank everyone individually, but this would become a long list of names. It was a pleasure to experience so much dedication on your jobs and the ease of getting information from different departments was encouraging, you helped me so much, with no exceptions. This includes the ease of walking along people when I needed additional explanation.

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Pim Jansen
Eindhoven, the Netherlands
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III. EXECUTIVE SUMMARY

A list of abbreviations and concepts is given on page XIV

This report presents a tool to help Engineer-to-Order (ETO) based capital goods manufacturers in deciding upon and supporting the transition to go to Configure-to-Order (CTO) order fulfilment strategy. The research is conducted in collaboration with Vanderlande Industries, worldwide market leader in baggage handling and parcel and postal sorting solutions and top 3 global supplier for warehouse automation solutions. The company is facing a large revenue growth perspective (doubling the revenue in 4 years) and wants to prepare the company's order fulfilment strategy to accomplish this growth with higher profit margin.

Vanderlande has three supply chain centres in the world and its own factory which is located in Veghel, the Netherlands. This factory is responsible for 45 million euros of supply, 42% of supply chain centre Europe, the rest of the supply is outsourced.

This research started with a problem stated by the manufacturing manager of VI factory in Veghel, the Netherlands as: "a lot of single items have to be produced which obstructs short lead time, batching and learning effect."

A deterministic analysis was done on the product and demand characteristics. The results were clear; in the year 2013, 82% of the 22.000 produced items were asked less than 5 times that year (49% of the items only once). Although the VI factory is there for special equipment, rush orders and R&D purposes, this amount of single time asked items is huge. The analysis revealed a high level of customer specific parts, whereafter the wish to go to a more configure-to-order order fulfilment strategy was expressed. With the large growth goal in mind, the organization has to be capable to process large volume with low effort in the future.

An academic point of view was chosen to investigate under which circumstances it would be beneficial to aim for a CTO order fulfilment strategy. The main research question therefore was formulated as:

"Under which circumstances is it beneficial to change the order fulfilment strategy to Configure-to-Order (CTO) to realize better efficiency in the overall sales to production process in a currently project-based customized capital goods Engineer-to-Order (ETO) environment?"

To investigate this main question, sub-questions were stated to assist in answering the main question. A literature review about ETO and CTO was set into place to explore all the advantages and disadvantages of both strategies. It was found that CTO implies standardization and modularization which effect both demand and product characteristics.

Because of the environment most capital goods manufacturers are dealing with (opportunities are normally scarce, the number of competitors high and potential profit involved when winning an order is typically high), capital goods companies tend to be more customer-accommodating than mass producers.

It became clear that neither a pure engineer-to-order nor a pure configure-to-order strategy would fit this specific environment of capital goods suppliers. We came up with a strategy to apply a hybrid CTO order fulfillment, so that most parts are standardized and smoothened for efficient supply, while under exception customer specific modules can be offered to accommodate customers' wishes. This included an operational plan to accommodate learning

from earlier developed customer specific items. (Appendix I. Suggested implementation ESoT and CTO-planning-BOM)

After the demand characteristics, the current business processes were investigated, which showed the route of a project through the functional departments; sales, engineering, supply chain, production/procurement and installation.

This process analysis showed, next to large current level of customization in the ETO company, another important barrier that has to be overcome to take advantage of standardization and modularization, namely the present way of activating the supply chain. Nowadays the supply chain is triggered activity by activity (activity = sub-project), because of the logistic delivery and installation sequence of projects. This means that projects are released bit by bit and procurement/production orders are created accordingly. This hinders ability to batch and to have insight in upcoming demand. The new developed process model suggests a CTO-planning-BOM implementation, which enables supply chain to make use of upcoming multi-project demand. (Appendix I. Suggested implementation ESoT and CTO-planning-BOM)

Advantages for Vanderlande

The main opportunities for Vanderlande when applying this hybrid CTO can be summarized as follows:

- Overall project cost can be lowered to improve profit margin or competitive pricing. Expected cost savings over 10 percent per project (realistic estimation based on MechZB experience and minimal engineering effort) Given 115 active PP projects with an average value of 1.8 mln euro this may lead to a cost saving of more than **20 mln euro** on current order book.
- Lead time reduction by skipping engineering for common modules/parts. Estimated possible project lead time reduction of 25 days. (currently 55 days on average for PP as shown in Figure 12). Shorter lead-time leads to lower utilization of engineering, so more engineering capacity for new projects. This enables future growth.
- Lead time reduction by knowing demand of common parts earlier (already after sales phase). Long lead time products can be purchased earlier. This reduces supply risk and overall lead time (critical lead time path), which enables faster time till commissioning, which improves competitiveness.
- Lead time reduction by making standardized items to stock, postponing CODP. In optimal configuration, production lead time only depends on production time Customer Specific Modules. (reduction of 3 weeks possible)
- Possibility to spread workload, by producing in advance (balance out peaks and declines in workload for VI factory).
- Reduction of setup cost (**€127.000**) and increased learning effect by batching in VI factory.
- Price reduction at suppliers by economies of scale. When being able to look over multiple projects, activities can be combined and purchased at once. The net effect is hard to estimate, but if supply chain centre Europe for example can reduce purchase cost by only 1%, the total cost will go down by **over €1.000.000 per year**. Because mechanical and

control equipment is responsible for more than 60% of the total project cost, a small reduction influences the competitive pricing of a project significantly.

- Reduction of number of orders at suppliers (by placing larger orders at once), 10 percent reduction of number of orders lead to a yearly cost saving of **€98.000**, mainly caused by reduction of administrative costs of supply chain and invoicing.
- Quality improvement, which leads to less extra materials. Estimated reduction of 10% will lead to a reduction of costs of **€525.000** on the parcel and postal order book of 115 projects.

Suggested actions to take

The suggested redesign of the business processes involves making sales decision-restrictions less voluntary. The sales department should be rewarded when they are able to sell as much as possible standard modules in a project. This can be encouraged by making customers pay a premium when choosing special design. Also the project engineers should be rewarded when making use of standard modules. Trainings about consequences of initial choices related to cost further in the supply chain should be given. The decision to make a module customer specific should cost a bit more effort to accomplish; mandatory discussion with multi-disciplinary team (sales, engineering, R&D, supply chain, production) is recommended.

When sales and project engineers think more in standard modules, the supply chain should be ready of making use of **early information and multi-project demand** instead of release activity by activity. This is crucial for harvesting the benefits and can be achieved by adapting the ERP system.

Integration with available resources and plans

The implementation plan that is made is based on practical and realistic adaptations of currently available resources. This means that:

- The ESoT engineering tool will be integrated as "configurators" with the new concept of CTO-planning-BOM.
- The standardization program of the system engineer in PP that includes the standardized "core" of a system and the customer specific "shell".
- STEP standardization in Parcel and Postal will be the standard component library for feeding ESoT of the sales engineers. This component library can also be used for evaluating standardization performance by calculating percentage of STEP components.

Expected difficulties

Expected difficulties are mainly in implementing and maintaining modular and standardized thinking philosophy:

- Rolling out worldwide standards; every customer centre should be aware of the standards and has to be urged to use them.
- Train sales engineers to sell standard where possible and only make customer specific modules where needed.

- Motivate engineers to early release parts.
- Try to get an integral knowledge among the departments about available technology (including all customer centres).
- Implementation of a new ERP system to enable early knowledge and ability to feedback on expected demand and real demand (change during engineering). Also after an item is bought via a multi-project order, the items have to be reallocated to the right activities.
- Because the suggested redesign still allows for special design, the risk of falling back into old patterns with a lot of Customer Specific Modules (CSM) is big.

Conclusion

For Vanderlande the potential cost savings and therefore competitive advantages when adopting the hybrid CTO order fulfillment strategy are huge. The key is to make restrictions instead of guidelines and allow only high exceptional customer specific design. When relaxing the rules, the risk of falling back to the same level of customer specific modules per project is high. Next to that, the processes (mainly the supply chain processes) should be adapted to enable to take the benefits of multi-project demand and early information. A radical change of the ERP processes is needed.

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VI. LIST OF ABBREVIATIONS AND CONCEPTS

Activity:	A part of a project.
ASUF:	Activity Split Up Form
BOM:	Bill Of Materials
Chute:	outfeed where parcels fall into and are collected after sortation.
CODP:	Customer Order Decoupling Point
Common items:	Items that are can be used in more than one product.
CSM:	Customer Specific Module
CSP:	Customer Specific Part
CTO:	Configure-to-Order
Depot:	A depot is placed in a local region and typically has less volume to handle than a hub and includes scales in the system to decide upon price.
EOQ:	Economic order quantity
ERP:	Enterprise Resource Planning
ESoT:	Engineering Suite of Tools
ETO:	Engineer-to-Order
HUB:	A (air)hub is a large transfer depot where large volumes of parcels are handled and time slots are important.
JIT:	Just-In-Time
MRP:	Material Requirements Planning
MTO:	Make-to-Order
MTS:	Make-to-Stock
PP:	Parcel and Postal
SKU:	Stock Keeping Unit
Special:	Product that is especially designed for a specific customer/project
SPEC:	Specification
TCO:	Total Cost of Ownership

Introduction

1. BUSINESS CONTEXT

This chapter is about the environment the research is done in. Section 1.1 describes the characteristics of the company including history, products, geographic, core values and organisational structure. Section 1.2 gives some insight in the Parcel and Postal (P&P) sorting business to get a feeling of the systems the company is dealing with.

1.1. Vanderlande Industries

This section will start with the history of the company, will continue with a description of the products and geographics. At last the core values of Vanderlande will be discussed, so that a good feeling for the company environment is created.

1.1.1. *History*

The company is founded in 1949 by Eddy van der Lande, who started 'Machinefabriek E. van der Lande'. He started with production, service and repair of machinery in the textile industry in Veghel, the Netherlands. In 1963 the factory was taken over by an American company called Rapistan, at this time they started to focus on internal handling systems. In 1989 the van der Lande family bought back their company. In the same year the Lockerbie terroristic attack took place, the reason a lot of security systems had to be integrated in baggage handling. The next year a big order of parcel company UPS was placed. The last decennia they grew out to market leader in Baggage Handling systems and also number one market player in sorting machines for parcel and postal companies. Besides that, the company is now focussing on innovative products and warehouse solutions for automatic storage and order picking. The organization is providing jobs to 3200 people.

1.1.2. *Products*

Vanderlande Industries installs material handling systems of many different sizes, from local sorting depots, airports and distribution centres to the largest installations in the world. The sales organization is differentiated into 3 different focus groups; Baggage Handling, Parcel and Postal, Warehousing.

Baggage handling systems is handling baggage from the start at the check-in desk of an airport, through sorting and scanning, optional temporary storage, and further on to the right aircraft. And the other way around after arrival; from the aircraft, through sorting, to the right arrival carrousel. This focus group counts for 46% of the total revenues.

Parcel and Postal sorting systems is handling letters and parcels in various distribution centres. The process the systems are able to handle start with unloading of trucks, infeed in the sorting system, scanning, and outfeed into different chutes with different postal areas. This focus group counts for 12% of the total revenues.

Warehousing systems is handling various types of products from pallets to boxes and crates, from the moment of arrival, through storage to order picking. This focus group counts for 21% of the total revenues.

Next to these three main markets, Vanderlande is generating revenue by providing service on the delivered systems, which counts for 21% of the total revenue nowadays.

1.1.3. *Geographics*

Vanderlande operates worldwide with its own offices in the Netherlands, Belgium, Germany, France, Great Britain, Spain, Canada, China, India, South Africa and the US. These are all customer centres. Next to these customer centres, there are three supply chain centres; in Veghel, the Netherlands, in Atlanta, US and in Shanghai, China. They are responsible for purchasing and delivery of parts to the installation site. In Veghel, Vanderlande operates their own factory where they produce mainly sorters, specials and rush orders.

1.1.4. *Core values*

Vanderlande has summed up some core values in their mission statement. These core values are visualized in Figure 1. Some of these values with direct business perspective will be explained in short below.

Figure 1 Core values

As shown in this picture the centre value is: **Build reputation with customers; improve the competitive position of our customer.** This value suggests customer focus to the fullest. Vanderlande understands that they provide the core capability to their customers businesses who need 100% reliability. Vanderlande recognizes that their reputation relies on their successes in the past, but has to be maintained to the fullest for being a reliable partner in the future.

The second value is **Drive to win; we aim to be the best.** Vanderlande does not stop when they win an order, they only stop once they have completed the project to the customer's total satisfaction, technically and financially.

The third value is about innovation and learning. **Every day better; continuously learn, develop and innovate.** Vanderlande encourages their people to develop themselves in order to sustain in a dynamic constantly innovating environment.

The fourth and last value that will be high lightened is the one about sustainability; **We care; to minimize our footprint.** Every day, they challenge themselves to design products and solutions that are healthier to work with, more energy efficient and designed to have minimal impact on the environment at every stage of their lifecycle.

The other values focus on personnel, their safety, environmental responsibility and teamwork but are not that relevant for the research later on.

1.1.5. *The organizational structure*

The recent structure of the organization is shown in Figure 2. Since 2014 a COO is set into place to manage the overall operations, including the supply chain and Vanderlande's own factory in Veghel. The market directors take care of each business unit, the chief technology manager of the R&D. Next to that, departments of communications, HR and Finance are supporting the other departments.

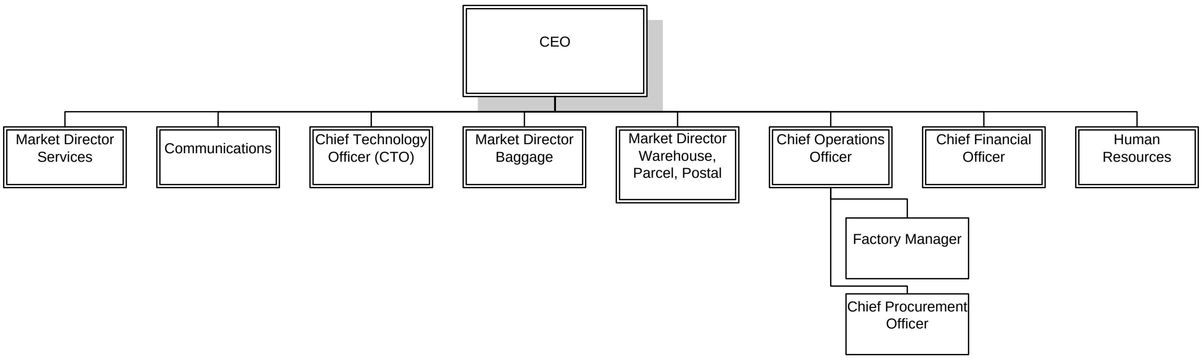


Figure 2 Organizational chart

1.2. A parcel and postal system

The available technologies for the parcel and postal industry will be shortly introduced in the first appendix to get familiar with the systems Vanderlande offers to their customers in the P&P business. It includes unloading of a truck, through infeed, scanning, sorting and outfeed. A typical P&P process is explained in Appendix A. Parcel and Postal projects.

2. PROJECT DEFINITION

The problem definition chapter starts with the problem statement (Section 2.1). In this section, the problems experienced by several managers within the company are discussed. In section 2.2, the objectives of the research are defined to keep a clear focus. The defined research questions are expressed in section 2.3. These research questions are translated into a research assignment in section 2.4. Section 2.5 discusses the related literature and the existing gaps in that literature. This chapter will end with the explanation of the methodology used in this research, which is explained step by step in section 2.6. A small section about the scope is inserted as section 2.7 to conclude the chapter.

2.1. Problem Statement

Vanderlande is facing a large growth perspective. The company wants to realize a revenue growth to 1.5 billion euro's in 2018 during upcoming years, compared with 790 million euro's in 2013. In the current business structure, the company can be defined as a project-based company. Projects are separated into so called activities that lead to production/procurement orders. While orienting on the company, via introductory meetings with different people of different departments, some issues became clear:

2.1.1. *Supply Chain Department*

The supply chain department experiences that a lot of customer specific items (specials) are asked by the engineering department. Therefore the economies of scale for ordering large quantities are difficult to negotiate about and achieve at suppliers. Next to that, they experience a lot of late revisions of the engineering department that have to be adapted last minute throughout the downstream supply chain. The last point that became clear through interviews with the supply chain department is the need for simplicity. In an example of the summer 2014, where the factory load was high and the supply chain decided to outsource other products than usual, it became clear that a lot of unwritten knowledge is inside in VI factory. External suppliers could not produce the products which were normally insourced because of lack of documentation, unclear documentation (vague drawings, limited assembly instructions) and complicated communication (help via supply chain to R&D, and information back via supply chain to the supplier). Another point that difficult the outsourcing of new products is the time external suppliers need to set up the supply chain and their manufacturing site. This leads to high setup lead times and therefore high costs.

2.1.2. *Engineering department*

The engineering department of parcel and postal experiences a large diversity of systems asked by the sales department. However it is not always needed regarding the functional requirements. Diversity in brands of electrical motors and controllers for example doesn't influence the performance of the system, but requires different component design and software development and integration effort.

2.1.3. *VI Factory*

At the production side of the company, the VI Factory, the stakeholders there also experience a lot of diversity throughout the product scala. Their main problem seems to be that orders are released activity by activity. Therefore it is difficult for the factory to make use of economies of scale (by collecting equal products into production batches). This results in more setups, low learning potential, higher cost price per piece. Next to that batching is not always possible because of the large diversity of product variants they have to produce.

2.1.4. *Installation*

In relation with production, the need for simplification can be seen when looking at all the different installation companies of all different countries Vanderlande is working with. Clear documentation is one important part, but simplification and standardization of installation methods is even more important, to achieve the quality customers require.

2.1.5. *Conclusion*

Because of the large number of orders (in May 2014 the number of active projects around the world were ±260 projects which consisted of ±80.000 activities), the potential efficiency gain through combining projects and/or activities in the supply chain seems to be big. Next to that it seems to be a problem that there are a lot of specials, customer specific equipment, which are designed and engineered for a specific customer.

To conclude this problem identification, it seems that different departments suffer from the gigantic diversity of products Vanderlande Industries delivers. Although one of the core strengths of Vanderlande industries is making customer specific solutions, it seems that the value chain suffers too much from this customization. Especially in reaching the financial objectives of the company. The ideal solution would be a solution that satisfies customers combined with a healthy profit margin and easy manageable supply chain.

To sum up the problems inside the company and the relations between them, a cause-and-effect diagram is created which can be found in Figure 3. Note that this diagram is based on a first interpretation and is not fully verified on correctness or completeness.

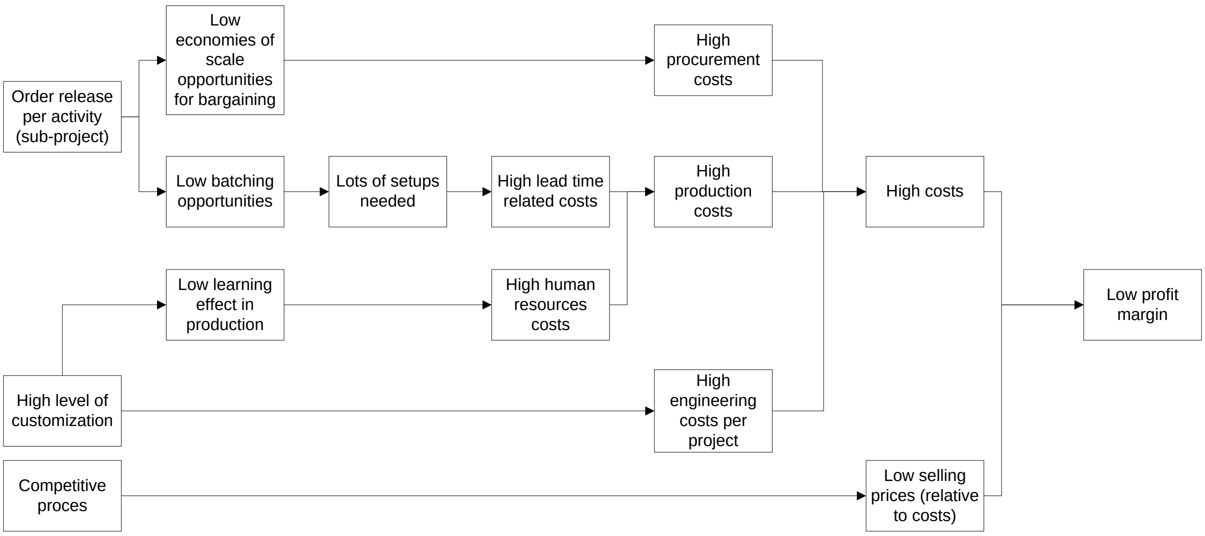


Figure 3 Cause and effect diagram

2.2. Objectives of the research

The aim of this research has two objectives. On the one hand the solution has to be useful, practical and applicable for the problems of the organization of Vanderlande. On the other hand the research should be generally applicable for similar cases in the capital goods market. The general aim is to **reduce overall value chain costs** and **reduce overall lead time** to achieve a better competitive position and enabling growth.

2.3. Research questions

2.3.1. *Main question*

After the problem identification, a common viewpoint was discovered. Most managers agreed that, for being competitive and being able to grow in the future (revenue goal of 1.5 billion Euros in 2018 (Hamers, 2014)), the product characteristics should be shaped to a more modular, standardized configuration. In this way the engineering department could be relieved, so they can focus on new concepts and innovation. If the company wants to grow in the same way they did before, the engineering department will be the bottleneck. Vanderlande will have to attract a lot of new engineers (some say 300 extra engineers) and train them, to realize the same performance. Finding these extra engineers on time and train them, will be realistically nearly impossible.

By getting more communality among the projects, the supply chain might be simplified for the majority of the products (common parts). In this way production and procurement could be done in a more efficient way (get better prices due to economies of scale). This standardization would lead to the so called Configure to Order manufacturing strategy, where systems (products) are configured from standard parts when a customer order comes in (SupplyChainInsights, Assemble-to-Order, 2014).

Because this common viewpoint affects a lot of different departments (not only manufacturing), the main research question is shaped as follows:

> *Under which circumstances is it beneficial to change the order fulfilment strategy to Configure-to-Order (CTO) to realize better efficiency in the overall sales to production process in a currently project-based customized capital goods Engineer-to-Order (ETO) environment?*

2.3.2. *Sub-questions*

In order to answer the main question, some relevant sub-questions were generated in order divide the problem into smaller pieces.

1. What is the problem and what is the severity?
2. Why should it change? What are the benefits of changing? When should we change?
3. What should be standardized and what not?
4. What will the consequences be for the organization as a whole?
5. How should we execute the change?

With these sub-questions the research approach can be defined, as shown in chapter 2.4.

2.4. Research Assignment

By having the research questions in place, the research assignment was shaped to get a clear view of the assignment. The assignment is shaped so that it will also cover the research gap.

> *Design/develop a tool to decide under which circumstances a change in order fulfilment strategy from a project-based engineer-to-order (ETO) strategy to a more configure-to-order (CTO) order fulfilment strategy is beneficial for a company that sells, engineers, produces, installs and services capital goods with focus on predefined target markets.*

This research assignment can be logically divided into different sub-assignments. These are based to give answers on the sub-questions in previous section:

1. Analyse the problem and severity.
2. Analyse the current business processes.
    2a. Analyse the relevant value chain processes.
    2b. Analyse what the relevant cost and lead time factors are.
3. What are the differences (benefits and disadvantages) of ETO and CTO.
4. Develop a framework for deciding to choose between ETO and CTO.
5. Apply the framework on the case study of Vanderlande.
6. Make an implementation plan.

2.5. Related literature

An extensive literature review was done to get some feeling and insight in the subject and company environment (Jansen, 2014). A summary can be found in Appendix B. The part that has been extracted in this paragraph is about the gaps in literature. This to express the need for this research.

2.5.1. *The gaps in literature*

As explained in the literature review (Jansen, 2014), there are gaps in literature which can be filled by this research. Especially the implementation of transitions of manufacturing strategies is poorly discussed in literature. A lot of characteristics are given for different manufacturing strategies, but no literature was found about the subject under which circumstances it would be better to change a ETO organization to a CTO configuration. This master thesis project focusses on this gap in literature.

Also the adaptations that have to be managed by the rest of the organization is poorly described. The article about a competitor of Vanderlande, Crisplant, aimed to create awareness and discussion about the problems around implementing standardization which they suggest have to be taken into account at the start of the implementation phase, but lacks to come up with solutions. This research project will hopefully be good addition to the field of implementing organization wide change.

2.6. Methodology

This chapter contains the project plan and explains step by step how research project has been approached. It is based on the research questions as well as on the deliverables combined with clear reasoning.

2.6.1. *Step 1 Deterministic analysis*

The first step to be taken will be the analysis of the existence and severity of the problem. Although there are signals of the problems obtained by interviews with the supervisor and other managers, the severity should be quantified. This will be done by an analysis of the demand characteristics and patterns that occur in the supply chain and VI factory. The level of detail of the components will be decided upon based on availability of data.

2.6.2. *Step 2 Current business processes*

The current underlying business processes involved in the sales to production process should be analysed in order to get a clear view about the project flow, and also about the involved departments/parties. This will be done by interviews with involved parties and by following a Parcel and Postal project from moment of sales up to the arrival at production/outsourcing. The need for this is to investigate the interactions between departments and possible improvements later on, in terms of process change. The current decision factors for choosing to make or buy will be investigated and analysed for getting insight in the relation between product characteristics and method of supply.

Next to that the already introduced standardization programs will be discussed in this part, to investigate successes, possibilities and pitfalls of these programs.

2.6.3. *Step 3 The differences between ETO and CTO*

In this section, the differences between ETO and CTO will be explained in various perspectives. This will lead to a structured overview of both manufacturing strategies, each with their advantages and disadvantages. The influences on R&D, sales, engineering, manufacturing, procurement, installation, services and finance will be explained.

2.6.4. *Step 4 Tool for deciding upon changing ETO to CTO*

Given the differences of both manufacturing strategies, related to some business/organizational characteristics, a tool for deciding when to change from ETO to CTO will be developed. Results of the literature review has to be taken into account. The goal of this tool should clarify the decision to transform an organization into CTO or stay in an ETO environment, or maybe choose a hybrid or more sophisticated approach. In the next step this tool will be evaluated in a case study at Vanderlande.

2.6.5. *Step 5 Apply the framework on the case study of Vanderlande*

Using the tool as developed in step four and applying it to the case study of the company, Vanderlande. The tool will figure out what strategy should be adapted and what will be the opportunities for the company.

This chapter will also discuss the opportunities and threats for the company.

Internal sources suggested that some pilot projects are done recently where standardization was applied which lead to large cost savings in supply chain. These projects could be compared with traditional projects that have a more ETO strategy. These savings potentials might be extremely important for getting a support base for implementing change later on.

2.6.6. *Step 6 Implementation plan*

This last step will investigate the implementation of the solution. This step will focus on process of implementation. How to get a solid organizational structure around the chosen ETO or CTO order fulfilment strategy, that is organizational widely acknowledged and applied, but especially how to initiate that change process.

This ideal situation is the situation to achieve optimal way of working, producing and buying. Processes will be redesigned in order to improve interdepartmental cooperation. Ways of working will be explained.

2.7. Scope

In this research we will focus on the parcel and postal business unit. This because the main problem stakeholder is the manufacturing manager, who is responsible for the factory. The factory mainly produces for the parcel and postal and warehouse automation business unit. The warehouse business unit is quite new and has a lot of immature products. The parcel and postal business unit is however quite mature. The aim for this research is to investigate how total cost and lead time can be reduced for the total value chain, including the factory and will therefore be most applicable for the parcel and postal.

Analysis

3. DETERMINISITIC ANALYSIS

For validation of the problem, an analysis has been done on the characteristics and the severity of the problem. This was done via interviews with managers and employees within the supply chain, engineering, manufacturing engineering and sales departments. The characteristics of the products were investigated and also the demand characteristics that appear throughout the supply chain. The data included data from supply chain centre Europe and the VI factory in Veghel; this to keep it relevant for the VI factory and because the total supply network of Vanderlande is incredibly complex; the 22 Customer Centres all around the world can purchase locally or at the allocated supply chain centres (EU / NA / AP). Next to that the supply chain centres can place orders at each other. This chapter will start with start discussing the product characteristics in section 3.1, including supply distribution and the characteristics of a typical Parcel and Postal project. The demand characteristics are discussed in section 3.2, this includes an analysis of the items produced, the quantities of items in one work order, demand patterns and a lead time analysis.

3.1. Product characteristics

The products/systems Vanderlande designs, engineers, produces and installs consist of a huge number of components. Some of these components are used very often and some of them are used just once (analysis in section 3.2). The unique products only made for just one project/customer are called “special” or customer specific. The definition of special is different for the supply chain department and engineering (Ex. A longer support stand is maybe not defined as special by engineering, because it is the same product with just a little adjustment in length, but for the supply chain department, that has to purchase the stand, it has a new product ID and is a special, never bought before, product).

3.1.1. *Supply distribution*

As mentioned before, Vanderlande has its own VI Factory, but it is not used for the total production. Of all the supply delivered by supply chain centre Europe (responsible for 106 million euro of supply per year), 31% appeared not suitable to produce in the VI factory and always has to be outsourced. Out of the left over 73 million euro, 45 million (62%) is insourced and 38% is outsourced. So the factory only takes 42% of the total supply of supply chain centre Europe.

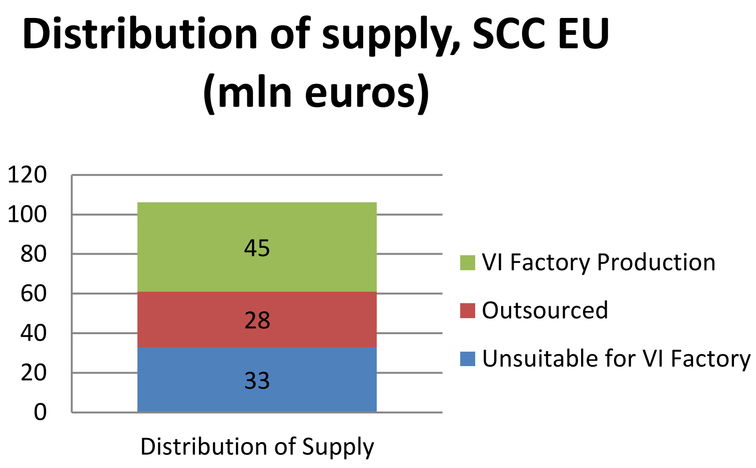


Figure 4 Distribution of supply SCC EU (2013)

3.1.2. *The characteristics of a P&P solution*

In this paragraph we want to get insight in the causes for differences in solutions in the different parcel and postal projects. The following factors are revealed by interviewing an experienced system engineer and sales engineers. The choices are made at the sales phase of a project. The system variety factors of parcel and postal projects are summed up:

- Is there an existing account (UPS, FEDEX, DHL,….) Or choose similar. This is done in an informal way, by experience or by asking collegues.
- Is it a Hub or a Depot? Varies in needed capacity, reliability, need for scanning and scaling or not.
- Region: this can create variety due to other current or safety standards.
- Kind of sorter: Line sorter or loop sorter
- Single sorter or multiple sorter
    - When using multiple sorters, the following configurations are possible:
        - Presort, two loop sorters with a presort to decide on which loop.
        - Crossover, one loopsorter fed on two sides with a shortcut to the opposite site at the beginning at each infeed.
        - Merging exits, one loopsorter with exits that merge, so that each exit has two exit places on the sorter.
        - Hybrid solutions from options above.
- Product family, DOTM, STARS or Baggage.
- Customer preferences on various kind of parts.

When a product family is chosen, the sales engineers will start with making a layout.

3.2. Demand characteristics

At Vanderlande the demand characteristics are quite complicated; it namely depends on the chosen viewpoint. In the end, formally spoken, the customer is the demanding party that wants a solution that fits their needs, normally expressed in sorting capacity, reliability and mostly non-technical requirements. These needs are translated by the sales engineers to a workable solution / system. One step back in the value chain; from the viewpoint of the supply chain department, the physical demand is determined by the specifications of the products the engineers come up with. In upcoming paragraphs the demand characteristics of the parts of supply chain centre Europe and the VI factory are analysed.

3.2.1. *Supply Chain EU*

By analysing supply chain data of the supply chain Europe department it was shown that out of 15.062 unique item numbers ordered by the supply chain department within a year, only 60 of them were considering stocked items. Note that the level of detail is the so called specification level (level 3) (see Appendix E. Level of detail). Of the 117.306 purchase order lines (PO), only 2.824 of them were considering stocked items. A perceptual figure is created and shown in Figure 5.

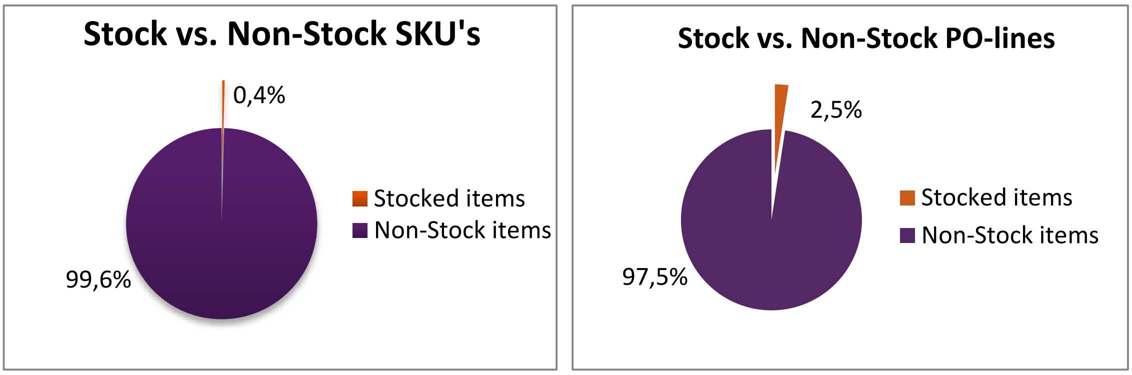


Figure 5 Stock vs. Non-Stock

The results indicate that it is presumably that most of the items are customer specificly bought by the supply chain.

3.2.2. *Factory*

Items produced

The supply chain outsources 58 percent of the needed equipment, while the leftover 42 percent is made in the VI factory in Veghel. By analyzing the 20.815 unique items numbers produced by the VI Factory on work order level over the last year, it turns out that a lot of them are just ordered once. Figure 6 shows a pie chart that visualizes how many times items are produced. The measure used data of a time span of one year. As one can see, for 49% of the 20.815 item numbers, the production volume is only one per year. Cumulatively speaking 82% of the unique items are ordered at most 5 times.

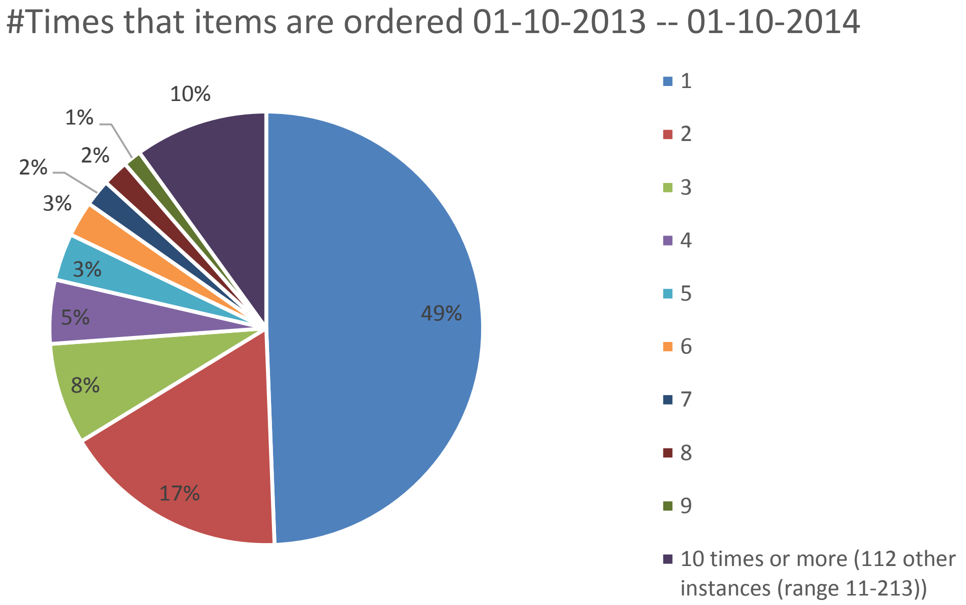


Figure 6 # times items are produced

Work orders

Item numbers are ordered at the factory through work orders. If one looks at the work orders and the quantity of products in these work orders, it is clear that the same effect is there as with the unique item numbers. Using the data, it is shown in Figure 7 that 27% of the 101.297 work orders only contain one piece. Cumulatively speaking, more than 65% of the work orders contain 5 pieces or less. The average work order quantity turns out to be 19.2. Another way of visualizing can be found in Appendix C.

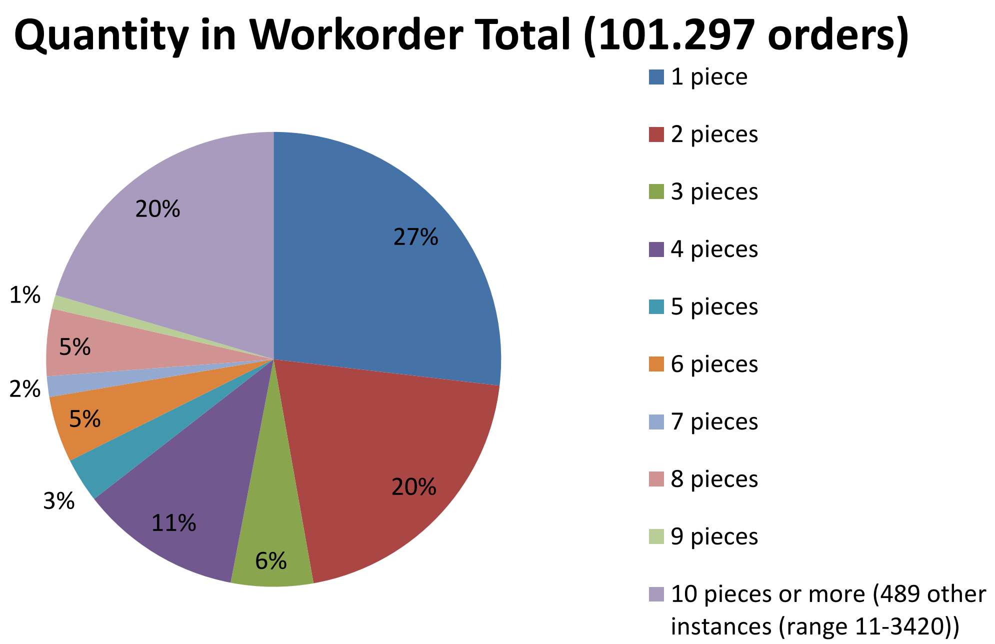


Figure 7 Quantity in Workorders, all items

Note that this analysis includes all work orders, including MRP controlled items. These MRP items are ordered in EOQ quantities and controlled by the factory itself and not controlled by the supply chain. The MRP items with an average order quantity of 121,3 are skewing the graph by a few percent. By excluding the MRP items, it is clear that relatively even more work orders contain just a low quantity (Figure 8 shows that 70% of the work orders contain less than 5 pieces). The average order quantity is 13,9.

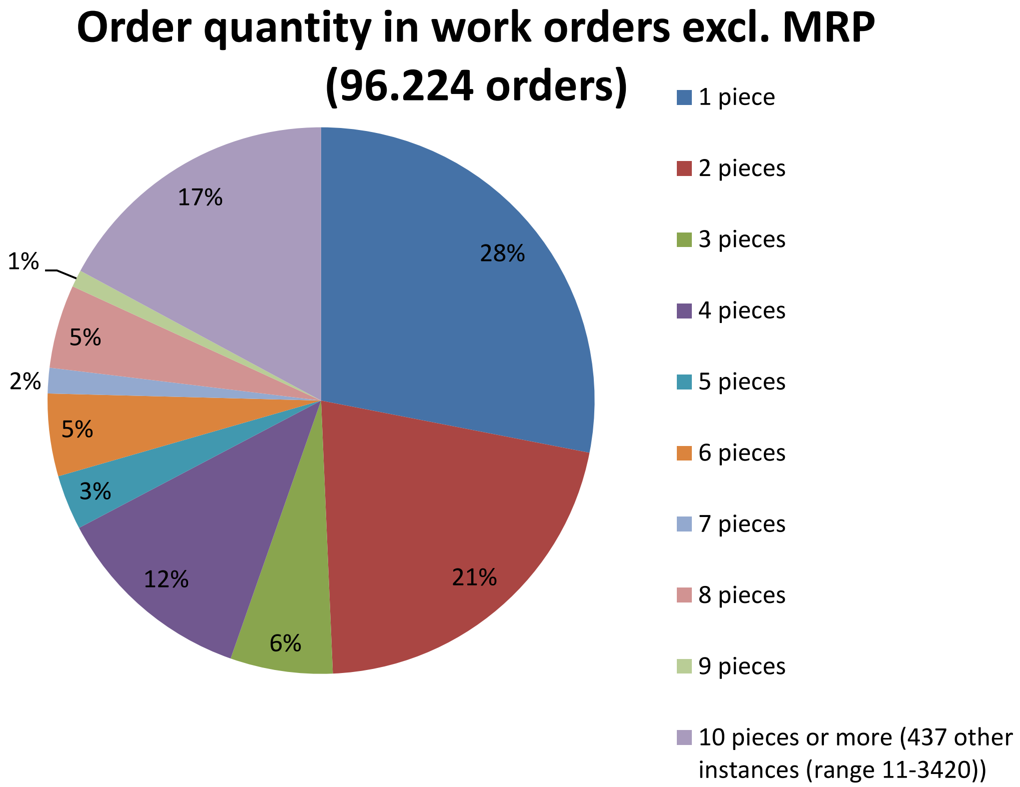


Figure 8 Quantity in Workorders excluding MRP items

Although the factory is also there for prototypes (which reduces common parts) and specials, it still seems that the communality in the systems/products is very low. Also because the factory is responsible for producing all the sorters, one would expect more communality.

Demand pattern

To provide insight in the demand patterns of the items produced by VI factory, a framework to classify them is provided by Syntetos, Boylan & Croston, (2004). They distinguish between smooth, intermittent, erratic and lumpy demand. The classification uses the average demand interval (ADI) and Coefficient of variance (CV) to distinguish between the classes. Figure 9 displays this framework.

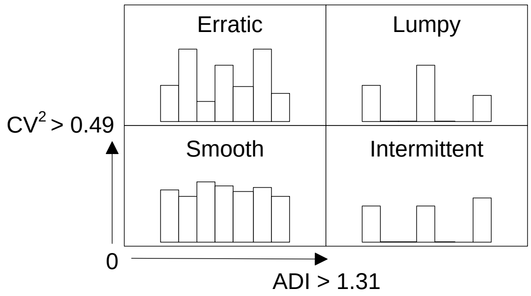


Figure 9 Demand classification framework (Syntetos et al., 2004)

For applying this framework to the demand characteristics of the VI factory, a dataset, that contained the demand per item on a specific day, was used. The Coefficient of Variance was calculated to determine if the demanded quantities vary a lot per order or not. The average demand interval was calculated by determining the average time interval between two successive consumptions of a spare part. When all the items were classified, a graphical representation was created, as shown in Figure 10.

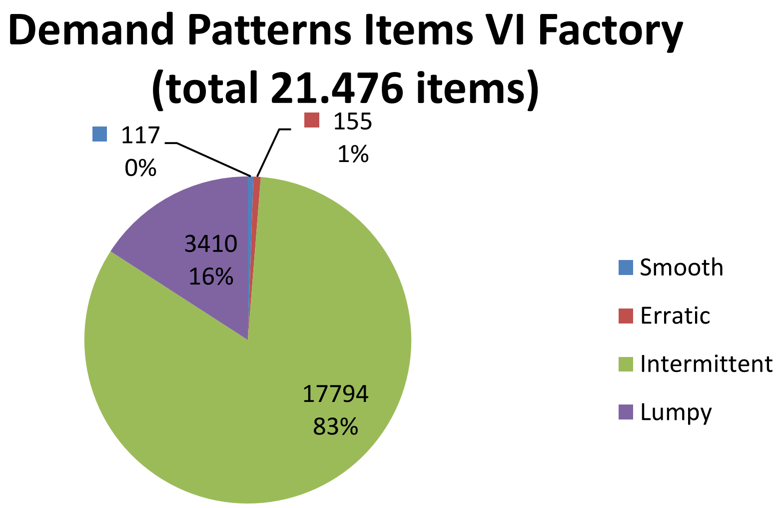


Figure 10 Classification of demand via work orders VI factory

Note that, because a lot of items are asked only once per year, most of the items are classified as intermittent and lumpy. Because the total number of items produced is large (21.476), the absolute values are added in the figure, to show the 117 item numbers that are smooth and the 155 that are erratic.

Next to these individual patterns, it is known that in history, there are some overall demand patterns for the VI factory. During the months December, January and February, the workload is usually much lower than the rest of the year. Although this is not every year (for example in 2013 it was not the case), it is good to notice.

Setup Times

In order to batch, multiple pieces in a work order are needed. Increasing the batch size leads to a reduction of setup time per piece, which reduces setup costs. Data of the year 2013 shows that over all work centers of the factory, on average almost 25% of the time is used for setups. The maximum percentage is 76% of the time for work center 123 (Excenterpers 45 ton), but as shown in Appendix F. setup times, this workcenter wasn't used a lot of hours. However, workcenter 153 (Buigen L=2050) for example, is used 11.832,65 hours in 2013 and almost half of it, 48% of the time, is used for set ups. Also the other workcenters that perform bending, (150, 152, 154) have relatively high setup times and a large amount of hours.

If yearly setup times could be reduced by batching more of (exactly) the same products or reducing product diversity to be handled, this would lead to a substantial cost saving. This because less time will be spent on setting up, less waste during setup time and higher net production time.

Conclusion

Research question 1; "what is the problem and what severity of the problem?", can be answered as follows. The problem is that a lot of unique products are made in the factory with low quantities per work order, which result in high setup times and lack of possibilities for batching and learning. The problem hinders the continuous improvement goals of the factory.

The analysis above shows that, although there are some standardization initiatives, which are explained in section 4.3 (Current initiatives), most items are ordered only once a year, and this leads that they are ordered in single work orders. Note that this analysis is done for the VI Factory that is only responsible for around 42% of the supply. Looking at the DOTM line (a product family of a standardization program), which is for 80% of the items produced by VI factory (source: Appendix G. supply matrix), the same pattern (lot of single work orders) is visible.

Therefore it seems that the diversity is structural throughout the supply chain. This diversity leads to avoidable setup times, low learning efficiency and inefficient procurement. This observation makes managers think about other ways of working to reach more communality in the products. The current business processes are analysed in section 4.1, to try to reveal some causes of this tendency to diversify.

4. CURRENT BUSINESS PROCESSES

In order to trace where possible flaws in the way of working are, the current business processes are inspected in next paragraph. After that, in paragraph 4.2, the relevant cost drivers are examined to analyse which departments influence which costs, this in order to see where possible savings can be obtained. Section 4.3 discusses the current initiatives caring about standardization within Vanderlande, to get a feeling of the progress Vanderlande is making in their wish to standardize more.

4.1. Current value process

In this paragraph the current business process from sales to installation will be discussed in order to get some insight into the way of working nowadays within Vanderlande, visualized in Figure 11.

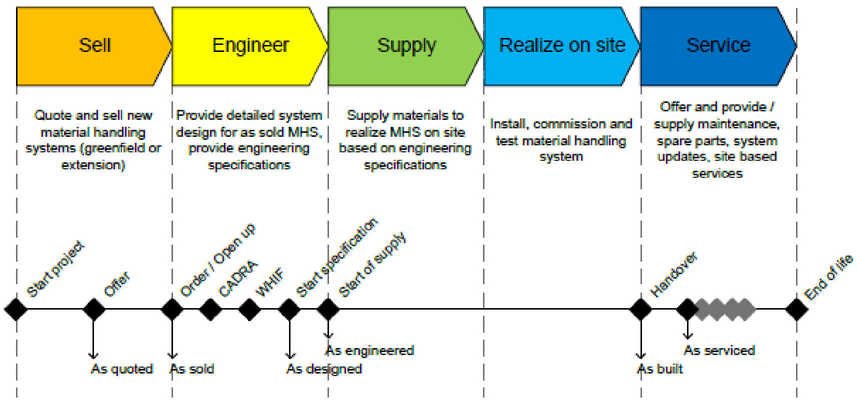


Figure 11 project phases including deliverables

This section will end with a conclusion about this way of working.

4.1.1. *Selling*

In the selling phase, sales people and sales engineers use some basic components to create a sales-layout. In this stage the project is separated into smaller functional chunks (so called activities). Equipment choices depend on customer restrictions and capacity characteristics. These items come with price indications. By adding these prices, together with some margin and unforeseen costs, a sales quotation is made and is send to the potential customer.

4.1.2. *Engineering*

After a project is sold (the hitrate for parcel and postal quotations is about 30%-50%), an open-up meeting is held to hand over the project from the sales department to the engineering and planning department. After a period of definition of the sold system, the total project is split up into activities by the ASUF (activity split up form) to separate the big project into a logical installation sequence. A project planning is made which will be separated into an activity planning. After this meeting, the engineers start to define in depth the requirements and specifications of the system. Normally they pick products out of the product data book (PDB) and combine it to complete the **engineering-layout** of the project. If necessary, they adapt standard components from the product data book to create customer specific items (so called specials) that fits the customer needs. When an activity is fully specified and the planning for this activity is known, it continues to the supply chain department.

4.1.3. *Supply chain*

At the moment supply chain gets a specification of an activity (SPEC) released and the activity planning is known, the spec proceeds through the supply chain. Each of the activities are classified as buy, make or switch item, which means that that they are normally bought externally, made by the factory, or can be done by both (internal/external). Which items are capable to insource or outsource are summarized in supply matrix, which is shown in Appendix G. Note that these choices are on high level of detail (Level 3, Appendix E. Level of detail). The choice for switch items to be made in the factory or to be outsourced depends on the workload of the factory. When the factory is highly utilized, switch items can be outsourced, but when the factory is underutilized these items can be made internally. Supply chain is responsible for getting the right amount of products at the right time at the right installation site.

4.1.4. *Production/outsourcing and shipping*

As said before, products can be outsourced to external partners or produced in the factory in Veghel. In essence both parties are treated the same, with an agreed lead time of 8 weeks, but the strength of the factory is that they can handle rush orders and extra material real quick and without extra ordering costs. The details of the internal production process of the factory are not relevant for the explanation sales to order process and are therefore out of scope. After production/procurement, the orders are sent to the distribution centre that will take care of the shipment to the installation sites.

4.1.5. *Installation*

The installation of the equipment is done by third parties, under supervision of Vanderlande. Some companies work together with Vanderlande for a long time and are very experienced in installation of their equipment. But in relatively new and bigger geographical regions like Africa, America and Asia, Vanderlande has to search for local companies that can do the installation for them is stead of flying in expensive mechanics from Europe.

4.1.6. *Commissioning*

After installation commissioning is done, this includes testing and small adjustments. Therefore the extra material flow of the supply chain needed in this phase should have a short lead time, in order to get the commissioning done as soon as possible to get the last payment and close the project.

4.1.7. *After sales/services*

In many cases Vanderlande provides service contracts in order to keep systems rolling. Next to that Vanderlande sometimes provides operators to operate the systems on a day to day basis and is therefore a total service solution provider. Spare parts are also an important part of the after sales services.

4.1.8. *Lead times decomposition*

By analysing the planned lead times of the different project phases of 18 different Parcel and Postal Projects, the following results are revealed.

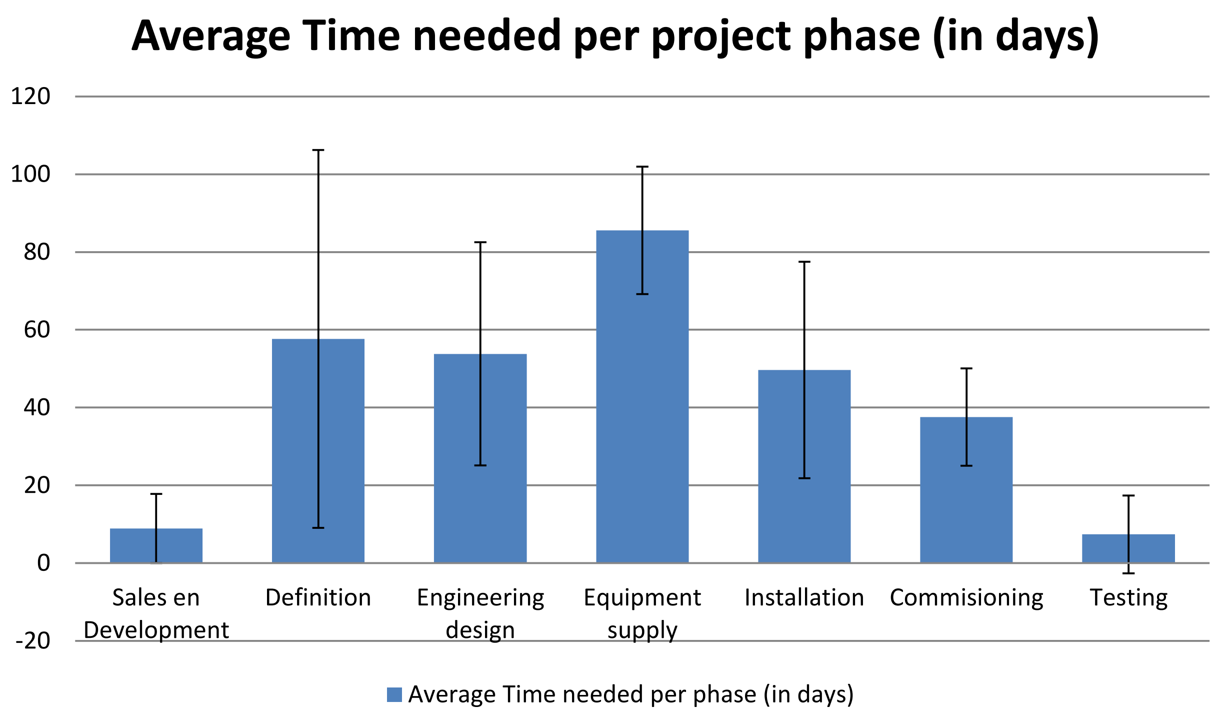


Figure 12 Lead time decomposition

Figure 12 shows the average lead times of the different project phases, including error bars counting for 1 standard deviation. Note that, in comparison with the sequence mentioned above, the Engineering phase is split up in Definition and Engineering design, also commissioning and testing is split up. As one can see, the times for definition, engineering design and installation are quite variable. This time needed for the different phases highly depends on the project planning and project size. Some projects allow for longer time slots, while others need to be delivered and up and running as quick as possible. Depending on these factors the number of engineers is scaled and the processes are planned in parallel accordingly, this is done in cooperation with the engineering department.

The average PP project (including overlap) takes 256 days, so around 51 weeks. The average overlap of a PP project is 15%, which means, compared with a serial approach, the total lead time is shortened by 45 days by working in parallel. Note that on lower level, things have to be done in parallel to obtain on time readiness, for example, multiple activities should be specified in the same time.

4.1.9. *Conclusion*

In the sketched business processes, it is clear that the organization and processes are structured around the projects. All of the processes are triggered by the project schedule and more in detail; by the activity schedule throughout the engineering and supply chain department. The company has around 260 projects running synchronously and this number is growing. The strength of this approach is the strong customer focus and local control of the projects, but the weakness of organizing these processes around projects is that the total organization cannot reach a higher level of optimization than on project level. Normally a project is finished when the customer is satisfied, where after no or little feedback is taken into account for future projects.

4.2. Relevant cost drivers

To shape the goal of reducing cost, relevant cost drivers for a project are determined. This to investigate where potential cost savings can be obtained. Phases where no of little cost are made are not as relevant for savings programs as big cost drivers.

Given the business processes, the relevant value chain cost drivers can be obtained step by step by walking through the processes (based on (Partridge & Perren, 1994)). Note that factors containing time can be related to cost by multiplying it by the average hourly wage of the specific employees.

To start at the **sales** department; decisions over there influence the following cost drivers (NOTE: these costs cannot directly be related to specific projects because of the risk of not selling, they are included in the overhead costs):

- Decision to bid or not
- Sales layout time
- Level of detail sales layout
- Equipment choices

If a project is sold, the engineering department starts to design and calculate the system in detail. The cost factors the **engineering** department is influencing are:

- Layout engineering time
- Re-engineering product time
- R&D time
- Quality related costs (if a part is designed inferiorly)

Supply chain has the following cost factors

- Sourcing time (which supplier) *(not directly relatable to specific projects, included in overhead)*
- Purchasing Economies of scale influences *(not directly relatable to specific projects)*
- Order quantities
- Location of sourcing (transportation / wages) *(not directly relatable to specific projects)*

Production and suppliers costs consist of:

- Manufacturing engineering costs (for preparing work for production)
- Batching Economies of scale influences *(not directly relatable to specific projects*)
    - o Inventory costs
    - o Production time

- Assembly time (setup time/costs)
- Learning / experience effects (variable time/cost per unit)

- Handling costs
- Quality control costs

The costs at the **installation** base consist of:

- Installation time

Service has the following cost drivers:

- Service employee training
- Spare parts inventory costs
- Quality control costs

Next to these low level factors, there are also influences of the **strategic** management level *(not directly relatable to specific projects)*:

- Timing of market entry
- Vertical integration
- Capacity utilization (slack for shorter lead time)

To conclude this cost drivers section, a lot of cost factors are not directly relatable to specific projects. This means for a project-based company as Vanderlande, that these indirect cost drivers are probably not optimized given the current project-based way of working. It is assumable that because of this project focus, project costs are optimized and the overhead costs are less optimized.

4.2.1. *Cost drivers decomposition*

The decomposition of the costs is analysed by data obtained from 22 parcel and postal projects lead by the Dutch project management. Taking all these projects together the sales value is around 40 mln euros, so on average 1.8 mln euro per project. An extended version of the decomposition of costs can be found in Appendix H. The graph is based on Latest Estimated cost instead of actual costs, because a few projects are still in an early stage, but the budgets are known. Next to that only the cost drivers that counted for at least 0,5 percent of the total costs were taken into account to avoid a too extensive figure. As one can see, the main cost drivers are the equipment (mechanical and control) and the installation hours. Next to that, transportation and project management (including supervision and leadership) is taking quite a bit of the budget.

The heading extra materials, counting for 1,41%, contains all the costs made caused by not doing it first time right.

4.3. Current initiatives

Within Vanderlande some initiatives are started to ease the business processes, in the upcoming paragraphs, the initiatives DOTM, ESoT and Standardization in P&P, STEP and Triple-i will be discussed.

4.3.1. *DOTM*

The standardization initiative DOTM (or .M) stands for Distribution On The Move and started in 2010. The aim is to improve competitive position of Vanderlande in Distribution and Parcel & Postal projects considerably through substantial cost reduction and lead time reduction. The underlying philosophy is the use of modular design and high commonality of parts/modules to reduce product variants and different products. The .M conveyer can be equipped with various kinds of transportation surfaces like rollers, a closed belt or a multi-belt (Figure 13).

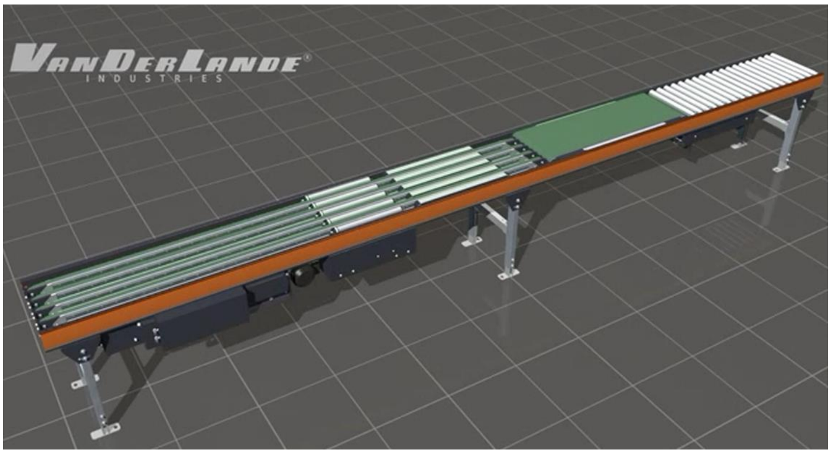


Figure 13 Example of DOTM conveyer with 3 types of conveyors (from left to right: Multibelt, Closed belt, Rollers)

According to the goals described above, the quantities in work orders suppose to be higher than when only using customer specific parts. But when looking at the quantities in the work orders, the average work order quantity is only slightly higher than the average without MPR; 16,8. Although this DOTM should be a standard, still almost 65 % of the work orders contain 5 pieces or less, as shown in Figure 14. A graph is shown in Appendix D.

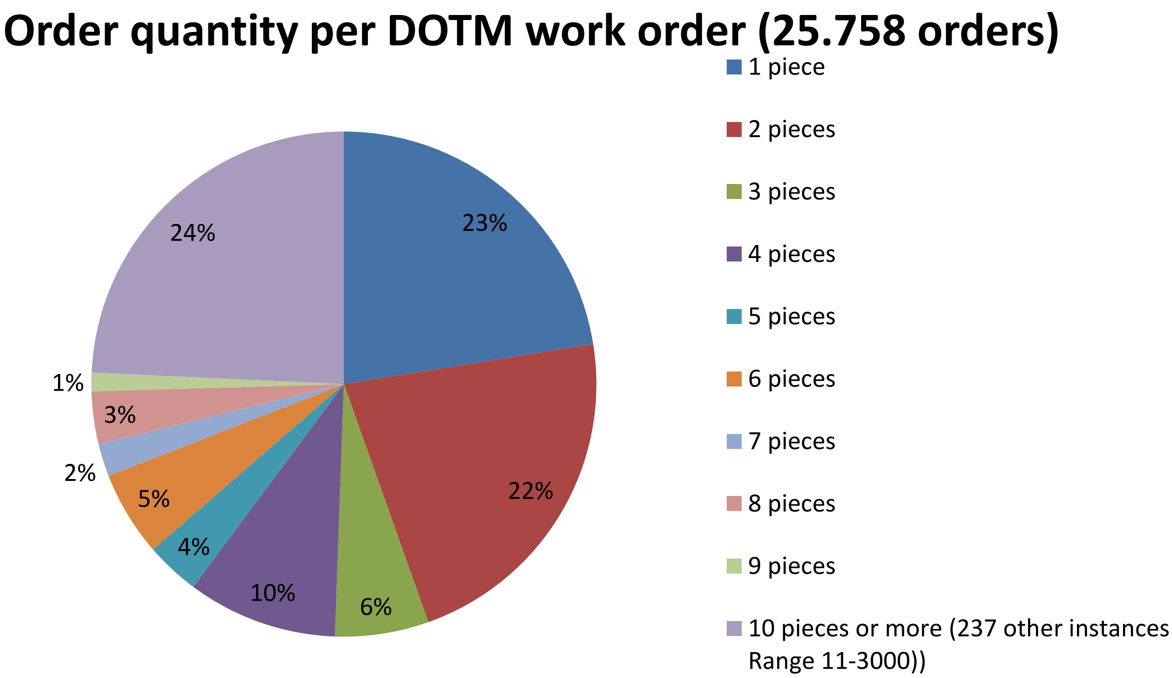


Figure 14 Order quantity in DOTM Work Orders

This suggests that DOTM philosophy doesn't work out that well, although there is a chance it saves engineering effort, it doesn't work out in the supply chain further on. DOTM can possibly save engineering effort, because the main conveyors have the same layout. But still lengths and widths can differ unlimited.

So although the initial thinking behind the DOTM line is good for lowering diversity and higher efficiency, but in practice it seems that engineers still customize too much, or at least are releasing in small portions to the factory.

4.3.2. *ESoT*

In 2010 Vanderlande introduced its Engineering Set of Tools (ESoT). With this tool Sales Engineers can configure a system with components of the library. Five reasons to develop ESoT were given:

1. Promote faster creation on high quality system design.
2. Improve information transfer to controls, supply chain etc. ESoT offers detailed system data from the early design stages of a project by the use of standard building blocks with default values.
3. Make implementation of products easier / less consuming.
4. Integrate tooling throughout engineering process.
5. Upgrade all engineering tools to one architecture.

The advantage of ESoT above other systems is that it already contains information of the underlying components on the bill of material. In this way, supply chain should be able to substract the items needed for the projects early in the project, and be able to make use of economies of scale from these projects.

The project is rolled out in the baggage handling business unit at first. In 2014 the system becomes available for parcel and postal projects.

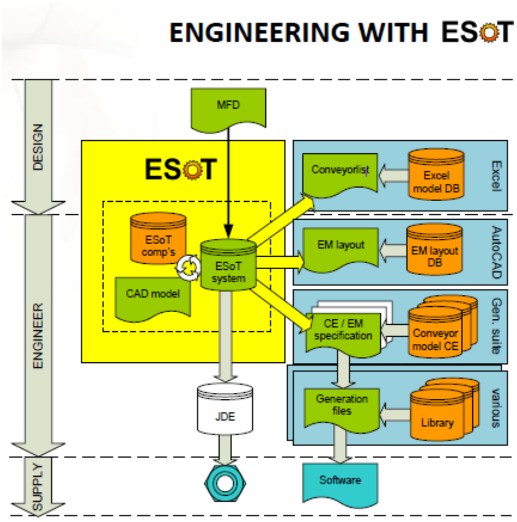


Figure 15 ESoT system architecture

After diving somewhat deeper into the ESoT theory, is became clear that ESoT eases the engineers to choose for modular standard solutions, but still allows for special customer specific equipment, because reason of developing ESoT number 3 is “make implementation of products easier / less time consuming.

Another issue that has to be taken into account is that although the sales engineers configures with chosen standardized modules in the initial quotation phase, these choices are subject to changes till the moment the project is completely specified in detail. These changes make the initial BOM less useful, together with the fact that the BOM can only be extracted on a project level and not on multi-project level.

Therefore the way ESoT is implemented feels as the result of some compromises between departments where total organizational wide advantage is not optimized.

4.3.3. *Standardization in P&P*

A system engineer at the parcel and postal engineering department initiated a standardization program from the practical viewpoint. He wants to create standards for parcel and postal solutions. The principle behind this is to create a standardized “core” of the VI system, with a flexible, customer specific “skin” in the work centers where operators interact with the system. The system engineer came up with 4 different product families that should be able to handle all different products; these include two DOTM variants for postal items, small and large and two airport equipment variants, for small and large express packages. This principle should reduce the number of variants to create more communality in the solutions.

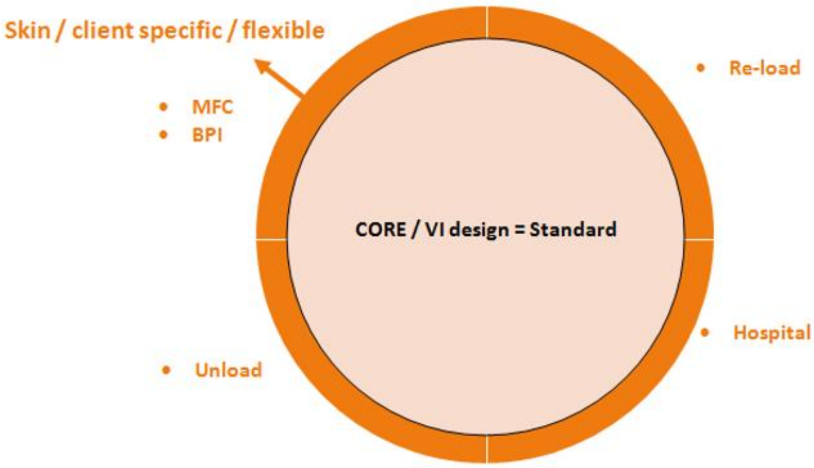


Figure 16 Core- Skin figure standardization in PP

4.3.4. *STEP*

STEP stands for Standardization Express parcel and Postal. This program is based on the lego-block style of configuration of zones. This program/library is operational and gives (sales) engineers choices for the right equipment. The system is separated into zones; infeed, collector, sorter, output, alignment, identification. For each zones the different options can be chosen. This program could be a good basis for applying modularization and standardization in P&P. An overview is shown in Appendix J.

4.3.5. *Triple-i*

The triple-i project is an improvement project, focusing on the Tubtrax product of the baggage handling, that aims to reduce the price and therefore the costs by a target of -30%. This project is divided into different teams with different responsibilities; Way of Working, Value Proposition and Technology. They want to make the product more competitive by getting more generic products to reduce inefficiency in product and process.

4.3.6. *Conclusion current business processes*

All the current initiatives mentioned above have a lot of potential, the main obstacle seems to be the organizational wide support base. The initiatives seem to stand alone and are not coordinated. This observation has to and will be taken into account in the implementation plan.

4.4. Conclusion

This analysis of the business processes and cost drivers also answers sub-question 1 about the severity and causes of the problem. It seems that the departments are working really independently and separately, deciding upon taking standard or special solutions on their own, which results in lack of communication and responsibility and presence of redundancy.

Given the analysis of the current business processes, the value chain strategy seems to be an ETO strategy with some standardization efforts. Because customers are involved from the beginning of the design process and projects will be adapted to all customer preferences. The main research question ("*Under which circumstances is it beneficial to change the order fulfilment strategy to Configure-to-Order (CTO) to realize better efficiency in the overall sales to production process in a currently project-based customized capital goods Engineer-to-Order (ETO) environment?")* is therefore relevant for the Vanderlande company.

In the next step, the differences between ETO and CTO will be investigated.

5. DIFFERENCES BETWEEN ETO AND CTO

In order to make a proper consideration on going from ETO to CTO or not, first the strengths and weaknesses of both strategies should be known. Therefore this chapter will summarize these characteristics. Sources of the literature review (Jansen, 2014) are used, together with some new sources. The chapter wil start with the characteristics of ETO (5.1) and CTO (section 5.2). Thereafter a comparison is made in section 5.3. This chapter will end by summarizing the consequences when changing from ETO to CTO (Section 5.4).

5.1. Characteristics ETO

The definition of Engineer-to-Order is not clearly described in literature. In this report the following definition will be used: **Engineer to Order** (ETO) is a manufacturing process defined by demand driven practices in which the component is designed, engineered, and built to specifications only after the order has been received. It is a more dramatic evolution of a Build-To-Order supply chain. This approach is only appropriate for specific and rare items, such as large construction projects or Formula 1 cars (SupplyChainInsights, Engineer to Order, 2014).

The concept Engineer to Order comes with some implications. As discussed in Jansen (2014), ETO fits to a pure customization type of products, where products are customized from the design phase. The CODP lies at the engineering phase and the supply chain is typically designed in a pull type way to avoid unusable inventory.

“High levels of customisation lead to increased costs, higher risks and long lead times. Furthermore it impedes outsourcing, since the requirements for component and subsystems can only be specified after completion of the design process. ETO companies have recognized these difficulties and attempt to increase design standardisation by utilisation of modular design principles” (Hicks et al. 2000)

5.2. Characteristics CTO

A **configure-to-order** (CTO) system is a special case of Assemble-to-Order. The components are partitioned into subsets, and the customer selects components from those subsets. A computer, for example, is configured by selecting a processor from several options, a monitor from several options, etc. The difference between a CTO system and an ATO system is important at the demand-elicitation level. At the operational level, however, the differences are minor. (Song & Zipkin, 2003)

Just as ETO, Configure-to-Order manufacturing implies some unwritten assumptions. CTO enables customized standardization, where the assembly is customized, but the fabrication is not. Each customer thus gets his or her own configuration but constrained by the range of available components.

The CODP therefore lies at the assembly phase and the order fulfilment strategy can be done in using a push or hybrid push-/pull strategy to reduce lead time. To enable CTO, parts should be modular, so need to have standardized interfaces. Note that there are more ways of modular design (Ulrich, 1995).

Increasing use of common parts enables:

- Buy with economies of scale
- Build inventory of parts
- Shorter lead time by postponing CODP

Increasing use of common modules enables:

- Build to inventory
- Increase assemble batch size
- Increased learning effect
- Shorten lead time by postponing CODP

5.3. Comparison ETO vs. CTO

The table below shows the comparison of ETO and CTO, based on descriptions obtained by literature review of Jansen (2014).

Table 1 Comparison ETO vs. CTO

ETO	**CTO**
Infinite varieties	Finite varieties (configurations)
Components only used in one end-product	Common components are used in more end-products
Procurement has to be done with low economies of scale	Procurement can be done with high economies of scale.
Maximal customer involvement	Less customer involvement
Production of components triggered by demand	Production of components can be triggered 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
No learning effect	High learning effect
Spare parts are quite specific and are costly to keep on stock	Spare parts are uniform for various systems and can be kept on stock less costly
Less easy upgrading	Easy upgrading by interchange of module
Higher costs when high communalities among customer needs	Lower costs when high communalities among customer needs

To conclude, CTO has a lot of advantages throughout the value chain. It is a balance between the best factors of ETO and MTS. The production is optimized for standardized components which can be made to stock. This realizes short lead times. On the other hand, the finished products are assembled to order, which takes into account the customer preferences. The concept is promising, but because it is a balance between two principles (ETO and MTS), the balance should be maintained and managed carefully to be successful. If you stick to your modules and never innovate, you will loose selling potential. On the other hand, if you want to make customer specific modules every time customers ask, you're module library becomes too big and you cannot realize efficiency from the CTO strategy.

CTO implies standardization and modularization to ease the configuration. Off course benefits come with risks which are summed up in Table 2 (Arnheiter & Harren, A typology to unleash the potential of modularity, 2005).

Table 2 Risks and benefits of modularity

Assembler		**Supplier**	
Benefits	Risks	Benefits	Risks
Reduction of capital requirements	Reduces entry barriers for competitors	Raises entry barriers for competitors	Modules can become commodities
Reduces direct labor requirements	Loss of some design control	Long term contracts	Increase direct labour
Reduces time-to-market for new products	Design limitations	Surviving suppliers have strong market position	Increases capital requirements
Facilitates mass customization	Suppliers lack the necessary competences		Suppliers not capable of producing modules lose market share
Increases productivity			
Simplifies supply network			

When the entry barriers for competitors are reduced, because modules become a commodity, it should be considered to protect copying. One can think about patents, but also about strategic insourcing to reduce the risk of copying by suppliers. One can think about the ink cartridges (interchangeable modules) manufacturers of printers and copy machines make brand/series specific in order to try to protect their own business and to discourage customers from buy imitational cartridges of competitors.

5.4. General consequences of changing from ETO to CTO

5.4.1. *Sales*

Sales of a CTO product can be easier than of an ETO system. The components of a CTO system are usually proven concepts where the quality and reliability is proven. The customer specific needs can usually be satisfied with limited different variants of modules. In consumer products, configurators are used to offer the preferred specification. One can think about (online) car configurators.

5.4.2. *Engineering*

When changing the order fulfilment strategy form ETO to CTO it influences the KPI's of the engineering department. In this part, the differences will be summarized.

For engineering processes the Key Performance Indicators (KPI's) that are typically defined are (based on (Zomeren, Engineering efficiency: Van ETO naar CTO, 2013)):

- Lead time
- Quality; number of errors per order
- Innovations per time unit
- Cost; engineering hours per million gross revenue and cost of product

KPI's ETO

Under ETO, the engineering KPI's are normally evaluated as follows:

- Lead time is typically long; the cause normally is the buffer of work in progress. This comes with the problem that not documented sales information dilutes if lead time is long. And due to demand uncertainty, the CODP cannot be moved backwards, so less inventory-controlled added value.
- Quality is not secured when product is not made and tested before. There is also the risk of coping failures when one copies from an old project.
- When using ETO, it is often the customer that comes with the ideas, this approach is following instead of leading. Real R&D is usually too costly, especially during crisis.
- Costs are normally not linear related with revenues; engineering costs tend to grow faster than gross revenue.

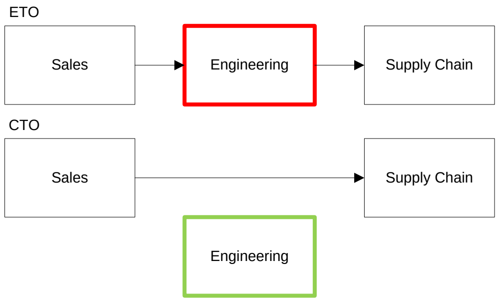
To conclude: ETO conditions are restricting structural growth.

ETO conditions can possible be a threat for competitiveness.

KPI's CTO

Under CTO, the engineering KPI's are normally evaluated as follows:

- Lead time is typically minimal; because at total CTO engineering is left out of the primary process. There is no work in progress between sales and engineering and no spill of order knowledge.



- Quality is typically high, because all modules are specified, produced and tested multiple times before, so quality risk is minimal.
- Innovation is possible in a leading way. Because engineering is relieved and can focus on continuous improvement of standards and innovation projects lead by the market.
- Cost of engineering is independent from revenue, which can lead to more investment in skills and education. Next to that, product knowledge is independent from the engineering crew.

To conclude: CTO enables more innovation

CTO follows a different path in the primary business process

5.4.3. *Production*

Production can be done much more efficient, because product communality will be higher, this will increase batch size and learning effect while reducing number of setups (including setup costs and time).

5.4.4. *Installation and service*

Modular products ease installation and service, due to the fact that the interfaces are the same and components are interchangeable. In this way old systems can be upgraded or maintained with more ease than pure customized products. Also maintenance personnel needs to have less system specific knowledge than in ETO.

5.4.5. *Integration*

A requirement of taking the decision to adopt a CTO strategy is that the total company should notice the taken decision. Not only it has to be communicated throughout the company, but also processes and way of workings should be adapted. Everyone must see the consequences of their own decisions they are responsible for throughout the value chain. Without organizational wide support / management, the CTO strategy is lost. More about this integration is taken into account in the implementation step; chapter 8.

Conceptualization

6. TOOL FOR DECIDING UPON CHANGING ETO TO CTO

Chapter 5 made clear what the strengths and weaknesses of CTO are, but no framework is available in literature how to decide when to transfer your order fulfilment strategy. This chapter aims to create a reliable **framework for project-based capital goods manufacturers to help the decision to transform form an ETO to a (hybrid) CTO order fulfilment strategy.** Note that this decision should be taken at the strategic level in the company, whereafter it can be rolled out downwards.

Deciding to go from ETO to CTO, in other words, making more standardized, modular systems, is depending on several factors:

- What is the strategic value of a product / business strategy?
- What is the product life cycle time? What is the innovative stability?
- Can exactly the same module be sold in more than one project?
- Can the effort of engineering something modular be less than the cost of making it order specific each time?
- Can the transition make the company more competitive in terms of price, lead time and/or customer satisfaction?
- Different types of modularity

The framework as developed walks through this questions in sequence of importance, starting at the strategic level in section 6.1. The way of applying CTO on the products of a capital goods manufacturer is discussed in section 6.2. Because the implementation throughout the organizational levels often fails (Jansen, 2014), this framework also gives handles to roll out properly at operational levels in section 6.3. Section 6.4 discusses the supply management supported by literature study. Section 6.5 contains the conclusion of the framework.

6.1. Strategic considerations

The first consideration that has to be made by the general management is to decide what the business strategy and value creation model of the company is. The company wants to satisfy customers and has to prioritize its goals in doing that. Customers of capital goods typically want a certain capacity, high quality, high reliability, total customized solutions, low operational cost and lowest investment as possible. Next to that, customers expect shorter and shorter lead times nowadays. The company management should make a priority list of those goals to come up with a business strategy. Next to that, the company management should already think about creative implementations of customer wishes in terms of restricted product scala.

The decision to adapt the CTO strategy should to be made when:

- The company wants to create customized products, with higher quality, reliability and lower production cost than before.

- The lifespan of different components is not equal to eachother and should be interchangeable during the lifespan of the system.
- The product is moderate to highly stable in terms of innovation and engineering changes and not changing its module interfaces or in total continuously.
- Outsourcing is key for the company.
- Customers fit within focus markets with same type of product needs.
- The company wants to reduce erratic and lumpy demand.
- The company wants to be able to spread workload more easily (produce in advance).
- The company wants to produce/sell medium to high volume of components with medium to low mix.
- The company wants to make a supply strategy that is ready for outsourcing and therefore able to grow in the future.
- The company wants more efficient after-sales.

A visualization is made and can be found in Figure 17

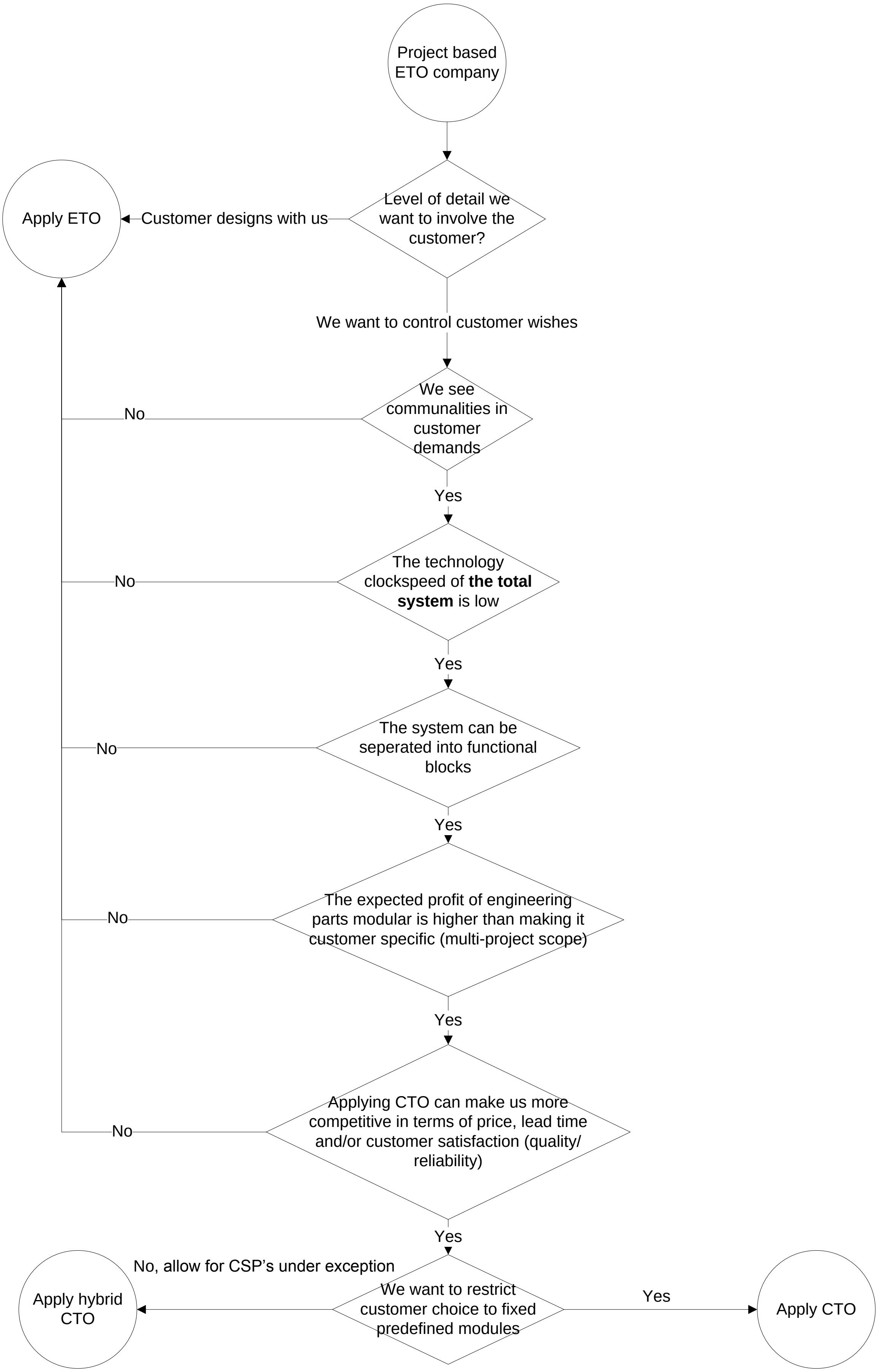


Figure 17 Strategic considerations

6.2. Tactical considerations

Once the strategic level has expressed its choice to adopt CTO, on tactic level people need to help to decide about the size and level of modularization and number of variants that will be included in the product program. This can be done using the following systematic approach applicable for **capital goods suppliers with relatively stable products in terms of changes**.

1. Start at the highest product level (customer needs) and investigate what different (potential) customers want in terms of:
   - Capacity
   - Quality
   - Reliability
   - Price/budget available
   - Regulations
2. Find communalities in these needs among customers and try to bundle them into a restricted set (concept development). Examples can be:
   - Capacity ranges (n ranges)
   - Set reliability threshold (choose one all-covering reliability threshold in proportion with company reputation aim)
   - Premium/basic variant to serve high/low budgeted customers
   - Try to cover as much regulations in served geographical markets as possible at high level
3. Than the design on system level can be done. Important in this phase is:
   - Set a “heavyweight system architect” as team leader into place. (These people have a long experience in product engineering, have knowledge of the systems sold and understand customer needs. Next to that they gained some prevalence to ease making decisions.)
   - Map functional elements to components
   - Create interface standards and protocols with restrictions on (for example):
     - Mechanic
       1. Sizes (length, width, height)
       2. Material (incl. thickness standards)
       3. Type of fasteners
       4. Etc.
     - Control
       1. Connections
       2. Motors

3. Sensors
4. Cables
5. Software
6. Etc.

When making choices about types of modularization, one should keep in mind all the different types of modularization like Slot, Bus and Sectional approaches (Ulrich, 1995).

4. The detailed module design can start based on the decisions above, with the following characteristics:
    - Component design proceeds in parallel
    - Monitoring of components relative to interface standards and performance targets.
    - Design performed by “supplier-like” entities which means that interaction can be structured and relatively infrequent.
    - Component testing can be done independently.
5. Product/system test and refinement phase of modular systems typically includes:
    - Effort focused on checking for unanticipated coupling and interactions.
    - The required performance changes can localized to just a few components.
6. Match supply strategy with product characteristics as explained lateron in this section.

A visualization is made and can be found in Figure 18.

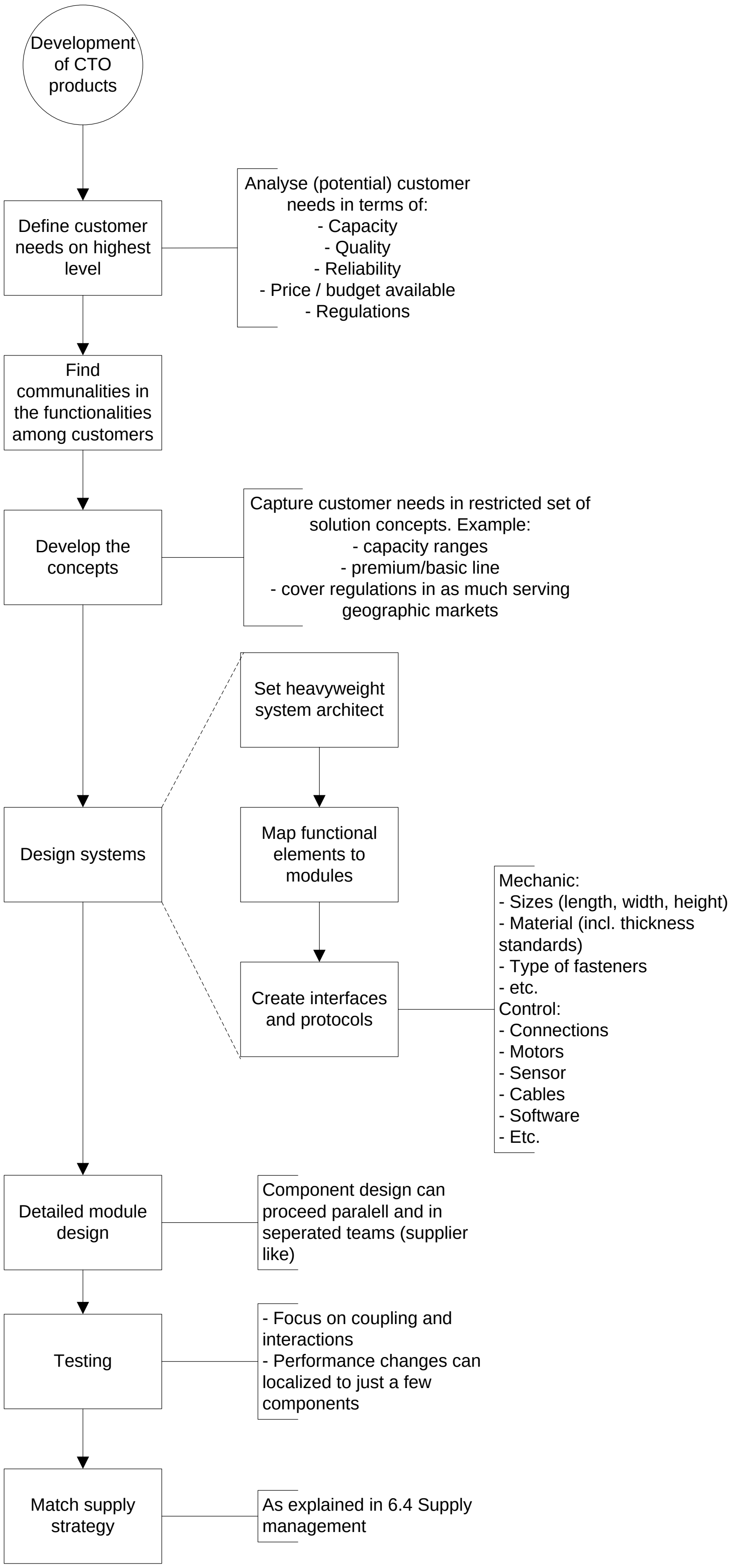


Figure 18 Tactical considerations

6.3. Operational considerations

If the steps of the product/module development are done correctly, theoretically the operations should be able to run smooth. The operational processes should live the rules and make use of the modules provided. Of course this is an utopia which can realistically only be achieved by consumer goods manufacturers like PC manufacturers that only allow limited configurations. For capital goods manufacturers the environment is somewhat more complex. The opportunities are normally scarce, the number of competitors high and potential profit involved when winning an order is typically high. This makes capital goods companies tend to be more customer-accommodating than mass producers. The operational steps in this framework are therefore based on a 'hybrid CTO' strategy that allows for exceptional customization, as visualized in Figure 19.

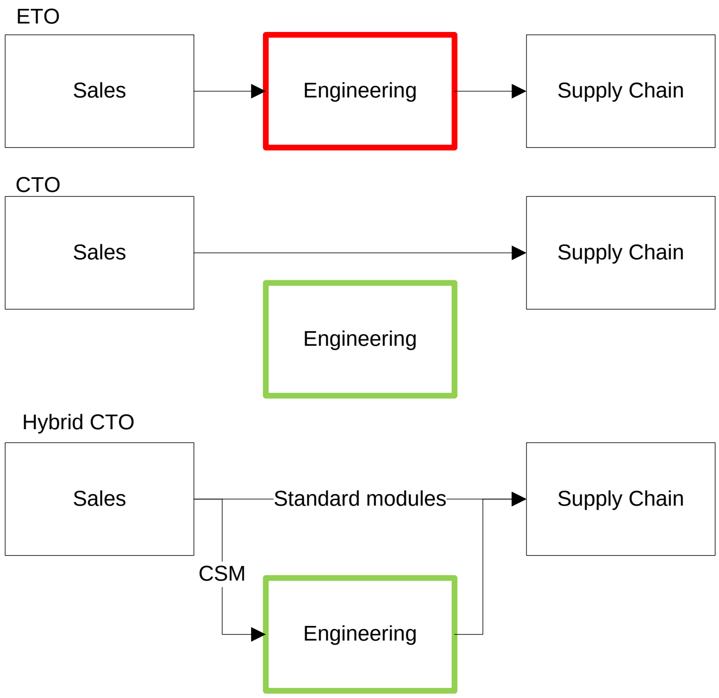


Figure 19 ETO vs. CTO vs. Hybrid CTO

This fact of the urge to win a bid feeds the friction between providing just standard solutions or making customer specific solutions. This needs to be managed properly to satisfy the customer on the one side and on the other side, ease the supply chain and reduce costs.

Therefore the sales people that interact with the customer should be trained to sell mostly standard modules and attract the customer with high-end options that fit the standard interfaces. A roadmap to give some handles for these sales people is created and shown below, please note the learning loop as described under statement 3.d.:

1. Configure a solution with standard modules as much as possible in proportion with the customer functional needs.
2. OR:
   - All requirements and needs of the customer can be met with the standardized modules and options, the bid can be made. Go to step 4.

- Customer specific module(s) (CSM) is/are needed. Go to step 3.

3. This step should be done in cooperation with the responsible product manager, the employee that is responsible for maintaining the modules. Things to be discussed are:
    a. What functionality and customer requirements does the CSM have?
    b. Can the needs be fulfilled with adapting an existing module or should there be a completely new module be designed?
    c. In both cases of question b., the consideration of adding the new/adapted module for future use has to be made.
    d. OR:
        - If the module is expected not to be used more than once, it should be designed customer specific. Make an estimated price to complete the bid and note that when sold, the CSM has to be engineered.
        - If a module is expected to be used in more than one future project, the following consideration has to be made:

        IF cost of engineering new standard < potential future order profit

            - Create new standard compatible with existing interfaces and protocols. Setup a multidisciplinary team with the engineer, a cost engineer, a supply chain employee and the product manager (R&D), to get the best integral optimized solution. Make an estimated price to complete the bid and start engineering when engineering capacity is underutilized or when the order is placed.

        ELSE

            - Make an estimated price to complete the bid and note that when sold a CSM has to be engineered.
4. Place bid.

When a bid is accepted:

5. Release standard components (modules and within modules) to supply chain and trigger engineering department for start engineering CSM's.

A visualization is shown in the figure below (Figure 20).

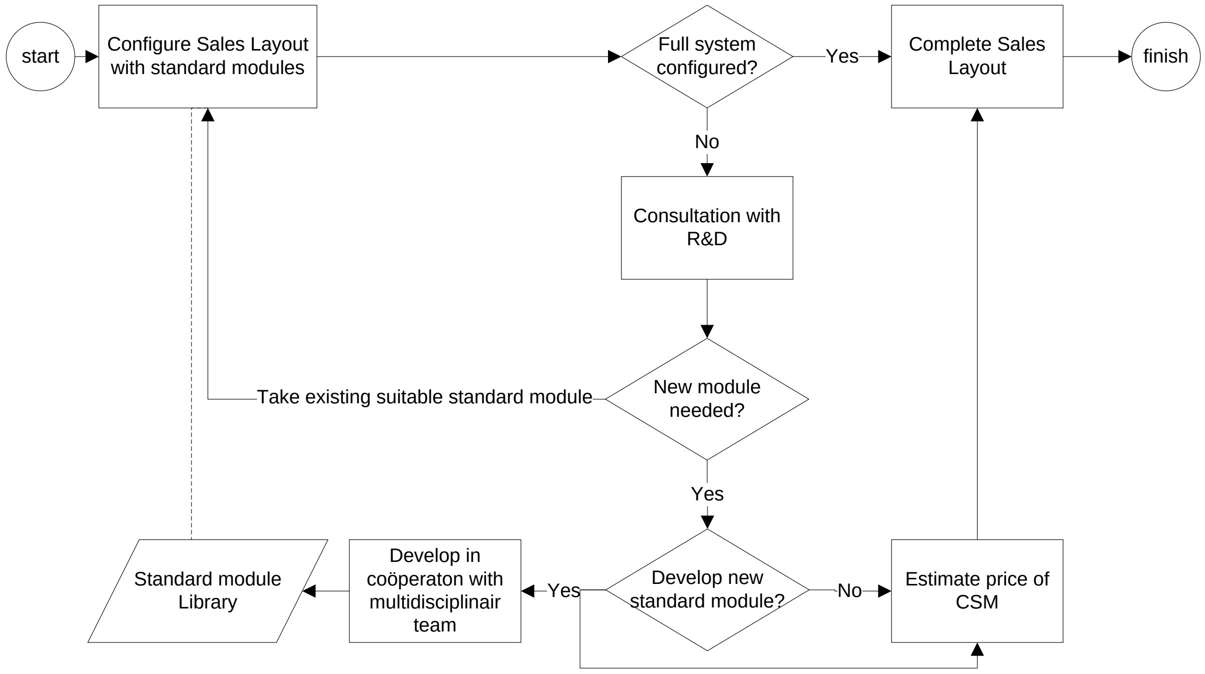


Figure 20 Operational considerations (extensive explanation see text)

6.4. Supply management

After the tactical considerations are made, or when the request for a new module comes in and after it is decided which parts will be modularized and standardized and which will not, the decision whether or not to outsource is relevant. Therefore the framework of Fine et al. (2002) can be used. First they sum up 5 qualitative key criteria that have to be evaluated to get insight in the strategic value in the product to be assessed.

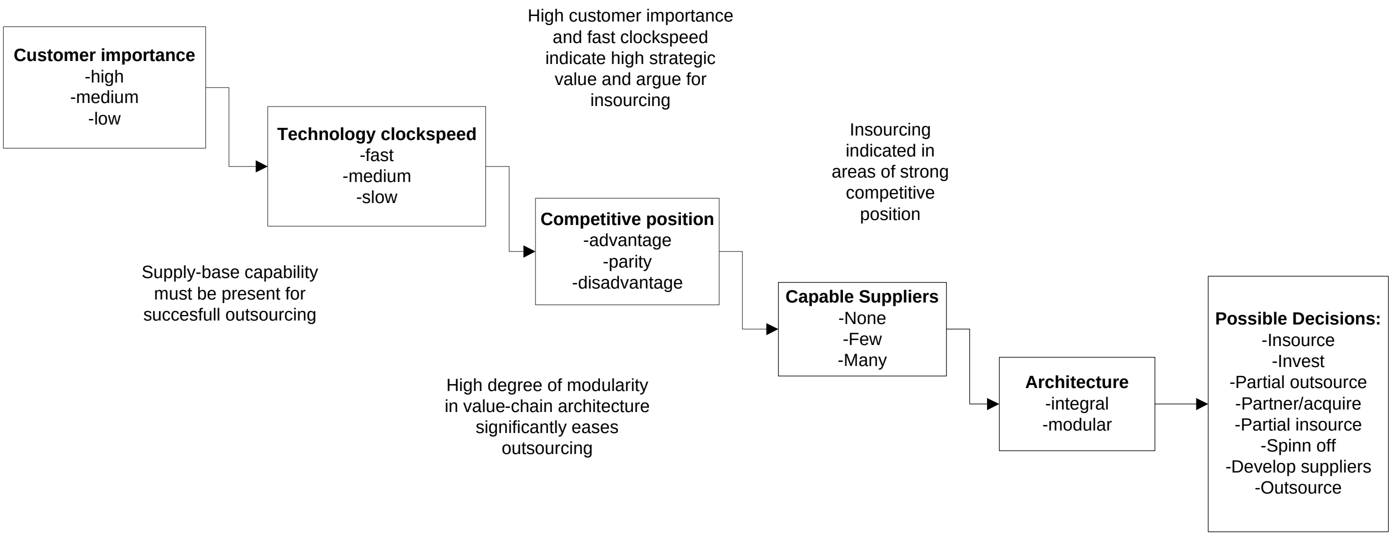


Figure 21 Strategic Value Assessment: Evaluating Five Key Criteria (Fine, Vardan, Pethick, & El-Hout, 2002)

The qualitative criteria should be considered carefully. To start with the **importance to the customer,** Fine et al. (2002) give an example of car manufacturing; customers do not have direct preferences on subsystems as engine blocks, valve trains or exhaust systems, they care about performance characteristics as fuel efficiency, acceleration, emissions and quietness and then relate those to powertrain subsystems. The *consumer base background is important*; sports car customers care about technical details, but minivan buyers care more about interior.

Technology clockspeed is important for outsource decisions. If technology is changing at slow pace, it is most likely that you will not lose competitive advantage when outsourcing these parts. On the other hand, when technology is developing at fast clockspeed like controllers and the company is dependent on suppliers, it can be difficult and/or costly to regain capability.

Competitive Position Strategic advantage can often be gained when companies insource those elements of their value chain in which they have relative competitive advantage. Especially in areas with high customer importance and relatively fast technology clock speeds. Fine et al. (2002) give the example of exact the same component that GM (General Motors) produces on the average cost in the market and decides to outsource it for lower costs. Toyota, however, discovered that they produce the same component at the lowest price in the market and decide to insource.

The capability of suppliers is also an important factor to notice. The fewer suppliers that exist for any outsourced component, the more considerable leverage those suppliers have over the receiving company. But when an extensive supply base exists, the key capabilities are more likely to be judged as commodities and not necessarily a source of strategic value.

The last factor, but not the least important in this research is the **architecture.** At this factor they follow Ulrich (1995), who explains that integral architectures exhibit close coupling among the elements of the product, where modular architectures feature separation among a system's constituent parts, where standard interfaces make the exchange of parts relatively simple.

These qualitative criteria, together with the economic value added can be used to decide on the sourcing strategy that fits the needs and values.

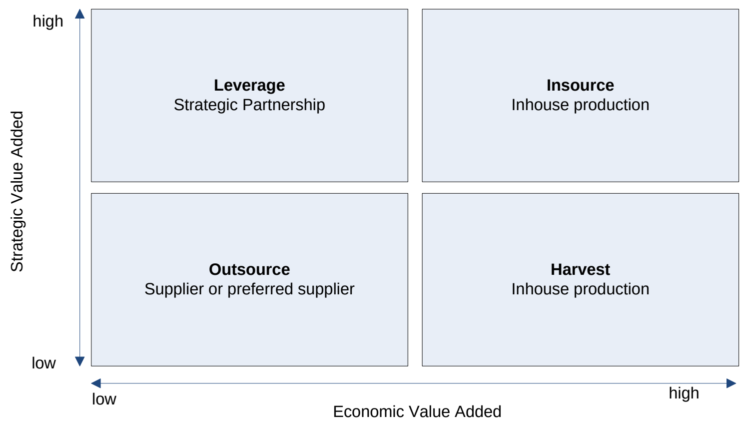


Figure 22 Value Chain strategy framework (Fine et al., 2002)

This last framework decides the sourcing strategy by evaluating the strategic added value and the economic added value. The strategic added value is a qualitative measure as explained above. The economic added value is a quantitative measure related to the difference between the profit margin and the cost of capital invested (Lambert & Pohlen, 2001).

Combining these two analyses, investigating the strategic and economic value, companies can decide which strategy fits which components.

6.5. Conclusion

This chapter introduced the framework for deciding and applying (hybrid) CTO. In the tactical phase, the framework gives guidelines to decide what should be standardized and what not. Therefore it helped to answer research sub-question 3; "What should be standardized and what not?"

Redesign

7. APPLYING THE FRAMEWORK AT VANDERLANDE

In this chapter, the tool as introduced in chapter 6, will be applied at the Vanderlande Company. Section 7.1 discusses the application and will start at the strategic level. If on strategic level the characteristics meet the requirements for applying CTO, it will continue to the tactical level and see what kind of considerations come up in the specific case of Vanderlande. After that, the operational guidelines will be explained. Section 7.2 will discuss the opportunities and pitfalls for Vanderlande. Section 7.3, Practical business applications at Vanderlande, integrates the findings of the framework with the already available resources and initiatives at Vanderlande. At the end, a conclusion on the application is given, section 7.4.

7.1. Application of the tool

7.1.1. *Strategic considerations*

Applying the strategic framework of Figure 17 step by step leads to the following reasoning. Note that this strategic level consideration is a management consideration. When the management decides to change the strategy, the rest of the organisation's change has to be lead up top-down.

Assuming that Vanderlande ideally wants to influence the wishes of a customer and advise them instead of letting free the creative mind of the customer and follow them, the next question to be answered is if we see communalities in customer demands.

Vanderlande's parcel and postal business unit is focussing on delivering sorting facilities for parcel and postal companies. All customers deal with packages and/or letters. The dimensions of these parcels differ between customers, depending on their acceptance policy. At their facilities parcels come in with trucks or vans, have to be sorted and have to leave in the right truck or van. On high level, the customer preferences seem to have large communalities.

The question about technological clockspeed of the total system can be answered with the fact that the clockspeed is low. The system is based on conveyors, scanners and sorters. These components improve independently over the years, but the interfaces can be remained. An example of a company where this condition is not met is for example prototype manufacturer, a structural steel company or a classical construction company.

The question if the system can be separated into functional blocks can be confirmed in the case of Vanderlande. The systems they deliver contain various functional sections like: (un)loading, scanning, weighing, transfer, infeed in sorter, sorting, outfeed.

The next question about the fact that the expected profit of engineering parts modular is higher compared with making it customer specific is confirmed in the case of Vanderlande. When using a multi-project scope, Vanderlande had 115 active projects in PP in February 2014. All of these projects consist of these functional blocks. This means if a module is made to be the standard, it can be developed once and used in 114 other projects that year. This is much more efficient than developing it for every project individually.

The last question is about the competitive improvement applying CTO could accomplish. We think that at Vanderlande CTO can improve competitiveness. We think Vanderlande can be more competitive in terms of lower selling price due to lower special design costs, reduction of lead time via make-to-stock possibility and customer satisfaction because lower lead time (also by easier installation) and lower spare parts stocking costs (more common parts).

The last question to be answered decides between the pure version of CTO and the hybrid one. Vanderlande has built a reputation that they are fully customer focussed and in their core values they quote "we will not stop until the customer is fully satisfied". This, together with the market strategy, makes it necessary to allow for customer specific modules under exception. As shown in Figure 23, the "customer specific module via exception" of Hybrid CTO tries to overcome the negative influence of standardization on customization. This hybrid CTO is in contrast with, for example, the car manufacturing industries, that only allow the customers to choose from predefined options (mass customization), and don't allow for customer specific influences.

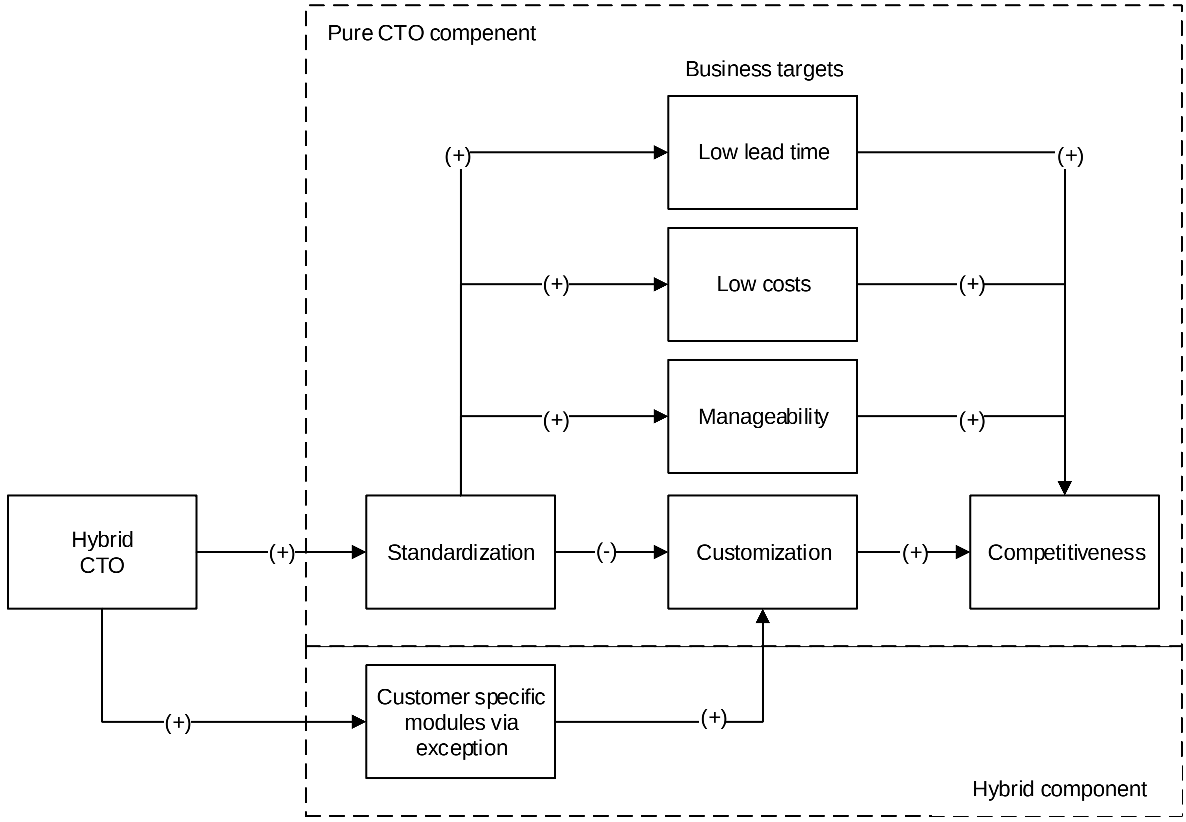


Figure 23 Interactions of Hybrid CTO

Conclusion on strategic considerations

Given the characteristics and core values it seems to be beneficial for Vanderlande to apply a hybrid CTO strategy. The last step, deciding between pure CTO and the hybrid CTO version, is depending on the customer influence the organisation wants to allow. The risk of applying hybrid CTO and allowing for customer specific design under exception is, that if poorly managed, a customer specific component is invoked too often if it is too easy accessible, which leads to a more ETO-like way of working. This seems to happen nowadays at Vanderlande with the DOTM product family; the product line that should be standard, but when analysing the data there are still a lot of customer specific items produced in the factory. (See Section 4.3.1, DOTM)

7.1.2. *Tactical considerations*

The tactical considerations are taking care of the development of the products. Applying this framework (Figure 18) to Vanderlande shows the following guidelines:

Define customer needs on highest level

As already mentioned in the strategic considerations, customers in parcel and postal have the following main high level needs: A system that processes packages from the unloading dock to the right loading dock for further distribution. Next to that they have requirements on capacity, quality and reliability. Especially reliability is a big issue in parcel and postal business, because they promise their customers on-time delivery. The sorting systems have to deal with a high workload in a short amount of time and typically have to work properly >99% of the time, so reliability comes with quality. Customers have different budgets and have to deal with local regulations.

Find communalities in the functionalities among customers

Next step is to analyse all the different customer needs and to group them into solution families to cover the varieties in needs. One can think about product families with different ranges in capacity, different prices (budget line / premium) and different safety/energy regulation levels to meet requirements. It is key to try to cover as much as possible requirements in as less as possible product families.

Design the systems

The next step is to design the products/system; this can be done by a heavyweight system architect. This employee has experience with engineering and knows exactly how the total product works. He has insight in the functionalities and customer needs and can therefore decide where a module can start and where it can end. Together with colleagues, he can decide upon module interfaces and protocols. Together with other departments as supply chain, suppliers / brands of specific components can be selected, so that in the detailed module design engineers can design with the right specifications (i.e. interfaces with purchase items).

Detailed module design

This design of the modules can be done in parallel, given that all the needed guidelines, protocols and interfaces are released. This can be done by internal teams as well as by strategic suppliers.

Testing

After designing of the independent modules, the interactions of the modules have to be tested. Performance changes can typically be localized to just a few modules which have to be adjusted.

Match supply strategy

The last part is to match the supply strategy with the components needed. For Vanderlande this implies the make/buy/switch decision, together with the economic order quantities etc.

More about the supply strategy can be found in section 6.4. Key for the supply strategy is the right consideration for the right item in terms of competitive position.

7.1.3. *Operational considerations*

The operational considerations of Vanderlande are visualized in Appendix I. Suggested implementation ESoT and CTO-planning-BOM), this appendix is based on Figure 20. It shows the process that has to be gone through and managed in order to realize efficiency. First the sales engineer has to start building a sales layout with as much standard modules as possible using the ESoT library and tool. When the system is not fully configured they have to consult R&D to discuss if a standard part can be used or a CSP has to be created. If a standard module is suitable, the sales layout is ready.

If a customer specific module is needed, it can be developed for general use (for future projects as well) or for just one project. If it is project specific, the costs can be estimated and the quotation can be done. After the project is sold, the module can be designed.

If it will be developed and used in future projects as well, the costs can be estimated and the development in cooperation with a multidisciplinary team can already start if resources/capacity are available.

7.1.4. *Conclusion on applying the tool*

To conclude the application of the framework on the business case of Vanderlande it seems CTO fits the company well, as long as there is a possibility to make customer specific modules under exception (hybrid CTO). This exception has to be maintained as "exceptional" and should not become a regular way of working. In the next chapters practical opportunities and pitfalls are discussed together with an implementation plan.

7.2. Opportunities and potential pitfalls for the Vanderlande organization

In this section, first the opportunities for Vanderlande of applying the framework, as discussed in the chapters before, will be discussed. After that, the integration of this framework with the more practical business applications will be discussed. This section will start with a section about integration of projects. Thereafter the MechZB orders are discussed. The other subjects that will be discussed are: ESoT, Standardization program in P&P, Ease of production and spread of workload, Mass Customization Index, Rolling out Worldwide standards, CTO Planning Bill of Materials with ESoT. These opportunities and pitfalls will be taken into account in the implementation plan (chapter 8).

7.2.1. *Results for Vanderlande when applying hybrid CTO*

Vanderlande could make use of following advantages of hybrid CTO when applying the framework of chapter 6.

- Design of new modules can be done in parallel, low dependency between them. (applicable for new CSM's as well as new R&D modules). This results in shorter lead time per project and shorter time to market of new concepts.
- Sales phase can determine costs more accurate, because less customer specific "unknown costs" parts. This leads to less risk, less engineering effort, so lower cost and more competitive pricing/higher profit.

- Still able to customize by applying hybrid CTO that allows for customization under exception. Efficiency of CTO with a customer accommodating exception via CSM. More competitive pricing.
- Overall project cost can be lowered to improve profit margin or competitive pricing. Expected cost savings over 10 percent per project (realistic estimation based on MechZB experience and minimal engineering effort) Given 115 active PP projects with an average value of 1.8 mln euro this may lead to a cost saving of more than **20 mln euro** on current order book.
- Less redundancy of work in sales and engineering phase when using same engineers or close collaboration in both phases to integrally complete project. More efficient transfer of (as-sold system) information, less risk of two people solving same problem in different phases. Improving "first time right" chances, saves extra materials that are usually ordered via rush orders.
- Lead time reduction by skipping engineering for common modules/parts. Estimated possible project lead time reduction of 25 days. (currently 55 days on average for PP as shown in Figure 12). Shorter lead-time leads to lower utilization of engineering, so more engineering capacity for new projects. This enables future growth.
- The engineering phase can be simplified and can focus on layout design instead of in depth customization (making 'specials'). As Figure 12 shows, definition takes 58 days and engineering design 55 days. Definition commonly implies layout design and equipment choices. If the engineering phase thereafter can be skipped/reduced as mentioned above. There is more engineering capacity for new projects which enables future growth.
- More engineering power for R&D and Sales by relieving assigned project engineering. This leads to more R&D effort, more innovations, more chance of selling and better competiveness.
- Lead time reduction by knowing demand of common parts earlier (already after sales phase). Long lead time products can be purchased earlier. This reduces supply risk and overall lead time (critical lead time path), which enables faster time till commissioning, which improves competitiveness.
- Lead time reduction by making standardized items to stock, postponing CODP. In optimal configuration, production lead time only depends on production time CSM's. (reduction of 3 weeks possible)
- Low risk of inventory of components (more shared demand of components).
- Possibility to make-to-stock with low risk, more shared components among 260 projects (+-80.000 activities). Cost savings calculated via minimal engineering effort.
- Reduction of production cost by possibility of increasing batch size. This reduces number of setups, this can especially reduce cost at the bending workcenters (See Appendix F. setup times). When a reduction of 30% can be achieved, given the hourly cost of bending of €61,59 a yearly cost saving of more than **€127.000** can be achieved. This doesn't even include the learning factors in the other work centers. Assembly, for example, can achieve large learning effects (speed and quality) when having bigger batches.
- Reduction of purchasing cost by possibility of high economies of scale. The effect is hard to estimate, but if supply chain centre Europe for example can reduce purchase cost by

only 1%, the total cost will go down by **over €1.000.000 per year**. Because mechanical and control equipment is responsible for more than 60% of the total project cost, a small reduction influences the competitive pricing of a project significantly. A reduction can also be achieved via the implementation of CTO-planning-BOM, where multi-project demand is summarized and can be purchased at once.

- Reduction of supply effort by less variety of components and less order lines to be processed. Combined with CTO-planning-BOM, this saves order and transportation costs, both internal handling and administration cost and external supplier. Supply chain centre EU (with 13 employees; 5 operational buyers, 5 buyers, 1 supply chain engineer and 2 supply chain coordinators (12,65 FTE)) yearly handles 7.971 PO's (117.306 order lines). The average handling cost for supply chain €118,47 per PO (per order line is €8,05) (including car cost and ICT Fee (Source: Vanderlande SSC EU)).

  For physical handling, the costs reduction per PO are estimated to be nihil; this because the administrative handling will increase a bit, due to the fact that products bought in bigger batch/order size have to be reallocated to the right project (activity) at the warehouse.

  The financial administration and paying of a PO counts for €5,10 (Source: Vanderlande Financial accounting) If the number of order lines can be reduced by 10 percent, the supply chain costs and financial administration costs that can be saved counts for **€98.000 per year**. Note that this saving can be obtained by reducing number of employees, or the other, more reasonable option, is gaining efficiency. By reducing PO lines the capability for future growth with the same number of employees will be enabled.
- Outsourcing becomes easier because products are standard. This may lead to cost reduction possibilities, but also to eases ability to spread workload on suppliers including the VI factory.
- Quality will improve, because higher learning effect in production and installation. Higher percentage "first time right", so lower cost on "extra materials". If a reduction of 10% less extra materials could be realized, this would lead to a cost reduction of **€525.000** on the parcel and postal order book of 115 projects.
- Easy upgrading and maintenance of the system by interchanging a module.
- Low inventory cost of spare parts by having common components. Non critical spares can be shared for multiple customer sites. Critical spares can be easily replenished from stock. This may improve customer satisfaction by the improvement of service level or just eases the spare parts management of Vanderlande.

The advantages off course come with disadvantages that have to be taken into account. The **disadvantages** that can occur when applying the hybrid CTO:

- Modules can become a commodity, interchangeable among competitors. If Vanderlande will change its interfaces to a standard, competitors can imitate the interfaces and implement their modules in the system.
- Design limitations. Sales layouts are only allowed to contain restricted modules.
- Supplier can become crucial for innovation. If supply is outsourced, suppliers are needed to help developing new modules.

NOTE: the saving percentages are based on reasonable estimations, but can however differ in practice. Experienced managers on the different expert fields can judge if these estimations are attainable, and can, if necessary recalculate euro savings given the data available in this report.

7.3. Practical business applications at Vanderlande

The advantages above can only be obtained when all resources are into place to facilitate this opportunities. This section is written to appoint the opportunities given the present resources and initiatives inside the Vanderlande organization together with practical considerations to apply them successful and seamless integration with the hybrid CTO strategy.

7.3.1. *Integration of multi-project approach in the supply chain to reach Economies of Scale improvements*

In the sketched business processes, chapter 4, it is clear that currently the organization and processes are structured around the projects. All of the processes are triggered by the project schedule and more in detail; the activity schedule. The weakness of this is that the total organization cannot reach a higher level of optimization than on project level.

The current way of releasing activity-by-activity to supply chain is very inefficient, because batching or buying economies of scale is very difficult. It is investigated that the current ERP software (JDE One and World from Oracle), is yet not able to deal with other ways of releasing than activity by activity. Currently artificial specifications are released when a bulk order is placed. It would be beneficial for the Vanderlande company to adopt the CTO order fulfilment strategy and allow customer specific modules under restrictions. In this way the number of common products will be higher and allows for more efficiency in buying and producing. A solution for enabling the supply chain for this will be discussed in the implementation chapter, section 8.5.2.

7.3.2. *MechZB*

In 2013 the MechZB deal with Deutsche Post DHL was closed. This involved installation of over 100 systems for sorting depot's around Germany. Vanderlande and DHL agreed that the system would be designed once and literally copied for all installation sites with only a few high level parameters, like number of infeeds and number of chutes. DHL guaranteed that every installation site would have the needed dimensions. This led to a massive efficiency in design and production/procurement and realized a cost saving of around 30 percent from the initial cost price of the first order (Pricing Department (2014)). A little side note is needed, because the initial price was 120% of the expected calculated price, because of extra investments for making it modular. So the costs are now (after around 40 MechZB's) at a level of 90% and are decreasing percentagewise each order.

When talking with the supply chain managers and production managers it became clear that these MechZB orders, which are released project by project, do not take a lot of effort for the production and procurement departments, they just roll smoothly through the processes without any problems. This because every detail of these projects is fixed and known beforehand, accordingly production capacity is reserved. Note that extra materials are nihil because of this fixed proven components.

The interesting part of this "pilot" is that a huge cost saving was revealed, but so far little is learned or done with this result. In this case standardization seemed to be involved, but actually the total system is designed as a 'special', a customer specific system, which was just repeated several times. It followed the STEP design philosophy, but changes were made on infeed length and width and also the width of the possisorter was adapted to fit the available space restrictions. Interesting to see is, that given this savings in the MechZB, the concept is not directly usable for other projects, because essential dimensions for standardization are adapted. This project can however be used as a study object to get organizational wide support by revealing potential cost savings when doing it the same every time. This case study can also emphasize that the organization is too project oriented because of the fact that this project is customer specific and not directly usable for other projects (modularity).

7.3.3. *ESoT*

ESoT, as explained in section 4.3.2, is a technical drawing tool that connects initial layouts with item lists. It eases the engineers to choose for modular standard solutions, but still allows for special equipment, because reason number 3 is "make implementation of products easier / less time consuming.

To start with the discussion of the opportunities ESoT creates. ESoT could be the new standard of knowledge base for modules inside Vanderlande. The advantages are that systems can be created faster, that detailed system information can be transferred earlier to controls and supply chain and an integrated system is used throughout the organization.

The main feature of ESoT could be that, if sales layout is detailed enough, when the customer signs the contract, immediately the production/procurement can start, because everything is already known at that moment.

Interviews with the people behind the development of ESoT revealed some interesting pitfalls. One major one is that although the sales department works with modules and make their considerations for equipment choices, still the engineering department can decide to totally changeover these choices. This makes the main feature of ESoT useless.

It is suggested to closely integrate the sales layout process with the engineering layout, so that changes are needed as less as possible in order later on in the engineering phase and make optimal use of ESoT.

Next to that it seems useful to fix already as much as possible components in the sales layout; like type of conveying system, infeed type and amount, chute type and amount, sorter width and length, motor choice, controls, etc. Examples of what can be decided later on are the heights of supports and the platform dimensions.

So despite ESoT is full of opportunities, there are some major pitfalls that have to be managed carefully. In literature review (Jansen, 2014) the CTO planning bills of materials is already discussed, this could be perfectly combined with ESoT and this opportunity will be discussed in next section.

7.3.4. *CTO planning bills of materials in combination with ESOT*

This section describes the potential of implementing the CTO planning bills of materials, suggested by (Wacker & Miller, 2000), combined with Vanderlande's ESoT. Wacker & Miller (2000) observed comparable issues as we found at Vanderlande. Citing Wacker and Miller: "A high number of engineering hours are devoted to each product in a CTO environment because engineers have to spend a great deal of time completely redesigning a product to meet the customer's order requirement. The underlying cause of the unique design is therefore the product's custom application. Many times the difficulty of uniqueness is exacerbated by the design engineer's desire to make a project a "work of art""…"without checks and balances, engineers are not limited to a specific set of subassemblies, but have a wide latitude in their choice. This latitude allows them to design subassemblies that are unfamiliar to the shop floor and to specify purchased components that are unique to the supplier. That not only causes product quality and delivery problems for the shop floor, as discussed above, but it also passes those same problems on to the supplier, which tends to drive up material costs and may further affect the shop floor with missed delivery issues."…"modifications of the bills of materials does not provide a consistent guideline for simplifying production procedures for shop floor personnel."

Wacker and Miller plea for the use of configurators for initial checks on compatibility of components that are selected so that engineering hours are reduced and costly errors from the selection process is eliminated.

They also see that most CTO environments have problem products that ask for customer specific products and suggest to put a premium price on them because they require more engineering, manufacturing and planning time. Wacker and Miller give four reasons for the necessarily of this premium:

1. Since the product is not specified, estimated engineering hours tend to be understated.
2. These products tend to use unique and unfamiliar purchased components that may need to be specially engineered by suppliers, causing higher material costs.
3. Because the items are unique to suppliers, suppliers tend to miss ship dates causing the manufacturing schedule to slip, increasing the inventory.
4. Because of uniqueness, the shop floor generally will have a difficult time getting all the components to fit together properly.

The planning bills of material works as follows; the key purpose is to tie specific time periods to specific decisions. The link is accomplished by computers software using classical MRP logic to generate time-phased plan for decisions. Exception reports are then generated when a decision is made on time. When the ship date approaches, the planning bill is detailed with more specific materials definitions and engineering requirements. Because triggers for the decision are built into the system, critical dates do not pass without calling attention to when the decision must be made. The basic approach is shown in Figure 24.

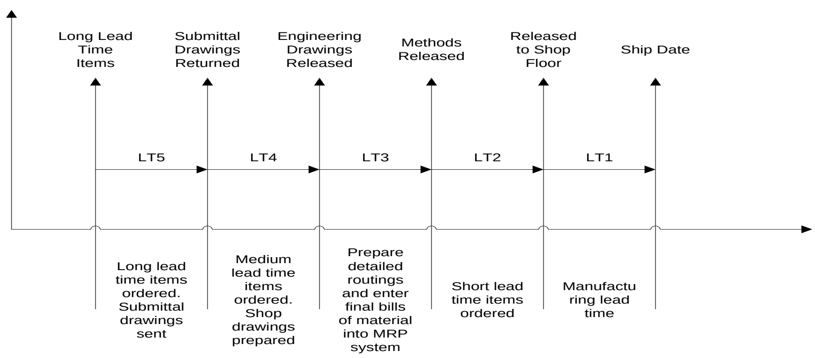


Figure 24 Tying decision lead times to planning bills of material (Wacker & Miller, 2000)

The role of ESoT in this CTO planning bills of materials is located at the configurator role. ESoT can contain the modules that can build a system, with the necessary BOM underneath it.

To improve this CTO planning bills of material, there should be a pre-project assessment and a post-project review. The pre-project assessment can be a derivative from the known Open Up meeting, including representatives of sales engineer, project leader, application engineer, production and supply chain engineer. This to discuss the possible project problems and to coordinate the responsibility for each decision stage of planning.

The same should be done after the project is completed, but this time the project will be reviewed and difficulties and positive things have to be assessed. In this way the CTO planning bills of materials can be updated given those points of attentions for proper future use.

7.3.5. *Knowledge centralization*

Knowledge centralization is key for future and organizational wide use (Zomeren, Engineering efficiency: Van ETO naar CTO, 2013). If knowledge stays in the heads of engineers, there is no shared knowledge. Gathering knowledge into one central database where sales, engineering, production, service departments and external key suppliers can have access to makes knowledge consistent and widely spread. In this way revisions can be held up to date and will be available for all engineers who don't have to invent something twice. This is especially important for a worldwide organization as Vanderlande with all its 22 customer centres. ESoT can be the basis for this database when it includes pricing and when it is able to handle revisions.

7.3.6. *The standardization program in P&P*

As discussed in section 4.3 Current initiatives, the standardization initiative of a heavy weight system engineer in Parcel and Postal is discussed. It is good to see that the system architect puts effort in the standardization of P&P systems in alignment with the organizational goals. As seen in the framework, these heavyweight system people are indeed the right people to make decision on this standardization. They have a long experience in product engineering, have knowledge of the systems sold and understand customer needs. Next to that they gained some prevalence to ease making decisions. Essential is that they think about the level of detail of the modularization. The challenge is to also get as much common products among the modules as possible. Main pitfall however is that there has to be a support base and structural integration and adaptation for this initiative to be successful. For example, the engineers should be motivated to early release fixed parts, which conflicts with the ability to change things later on. The initiative should be discussed, adopted and facilitated organizational wide in order to reach the efficiency potential.

7.3.7. *Ease production and spread workload*

CTO eases the production, because the number of common items will be larger than when having an ETO order fulfillment strategy. Therefore batching can be done in order to get more economic order sizes. The setup times will be decreased and the learning effect in the assembly phase will be enlarged. Also, because of the high number of common items, it is less risky to make subassemblies to stock, in this way the workload can be spread. For Vanderlande this means that the capacity underutilization which typically occurs during the months December, January and February, can be used to produce items in advance to cover the fixed factory costs and have slack capacity in the busy period after.

7.3.8. *Mass Customization Index*

When adopting CTO, this implies adopting standardization and modularization, there has to be a way to evaluate the performance of this implementation. This kind of measure is not available at Vanderlande at the moment. The most important measures that can possible be used for measuring mass customization are (Kengskool, Chow, Chen, & Puri, 2006):

- Modularity Index; $MI = \frac{Nc}{Nt}$, defines sharing ability of common products with Nc as the number of common components and Nt as the total number of manufacturing components.
- Variety Index; $VI = \frac{Vp}{Vopt}$, which defines how close the current state of variety is compared to the optimum variety corresponding to cost/benefit($Vopt$).
- Product configuration index; $PCI = \frac{Na}{Nt}$, where Na is the actual number of configuration developed to all possible configurations.

The variety index is difficult to define for the complex systems Vanderlande is delivering. The Product configuration index shows how much of the configurations are actually ordered by the customer, this is a good measure when deciding on the product program.

The Modularity Index, however, is pretty easy measurable and implementable, but is a quite static measure. We suggest to apply a more dynamic measure that reveals the ratio between #configurations delivered and #unique components purchased and manufactured. The higher the number, the better the modularization and standardization. In this way, individual projects can be evaluated by the criteria and can be compared with other projects, but also multi-project average over time can be evaluated. Off course this measure can be incredibly small when a lot of customer specific items are developed, so a proper way of layout should be chosen. We suggest a scale-like measure (ex. 1:500, where 500 unique items are needed for one configuration.)

7.3.9. *Rolling out worldwide standards*

After interviews with people of different standardization/modularization programs, it became clear that they communicate with each other via informal channels in order to keep up with each other efforts. If this works out well for Veghel this is okay, but there is a risk in this. Other customer centres (21 centres) are independent with their own engineers and own local suppliers. If Vanderlande wants uniform products around the globe, the communication within the company among the different customer centres should be improved. Contracts with worldwide suppliers should be offered to the customer centres, so they can make use of the worldwide Vanderlande buying power.

- Knowledge should be stored in one single source to ensure consistence throughout the different users of different customer centres and departments.
- Engineers at customer centres should have the same vision on modularity and standardization all around the world. Training programs should be provided and maintained.

7.3.10. *Integration of sales and engineering department.*
Varieties in solutions have different causes. One big factor is interpretation, the more people who pass the message, the more interpretations are done by these individuals.

An example of interpretation variation was revealed during an interview with a sales engineer who took a standardized merge module which was oversized a bit compared to its use, but did the job. He told us that he was aware that when he would pass this to the engineering department after the project would be sold, the project engineers would most likely downgrade the merge module (by making a 'special') to get a more smoothened overall conveyer line. The functional requirements are met by both modules, the downgraded module requires less material, but is more expensive than the standard module including the development cost. When thinking a bit more about what is happening here, it seems that two people are thinking about the same problem and come up with a different solution.

To reduce this unnecessary redundancy, we suggest to make a combined pool of sales and project engineers, these people have the same educational background, and place them together in one department. The aim of this initiative is to reduce interpretation variations by involving the same engineers from the sales phase till the execution of a project.

7.4. Conclusion

This chapter revealed the potential advantages and threats for Vanderlande as a whole. Next to that, we zoomed in on the existing initiatives and business context make use of these in the to-be situation. This chapter answers research sub-question 4; "What will the consequences be for the organization as a whole".

8. IMPLEMENTATION PLAN

This implementation plan is made in order to achieve the following transformation:

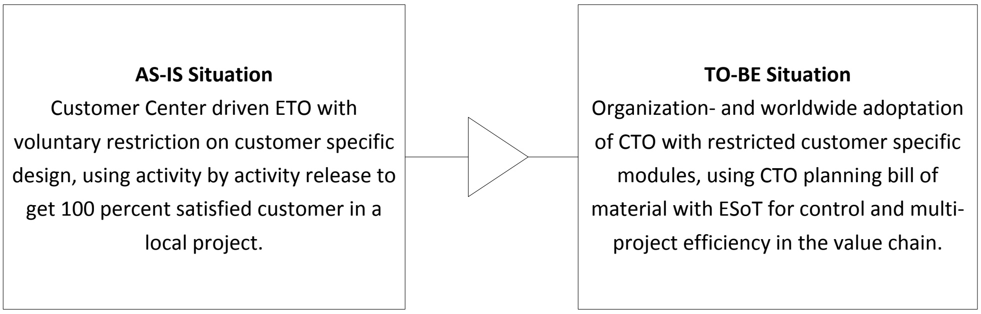


Figure 25 AS-IS and TO-BE situation

This transformation is based on practical executable improvements using available resources.

This chapter will start with section 8.1 that discusses two examples of problems during execution and implementation of a standardization project within Crisplant, a competitor of Vanderlande in material handling. Thereafter lessons from these case studies will be taken into account, responsibilities will be designated to the right roles (section 8.2), and together with knowledge gained from literature and the knowledge about the situation at Vanderlande a solid implementation plan has been created. This starts with a discussion about the adaption of processes, the product and the resources that have to be in place, inspired by (Zomeren, Engineering efficiency: Van ETO naar CTO, 2013). The next step is to ensure organisational wide support, section 8.4. Thereafter the practices to ensure systems and people are ready are discussed in section 8.5. The last, but not least important, part (8.6) will discuss the time span and roll-out strategy.

8.1. Problems with Standardization at Crisplant

By the reasoning: "Learn from the faults of your competitor so you don't have to make the same mistakes again", this section about Crisplant is added. The literature review (Jansen, 2014) revealed an article with two case studies at Crisplant (Gudmundsson, Boer, & Corso, 2004). In this article two case studies about standardization were presented.

First case study is about a prototype in early stage that suddenly was sold and the total product design and supply chain had to be set up from scratch in no time. The result was that no one cared about standardisation; the only thing that mattered was the lead-time. It turned out that at the moment the prototype was built, there were 1000 variants created through the development phase. That was excluding the adjustments that had to be made to get the prototype function properly.

The other case study was about using standardization on an existing product. The idea was to create a new platform for sorters with modules that could be used for three different sorter types. The following sentence shows the resistance of the different stakeholders against this principle: "Discussions on how to define and use standard solutions given that customers have different facilities and needs led the team to conclude there would always be special sorting solutions and even the smallest adjustments would create new variants. Thus, standardization would be therefore simple unobtainable."

These two case studies result in a sum up of the problems experienced:

Table 3 Summary Case Studies at Crisplant

	Case 1 (prototype)	Case 2 (platform)
Problems	- Difficulties in selling the concept - Management did not support concept - Proliferation of design rules - Crisplant used other design rules than strategic partner - The layout was changed several times during the mechanical development - Weekly meetings were not enough to support integration in the development team - Time pressure	- Disbelieve in concept - Worried that it would be too difficult to stretch the design requirements for standard components - Difficult to reduce the cost of components - Lack of interest from other departments - Basis for decisions, both for integration and modularization, was missing - Defining modules in general was difficult - Implementing standardisation meant that some employees could loose their jobs
Causes	- Limited resources - Project definition was not clear in the beginning - No common understanding of the overall task - Ownership was lacking over the construction - Bad project planning in the beginning - Market needs and wants were not fully understood - Concept was offered promiscuously to different marketing segments.	- The development team was not informed about the standardisation concept - Fear to take too much responsibility - No planning for the product structure in the product development process - There was no corporate language for the standardization concept - The consequences for the organisation of implementing the concept had not been estimated by the management - Decisions about the construction were made on the lowest level
Consequences	- More than 1000 variants were created - Negative contribution margin - Lack of resources - Inefficient planning and managing of development process - Failure in implementing standardization in the product architecture	- Delay in design process - It was time consuming to take decisions about the product architecture, later in the process - Communication about integration was difficult between departments - Implementation of the standardisation concept did not have any effect in the organization

8.2. Responsibilities

With every change plan, responsibilities should be taken into account to get a proper implementation. Everyone should take their responsibility and has to point others on their responsibilities. The following three decision levels should be taken into account along with the responsibilities and activities of the different departments on each level; Strategic, Tactical and operational. The implementation of this change starts at the strategic level, the management board has to agree upon the choice to apply hybrid CTO, with clear intentions. They have to decide upon core competences, focus markets, make/buy, and supply chain configuration. Next to that they are responsible for ensure organizational support of those decisions.

On tactical level, every department has its responsibilities as well; sales determines customer needs and decides when to bid or not. Engineering and R&D decides on product portfolio and innovation directions. Procurement is responsible to search and select suppliers. Production decides on production control/capacity/quantities and lead times. Shipping decides upon transport modes.

Explicitly for Vanderlande there are 2 main responsibilities in the change implementation. First one is to make the CTO way of working common thinking and ensure availability of tools for enabling CTO. This can be realized by the systems department, responsible for the products. The second is to enable the processes in the organisation take advantage of the CTO way of working. The supply chain should be able to have insight on early released parts, to enable batching, economies of scale, learning effect, etc.. It is suggested that Supply Chain takes the main responsibility in this implementation part, because they are will be the main users of the system.

On operation level sales makes quotations, engineering and R&D have to execute projects. Procurement is responsible for operational buying and monitoring on time delivery. Production is responsible for manufacturing and shipping for the packaging and shipping of orders. An overview can be found in Appendix K. Responsibilities.

8.3. Process, Product and Resources

A presentation about ETO to CTO of Erwin van Zomeren (2013) revealed the following three stages of adoption of a CTO strategy; adapt the processes, adapt the product, and get the resources in place. For Vanderlande this implies the following:

8.3.1. *Adapt the processes*

Nowadays Vanderlande is working following the ETO way of working; every sales order passes through an extensive engineering revision. When adopting a more CTO way of working, the modularization should lead to configuration by the sales department. Only necessary CSP's should be passed through to the engineering department. This is a hybrid solution, taking the core competences of Vanderlande of high customer satisfaction into account.

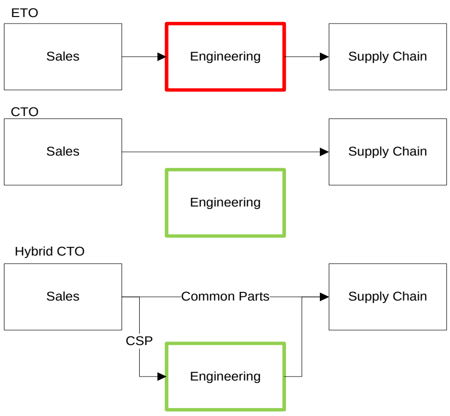


Figure 26 ETO/CTO configurations

8.3.2. *Adapt the product design*

Following the framework created in Chapter 6.2, heavyweight system engineers should be used to get the right ways of standards and protocols into place. They know what is commonly used and needed and what is essential for quality products. For Vanderlande, suggested variables to fix are for example:

- Drive lengths (3 variants, see triple-I program of tubtrax for examples)
- Drive widths
- Curve angles (only 90 and 45 degrees)
- Scanner brand
- Sectional interfaces (every module can fit everywhere)
- Control software (take MechZB example where number of inputs/outputs is fixed, and it is possible that not all of them are used)

Note that this choice of variables to fix requires specialist engineering knowledge and experience and cannot be done by inexperienced external parties. Ulrich (1995) gives handles about different types of modularization like Bus, Slot and Sectional modularity, together with some interface approaches like coupled and decoupled interfaces.

8.3.3. *Get the resources in place*

For Vanderlande it is important to get the right resources into place, this involves a variety of resources; people, software systems, production capacity, inventory places.

One suggestion is to **place sales engineers and normal (project) engineers together**, instead of having two departments, so that the sales engineer can also be part of the engineering team that elaborates the sold system to producible parts. This, so that better initial solutions can be made, so more parts/modules can be fixed from the beginning, at point of sales.

The supply chain should be adapted to deal with these earlier known fixed parts/modules, so they are able to place multi-project orders to create economies of scale and batching opportunities for the factory. Note that this includes effort in deciding upon order sizes and splitting up these multi-project orders and allocating them to the right order after production.

As discussed in the responsibility section (section 8.2), this is an essential part to take advantage of CTO.

Another suggestion is to make use of the factory in Veghel for the knowledge about production standardization and then take the benefits when outsourcing.

8.4. Ensure organizational wide support

Organizational wide support is essential for the success of the implementation of CTO, especially in the worldwide operational company.

8.4.1. *Express the need for change*

Employees should be informed about organizational goals, to get a feeling what is going on with the organizational as a whole. The need for CTO should be expressed in terms of selling potential for new projects and to ensure future revenue.

An important but difficult factor is that it should be made clear that the choice is made to go for the new plan and that everybody should be part of it. Because there will be a hybrid CTO strategy, where still "specials" can be made, employees must understand that these specials are restricted for highly exceptional use.

8.4.2. *Explain consequences for employees*

Every change leads to uncertainty at the side of employees. CTO is a strategy that enables to skip the engineering department, which will lead to uncertainty among the engineers. This excess engineering power can be used to put more effort into R&D and modularization. Because of the good future perspective of Vanderlande, the company is in the luxurious position that they can ensure that nobody will be fired, as long as the employees are willing to bend with the changing role of engineering.

8.5. Ensure systems and people are ready

8.5.1. *Ensure standard modules for most needed activities are created*

Before just starting with a total changeover and a different setup of the departments (gathering sales and engineering), enough standard modules must be available in ESoT. When not enough modules are available, engineers will start to make specials and will disregard the modular way of working.

8.5.2. *Enable supply chain to get early information*

By making information earlier accessible for the supply chain, they no longer only have to work on 'deliver what is released this activity'-basis, but also have to think about what can we combine. The earlier in the process the equipment choices are fixed, the further supply chain can look ahead, make economies of scale deals and can deliver earlier. This ability for early insight in supply demand can be accomplished by a combination of the ESoT system and the CTO-planning-BOM, to create a multi-project demand database. This is how it should work:

Implication of CTO-planning-BOM at Vanderlande

In this section a suggested strategy of implementation CTO-planning-BOM together with ESoT at Vanderlande is explained. A visualization can be found in Appendix I. First the ESoT modules contain a BOM, in this BOM each item number (SKU) needs to get a variable of needed lead time (NLT). It is suggested to take the number if weeks needed, so the higher the number, the longer the lead time, the earlier the item has to be released. This variable, together with the project planning, can be used to trigger engineering phases. If the item (not the complete module) is fully specified (fixed), it will be released to the multi-project demand (MPD). This is a workbench where all needed items for different projects will be collected per item number. This MPD needs to be sorted on shortest lead time first.

This will enable the supply chain department to see which parts are needed first and how many of these parts will be needed in upcoming projects. They can decide to buy for only one project, bundle it for multiple projects or place another economic order quantity (EOQ). The ordered items should be subtracted out of the MPD, copied and added to the inventory position database. This database contains the on-hand inventory plus outstanding orders minus backorders. Also a copy of the subtracted items of the MPD should be made to a reallocation database, to enable reallocation when receiving the demand.

When the actual items are received from suppliers or factory, they have to be allocated back to the project/activity. Thereafter they can be shipped to the right worksite.

Important site note: the organizational strategy should allow make-to-stock instead of only JIT delivery. This means the components that will be made-to-stock should have a high demand among different projects. Risk of overproducing and never sell is too high (high priced products, voluminous to store).

8.5.3. *Stimulate sales engineers to take standard equipment*

The difficulty in taking standard solutions in the capital goods industry is due to different causes; level of competition is high, opportunities are scarce and the potential profit when winning is high. As explained before, this leads to the fact that sales employees tend to be more accommodating to the client with the goal to win the bid. But when applying more standardization/modularization, the price of the total solution can be significantly lower, so that the company has a better competitive position in terms of pricing. Literature, however describes that companies are able to shape customer needs to a solution that fit's the company (Lampel & Mintzberg, 1996), this fact should be well-understood by the sales employees/engineers.

One main thing that has to be changed to reduce variety and encourage taking standards is the first step in sales engineering; currently, sales engineers search first for a comparable account (project). This step may result in taking special because it is used before. This reason should not be accepted. The first step should be to try to take as much standard "STEP" modules as possible and only use special design when needed.

Extensive consultation about whether or not deviate from standards with multiple disciplines is recommended at different stages. For example:

- Bid/no bid decision (does the opportunity fit in our hybrid CTO strategy? (i.e. can we fulfil it with mostly standard modules (>…%)))

- Design meeting (does the system layout fit in our hybrid CTO strategy? (i.e. is the design optimized to fulfil it with mostly standard modules)))
- Open up meeting (where CSM is chosen by sales and why?, is it necessary)
- What-Happens-If-meeting (fully designed system can be evaluated in terms of %-standard)

To stimulate the sales engineers' choice for standard equipment, three suggestions are:

- Create awareness of consequences of choices via trainings, this should include training in the 'need to ask' customer. What is relevant for the customer? Is it relevant to ask client for detailed specifications, or can we make a choice ourselves within our standards?
- Extra approval needed (by for example product manager (R&D)) when choosing different than standard solution. When product manager approves the need for a special design, a multidisciplinary team has to discuss the consequences for supply chain, production and installation.
- Extra premium should be paid when choosing different than standard solution, or a penalty can be given if not enough standard modules are used in the solution.

8.5.4. *Stimulate engineers to work with standard modules as much as possible when creating customer specific.*

When still the need of a customer specific item occurs and the approvals and premiums are accepted, it is necessary to develop these customer specific modules with as much as standard components to ensure low price and on-time delivery. Therefore it is recommended that a multidisciplinary team of experienced employees from supply chain and cost engineers is involved in this process of designing customer specific modules.

8.5.5. *Enhance communications between sales, engineering and supply/production*

The growth of the organization may lead to inefficient ways of working. It is possible that employees are working on the same subject without knowing it. Therefore new (standardization) initiatives or programs that are started have to be communicated. We suggest to introduce a coordination organ for the improvement initiatives all around the world, to match focus groups and improve knowledge centralization and sharing.

But also the day-to-day communication between departments should be easy accessible to ensure most efficient overall performance. It could be that a complicated customer need can be solved by an easy solution known by the engineers, or that a solution that supply chain knows can be much cheaper than the suggested solution by sales.

An example of this, raised by the COO, can be the customer of a warehouse solution with Vanderlande's ADAPTO micro-shuttles (Figure 27) requires that the shuttles, normally controlled via WiFi signals, must not interfere with its WiFi internet connection. The sales department may see this as a massive problem and suggests a Bluetooth controlled solution. If there is no communication between the departments, the R&D department is commanded to develop Bluetooth control for these shuttles. But when the engineering department has direct communication with the sales department, they could suggest reserve some specific WiFi channels for controlling the shuttles and reserve some others for the customer's wireless internet to prevent interference.

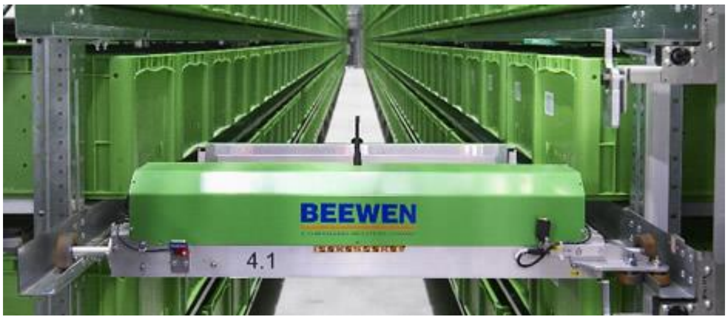


Figure 27 Shuttle technology by Beewen, a Vanderlande Company. (Notice the WiFi Antenna in the centre)

By these kinds of communications >€50.000 can be saved. Imagine if, in the WiFi case, the R&D department was indeed asked to develop a Bluetooth platform. That would have cost a lot of engineering and programming time, together with finding new suppliers in the supply chain and training installation and service personnel. And don't forget about the spare parts that have to be kept on stock for this specific customer in case of breaking. This in contrast with the solution of reserving other WiFi channels for the shuttles, which would cost around one day of programming effort by only one IT employee.

8.6. Time span and roll-out strategy

8.6.1. *Time span*

The time needed for implementation highly depends on the development of the product families. We think that Vanderlande already has a lot of module potential available in the DOTM line. Extra needed modules can be developed in an estimated time span of 10 months whereof 6 months mechanical development, 2 months production, 1 month testing and 2 months implementation into ESoT and CAPE (the pricing tool).

Next to the missing modules, the enterprise systems should be adapted when applying the CTO-planning-BOM. A multi-project demand database should be created and the total way of working will change. This is a very complex interference and has to be managed carefully to keep all active projects running. We think proper implementation can be realized in 1-1.5 year.

8.6.2. *Roll out strategy*

In the complex worldwide organisation of Vanderlande, it is suggested to use a phased roll-out instead of a big-bang roll-out. It is undesirable that the organization completely paralyzes if the big-bang roll-out fails. We suggest to take the parcel and postal business unit in one geographical region (example Europe or North America) with a new CTO-planning-BOM supply chain software module to do a pilot. This to keep the backup system running for the rest of the organisation. When the system is solid (after start-up problems are solved) and employees of the different departments are comfortable using it, another business unit or geographical region can be selected to be changed.

8.7. Conclusion

This last step of the research assignment answered the last research sub-question; "how should we execute the change". The aim of this chapter was to give handles for implementing the change.

9. CONCLUSIONS AND LIMITATIONS

This chapter starts with a summary of the report (9.1) followed by the conclusions (9.2). Thereafter the limitations (9.3) and contribution to literature (9.4) is discussed. The chapter ends with the recommendations (9.5).

9.1. Summary

This research started with a problem stated by the manufacturing manager of a project-based capital goods manufacturer as “a lot of single items have to be produced which obstructs batching and learning effect.” After a quick scan of the product and demand characteristics that revealed high level of customer specific parts, the wish to go to a more configure-to-order order fulfilment strategy was expressed. With the large growth goal in mind (double revenue in four years), the organization has to be capable to process large volume with low effort. An academic viewpoint was chosen to investigate under which circumstances it would be beneficial to aim for a CTO order fulfilment strategy. The main research assignment therefore was formulated as:

Design/develop a tool to decide under which circumstances a change in order fulfilment strategy from a project-based engineer-to-order (ETO) strategy to a more configure-to-order (CTO) order fulfilment strategy is beneficial for a company that sells, engineers, produces, installs and services capital goods with focus on predefined target markets.

The methodology used to investigate this main question divided the question into sub-questions to be answered. A literature review about ETO and CTO was set into place to explore all the advantages and disadvantages of both strategies. It was found that CTO implies standardization and modularization which affect both demand and product characteristics.
Because of the environment most capital goods manufacturers are dealing with; opportunities are normally scarce, the number of competitors high and potential profit involved when winning an order is typically high, capital goods companies tend to be more customer-accommodating than mass producers.
It became clear that neither a pure engineer-to-order nor a pure configure-to-order strategy would fit this specific environment of capital goods suppliers.
We came up with a strategy to apply a ‘hybrid CTO’ order fulfillment, so that most parts are standardized and smoothened for efficient cost and supply, while under exception customer specific modules can be offered to accommodate customers’ wishes. This included an operational plan to accommodate learning from development of customer specific items.

Next to large current level of customization in the ETO company, an important company specific barrier has to be overcome to take advantage of standardization and modularization; the present way of activating the supply chain. The supply chain is triggered activity-by-activity (activity=sub-project), which means that projects are released bit by bit and work orders are created accordingly. This hinders ability to batch and have insight in future demand. The new developed process model suggested a CTO-planning-BOM, which enables supply chain to make use of upcoming multi-project demand.

9.2. Conclusions

9.2.1. *Problem identification*

The deterministic analysis of the product and demand characteristics gave insights in the severity of the problem. Data showed that there were a lot of unique items produced in the VI factory and that batch sizes were low. This analysis confirmed the indication of the manufacturing manager.

Other causes were investigated via an analysis of the current ways of working. This revealed the project oriented way of working inside Vanderlande, which hindered the ability to optimize overall performance. The project scope enabled the focus on project budgets and project lead times, but seemed to obstruct overall (multi-project) focus. Also the way of triggering the supply chain activity-by-activity obstructed the ability to combine projects and have stronger buying power.

9.2.2. *Conceptualization*

Via literature review and investigation of processes, a framework to help deciding whether to apply (hybrid) CTO or not. This decision starts with strategic considerations, tactical implementations, and ends with the operational process design, which included a hybrid CTO option to include customer specific items. It was shown that a lot of potential was there for Vanderlande when taking advantage of the hybrid CTO concept. Main advantages were lead time reduction, lower supply cost by economies of scale, batching and learning effect, simplification of engineering, higher quality and ease of installation.

9.2.3. *Redesign*

The literature review showed that a hybrid CTO application would fit the needs of capital goods manufacturers. The suggested adaptations in the business processes at Vanderlande keeps in mind the existing resources in order to keep the transformational cost as low as possible. The redesign includes a part that focuses on standardization and modularization with a “cooperation with multidisciplinary team”-step when customer specific design is needed. Next to this it includes the application of the CTO planning bill of material via ESoT, a necessary step to enable the supply chain to have insight in medium-long term upcoming demand. This to enable batching, learning and economies of scale.

9.3. Limitations

Limitations of this research are related with level of detail and scope.

First it has to be clear that this research is done to reveal opportunities for Vanderlande when applying hybrid CTO. The choice of type of order fulfilment strategy is a strategic/management choice. This research focuses to support this decision on high level. These opportunities are described qualitatively with approximated quantitive cost and lead time reductions.

The chosen level of detail lacks in practical choices of equipment and concepts. This is due to the lack of “weight” and in-detail knowledge of us about the applied technology of Vanderlande. As discussed, experienced system architects should lead this discussion and make choices in these tactical considerations.

The scope of this research is restricted to project-based capital goods manufacturers who currently apply an ETO order fulfilment strategy. In the strategic considerations some factors are discussed that suggest when it is profitable to apply CTO and when not. For example when customer needs have no communalities, it is not profitable to apply CTO.

9.4. Contribution to literature

This research contributes to existing literature in a way that it gives a framework for capital goods manufactures. Especially the implementation of transitions of manufacturing strategies is poorly discussed in literature. A lot of characteristics are given for different manufacturing strategies, but no literature was found about the subject under which circumstances it would be better to change a ETO organization to a CTO configuration. This master thesis project could focus on this gap in literature.

Also the adaptations that have to be managed by the rest of the organization is poorly described. The article about a competitor of Vanderlande, Crisplant, aimed to create awareness and discussion about the problems around implementing standardization which they suggest have to be taken into account at the start of the implementation phase, but lacks to come up with solutions. This research project will hopefully be good addition to the field of implementing organization wide change.

9.5. Recommendations

Most of the recommendations are discussed in the implementation part (Chapter 8), the main recommendations are:

- Adapt the processes, implement hybrid CTO with customer specific parts on exception and manage these exceptions with a multi-disciplinary team and price premiums at sales phase.
- Adapt the product design, ensure modules are available and let a heavyweight system architect lead the design of interfaces, protocols and product families.
- Get resources in place; Enable systems (ERP system) to early release information to supply chain (CTO-plannning-BOM). See section 8.5.2 for the implementation strategy.
- Manage communications between departments and customer centres in the strongly expanding company.

Most difficulties of bringing this research to practice will be at the implementation phase. The creation of support base is crucial and has to be done via a top-down approach. The general management has to explain why choices are made and why restrictions will be set into place. Despite the usual compromises approach, deciding on order fulfilment strategy is an exclusive choice which has to be embraced by the total organization.

Next to the psychological obstacles of the implementation, there is also a huge practical barrier at the CTO-planning-BOM implementation. (Sales) engineers should be motivated to use standard modules and to early release common parts in order to make use of the CTO-planning-BOM. Because business processes have to continue while implementing a redesigned system it is recommended to take a small sub-business unit to do a pilot.

It is also recommended to create a framework to show influences on the rest of the value chain when adapting a specific item in the sales phase. This so sales engineers can see what their choices cause for the rest of the supply chain. For example a change in colour seems to be a small change, but when the item is normally produced to stock in large batches, this inventory of items becomes useless because the colour is not appropriate, although the functionality is exactly the same.

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APPENDIX A. PARCEL AND POSTAL PROJECTS

This appendix explains a typical parcel and postal sorting facility. It starts with unloading of trucks/vans/planes, goes through scanning and infeed in the sorter, via a sorter (different models possible), to the outfeeds where they are loaded into other trucks/vans/planes again.

10.1.1. *Unloading*

The sorting of parcel and postals start with unloading a truck, this can be done by hand or using the so called extendables that can extend a conveyer into a truck which eases the unloading process. Another manner that parcels or postals can be unloaded is called bulk, this is a stack of items that needs to be separated first by a singulator before to be processed by the system.

Figure 28 Extendable to ease unloading/loading trucks

10.1.2. *Scanning*

After unloading, scanners are used to scan the barcodes on the parcels and sometimes also the size and weight is measured. These data will be used to decide upon the outfeed location of the parcels.

10.1.3. *Infeed*

The next step is to get the parcels and postal into the sorter which is running continuously at the same speed. Therefore the infeed conveyer will align the speed of the incoming parcel with the sorter speed and places it on the calculated position.

Figure 29 Infeed zone, the infeeds (right) place the packages on the sorter (left)

10.1.4. *Sorting*

In sorting parcel and postals, Vanderlande distinct two types or sorters; the line sorters and the loop sorters. As the names suggest, the line sorters are unable to go around the corner and have therefore not the ability to store the items temporary. On the loop sorters, the item can stay on the sorter infinitely, which enables temporary storage on the sorter. Off course it is not high capacity storage, because it takes sorting capacity. All solutions have their own strengths and weaknesses in terms of dimensions of the products to handle, capacity and price. These capacity details are left out the overview below.

Line sorters

Posisorter

The posisorter is a sorter that uses plastic blocks to push the parcel in the right chute. Single sorters can push out only at one site of the sorter (all blocks will start at one site), while dual sorters can push out parcels at both sides and the blocks will be pre-sorted on the correct side before the parcel arrives on the sorter.

Figure 30 Posisorter

Truxorter

The truxorter uses little rollers that can change direction in order to steer the package in the right chute. In the infeed zone, packages are aligned at one side of the conveyer.

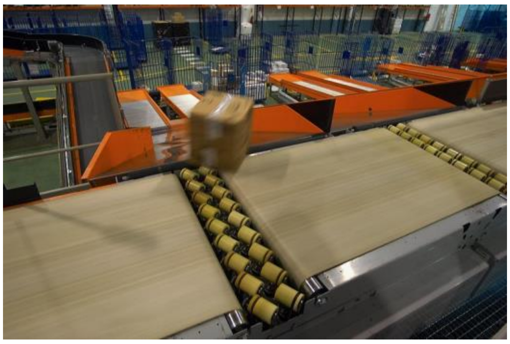


Figure 31 Truxorter

Paxorter

The paxorter is a line sorter can handle a high diversity of package sizes. The packages are aligned at one site of the conveyer and hangs a little bit over the edge. At this over hanging strip, rollers will pop up at the right chute in order to steer the package into the chute.

Figure 32 Paxorter

Loop sorters

As mentioned before loop sorters are able to loop items infinitely. In this system every item is assigned to its own tray (or more for bigger packages) on the sorter. Both solutions later on are able to unload on both sides of the line.

Crossorter

The trays or the crossorter consist of a little traverse conveyer, which is able to roll both sides. This allows the trays to unload the packages on both sides.

Figure 33 Crossorter

Exprexorter

The exprexorter is a tilted tray sorter, which will unload by tilting the carrier.

Figure 34 Exprexorter (tilted tray)

10.1.5. *Outfeed*

The outfeed starts with the chutes the parcels fall into. From this point on the parcels are typically loaded into smaller vans to be delivered to the client.

Figure 35 Outfeed chutes

10.2. Manufacturing / order fulfilment strategies

The manufacturing strategies discussed in this research are ETO and CTO (Vanderlande approaches projects nowadays as ETO, although they try to go to CTO for several years). The strategies are almost on the opposite sites of the manufacturing strategy spectrum from MTS to ETO.

10.2.1. *Engineer to order*

Engineer-to-Order (ETO) is a manufacturing process defined by demand driven practices in which the component is designed, engineered, and built to specifications only after the order has been received. It is a more dramatic evolution of a Build-To-Order supply chain. This approach is only appropriate for specific and rare items, such as large construction projects or Formula 1 cars. (SupplyChainInsights, Engineer to Order, 2014)

10.2.2. *Configure to order*

A **configure-to-order** (CTO) system is a special case of Assemble-to-Order (ATO). The components are partitioned into subsets, and the customer selects components from those subsets. A computer, for example, is configured by selecting a processor from several options, a monitor from several options, etc. The difference between a CTO system and an ATO system is important at the demand-elicitation level. At the operational level, however, the differences are minor. (Song & Zipkin, 2003)

Configure-to-order is more or less the same as assemble to order when used in frameworks. The framework in Figure 36 the balance between forecast (speculation) and commitment of the customer is visualized for the different manufacturing strategies.

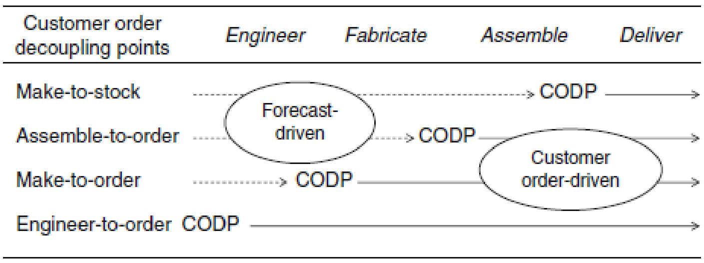


Figure 36 Framework CODP at different manufacturing strategies.

In literature some of the characteristics of ETO and CTO are described. These is investigated further on in chapter 5, the differences between ETO and CTO.

Some interesting literature about the CTO planning bill of material was found, which suggest a simple but effective way for project time management. (Wacker & Miller, 2000). It shows challenges in configure to order environments and present planning bills of materials for CTO as a solid solution. This method is further investigated in the implementation plan.

10.3. Standardization and modularity

One thing that comes with CTO environment is some level of standardization to be able to produce components to stock in order to respond quicker to the market. Modularity and standardization are closely related. The interfaces of modules should be standard in order to enable easy configurations.

10.3.1. *Standardization*

About standardization an interesting article of Grudmundsson, Boer & Corso (2004) about a competitor of Vanderlande was found. The Crisplant Company provided two case studies.

The first case study was about an early prototype that suddenly was sold and the total product design and supply chain had to be set up from scratch. The result was that no one cared about standardisation; the only thing that mattered is the lead-time. It turned out that at the moment the prototype was built, there were 1000 variants created through the development phase. That was excluding the adjustments to be made to get the prototype function properly.

The other case study was about using standardization on an existing product. The idea was to create a new platform for sorters with modules that could be used for three different sorter types. The following sentence shows the resistance of the different stakeholders against this principle: "Discussions on how to define and use standard solutions given that customers have different facilities and needs led the team to conclude there would always be special sorting solutions and even the smallest adjustments would create new variants. Thus, standardisation would be therefore simple unobtainable."

These case studies can serve Vanderlande in a way to show the do and don'ts when applying standardization and is also used in the pitfall section of chapter 0.

10.3.2. *Modularity*

Baldwin & Clarck (2000) define a module as "a unit whose structural elements are powerfully connected among themselves and relatively weakly connected to elements in other units". The purpose of modular production is to decrease product complexity, while raising product variety offered to the customer. (Hoek & Weken, 1998).

On the continuum of standardization-customization, the customized standardization resembles modularization (Lampel & Mintzberg, 1996). The assembly is customized, but the fabrication process isn't.

The modularity mentioned above is more like manufacturing modularity, but there exists more variants; product use modularity, limited life modularity and data access modularity (Arnheiter & Harren, A typology to unleash the potential of modularity, 2005). A well-known article of Ulrich (1995) discusses all the different types of product design modularity and the influences on the supply chain.

10.4. Demand forecasting

Because Vanderlande has the wish to reduce lead time, demand forecasting is researched in the literature review. The ABC analysis is discussed and the Pareto effect accordingly. Inventory policies together with the Economic Order Quantity (EOQ) are discussed in the forecasting perspective. The three rules of thumb, where the first one is: forecasting is always wrong, reveal the bias of forecasting. The most important issue with forecasting is regular updating and feedback.

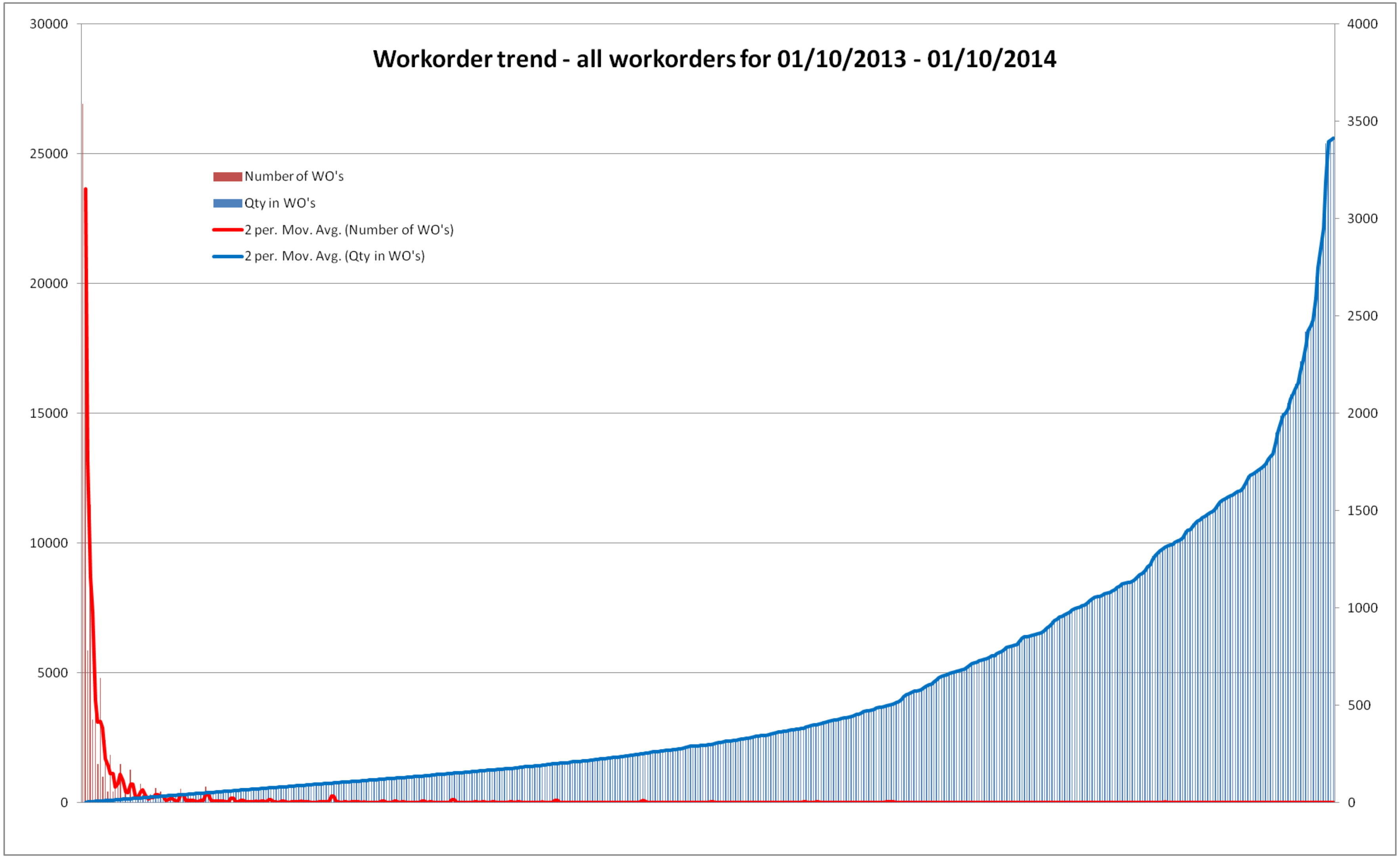
10.5. Shorter lead time

To realize shorter lead time, business processes should be as efficient as possible. Concepts of lean production, capacity slack and inventory buffers can help to shorten the time needed from order placement till order fulfilment.

10.6. Business process management

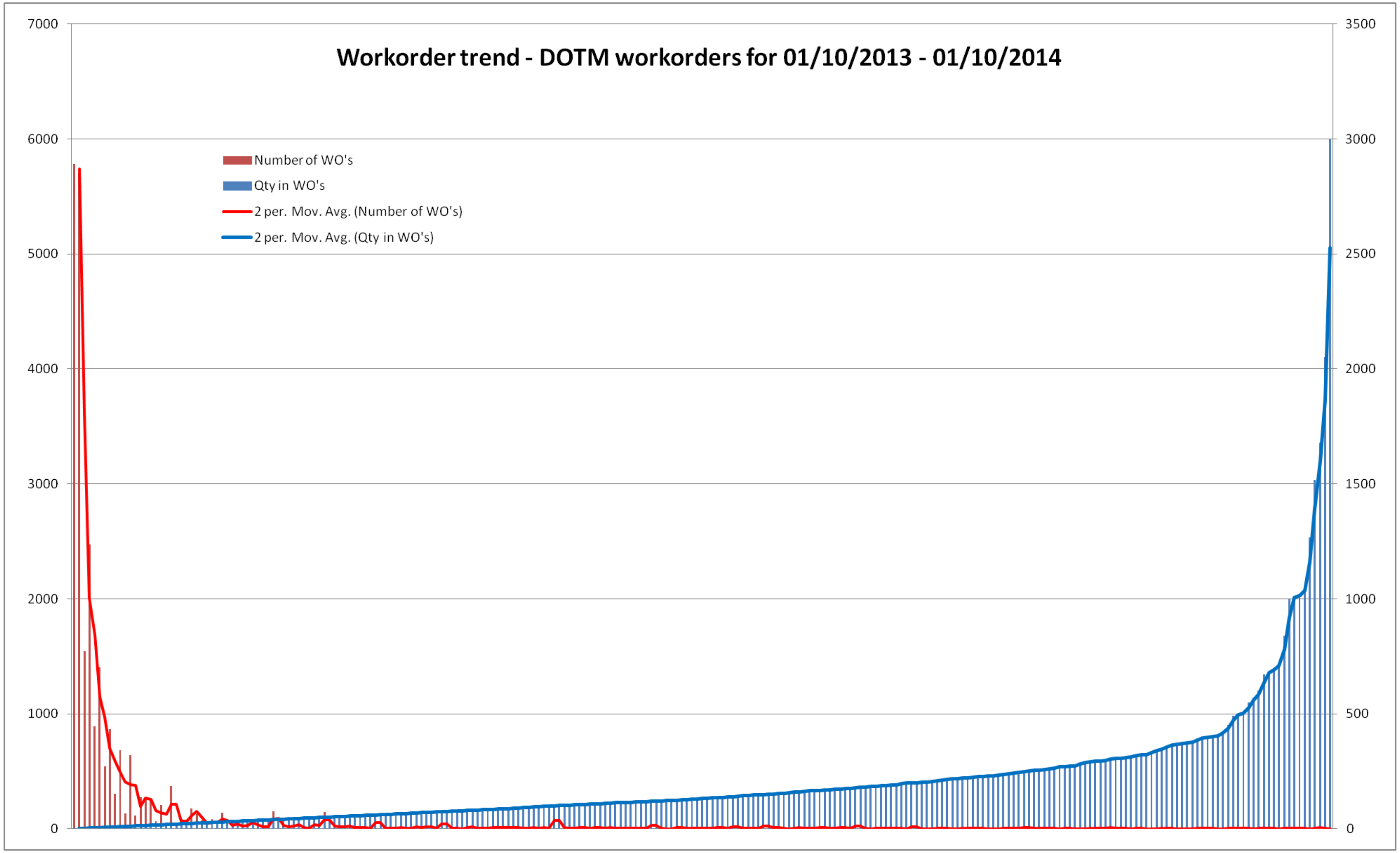
A short chapter about BPM was put in the literature review. Here some references for investigating business processes are placed. This subject was discussed to refresh the knowledge about BPM, and for having information for implementing a change of processes later on, if needed.

APPENDIX C. WORK ORDER TREND – ALL WORKORDERS



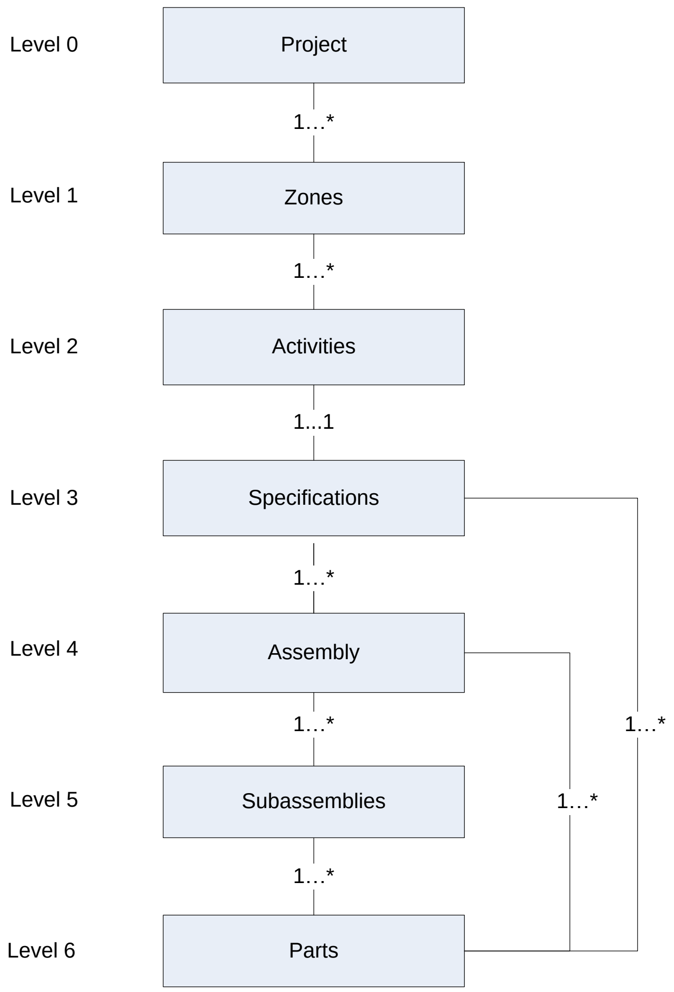
Source: P. van Uden, Manufacturing Engineer,Vanderlande Industries B.V.

APPENDIX D. WORK ORDER TREND – DOTM WORKORDERS



Source: P. van Uden, Manufacturing Engineer,Vanderlande Industries B.V.

APPENDIX E. LEVEL OF DETAIL



APPENDIX F. SETUP TIMES

Work Center	Yearly net production time (excl. Setup time) (in hours)	Yearly setup time (in hours) 01-jan-2013	Total time (in hours) 2013	Percentage Setup time 2013
100 - Hulpbewerkingen				
110 - Knippen LVD				
111 - Knippen Safan	75,73	122,99	198,72	61,89 %
121 - Stampen MUBEA	129,71	68,25	197,96	34,48 %
122 - Excenterpers 45 ton	33,54	105,85	139,39	75,94 %
123 - Hydraulische Pers	178,46	3,70	182,16	2,03 %
150 - Buigen L=4000	493,09	261,42	754,51	34,65 %
152 - Buigen L=3050	949,31	872,04	1.821,35	47,88 %
153 - Buigen L=2050	6.096,42	5.736,23	11.832,65	48,48 %
154 - Buigen L=1250	14,19	10,60	24,79	42,76 %
160 - Pijpen snijden tbv rollen				
170 - Lasermachine trumpf 3030				
175 - Hulpbewerkingen	0,11	0,05	0,16	31,25 %
180 - Pons laser mach. Trumpf	8.619,20	5,20	8.624,40	0,06 %
181 - FMC (actual mat.verbruik)				
210 - Zagen kaltenbach I	1.848,96	428,61	2.277,57	18,82 %
211 - Zagen t.b.v. afsteken	91,48	109,61	201,09	54,51 %
213 - Lintzaag Behringer HPB360A	141,86	27,75	169,61	16,36 %
225 - CNC Draaien OKU A LS 30N				
226 - CNC Draaien OKUMA LB 15	3.889,02	400,69	4.289,71	9,34 %
227 - CNC Draaien OKUMA LB 35II	4.355,79	761,66	5.117,45	14,88 %
228 - Draaibank Ecoca EL-6120	386,28	161,45	547,73	29,48 %
240 - Frezen Universeelbank	490,09	70,60	560,69	12,59 %
245 - Boren	1.964,18	484,77	2.448,95	19,80 %
260 - Spiebanen steken	61,14	30,56	91,70	33,33 %
270 - Boren/ tappen kett.WLN/ SNA	44,83	9,95	54,78	18,16 %
280 - Montage trommels	964,91	283,25	1.248,16	22,69 %
310 - Walsen	564,88	267,66	832,54	32,15 %
311 - Walsen BRESCO profielwals				
330 - Lassen/ bankwerk alg.	15.920,51	2.689,48	18.609,99	14,45 %
331 - Lassen/ bankwerk alg.	252,76	177,21	429,97	41,21 %
343 - CO2 lassen trommels/ rollen	745,09	67,33	812,42	8,29 %
350 - BKW RVS incl. lassen/ af.	570,07	62,00	632,07	9,81 %
351 - BKW RVS incl. lassen/ af.	14,67	4,30	18,97	22,67 %
401 - Afsnijden spacers	88,78	135,86	224,64	60,48 %
410 - Voormontage	2.673,84	112,90	2.786,74	4,05 %
420 - Voormontage tbv test	187,68	9,65	197,33	4,89 %
430 - Montage algemeen	39.754,07	4.604,08	44.358,15	10,38 %
431 - Montage VI loop	13.074,30	68,16	13.142,46	0,52 %
432 - Montage SPO carriers	5.872,34	91,55	5.963,89	1,54 %
433 - Montage DOTM drives	6.069,24	483,37	6.552,61	7,38 %
460 - Eindmontage	7.606,46	1.344,45	8.950,91	15,02 %
471 - Montage Small Products				
473 - Montage				
480 - Packaging				
490 - Verzamelen	0,00	0,08	0,08	
500 - Flow montage	113,68	0,80	114,48	0,70 %
520 - Voormontage tbv van Flow	3,76	4,80	8,56	56,07 %
610 - Moffelen	2.568,11	609,21	3.177,32	19,17 %
620 - Moffelen tbv test	1,07	0,00	1,07	
630 - Moffelen tbv Flow-montage	92,76	0,00	92,76	
640 - Moffelen tbv FM -Voormont.	126,82	0,00	126,82	
649 - Verzinken				
671 - Coating Small Products				
673 - Coating				
720 - Controls Helpdesk				
888 - EFC				
Grand Total	**127.129,19**	**20.688,12**	**147.817,31**	24,69 %

APPENDIX G. SUPPLY MATRIX

VanDerLande

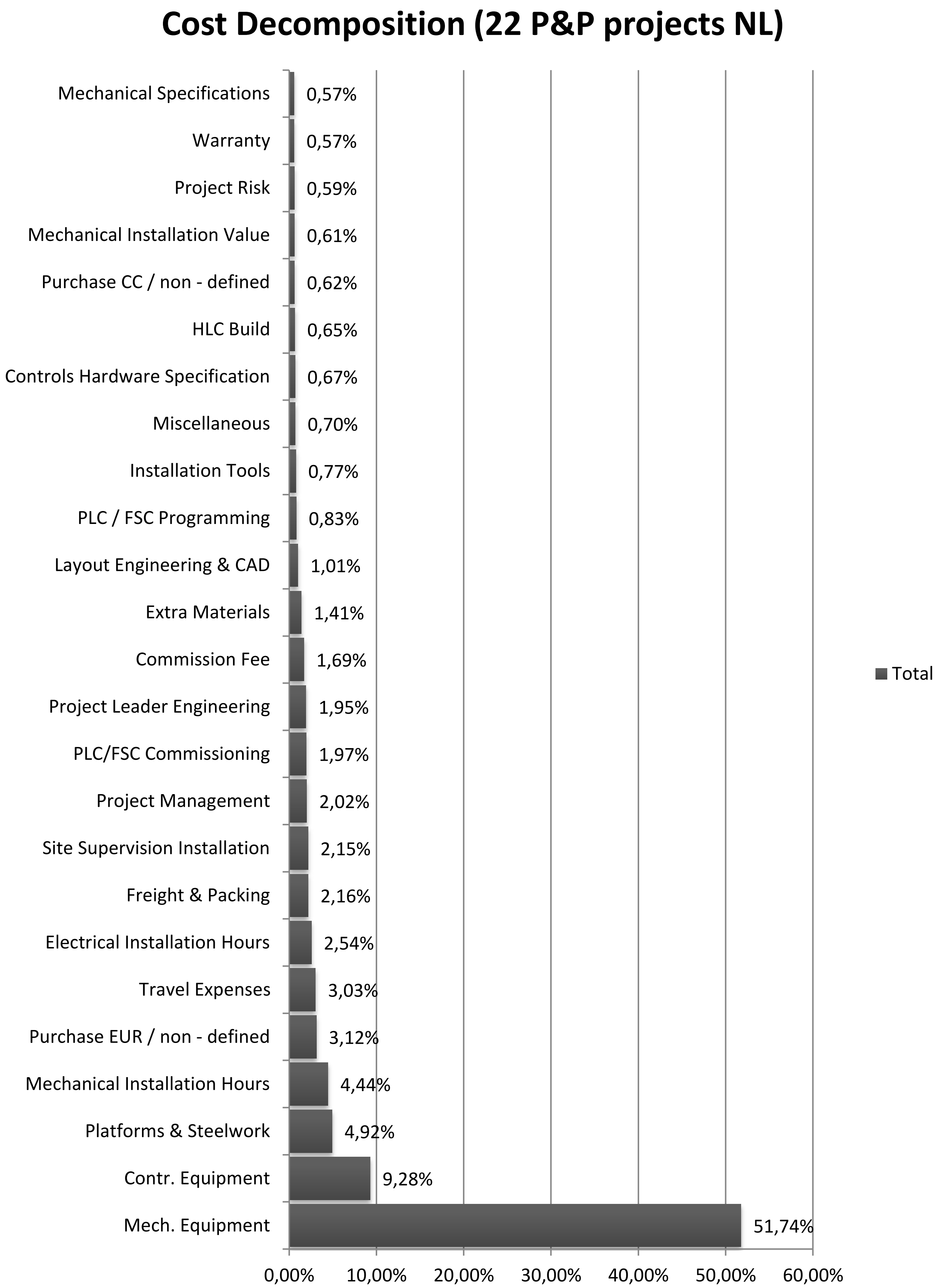
Supply Matrix - Mechanical Equipment - Baggage

From: W. van Beusekom

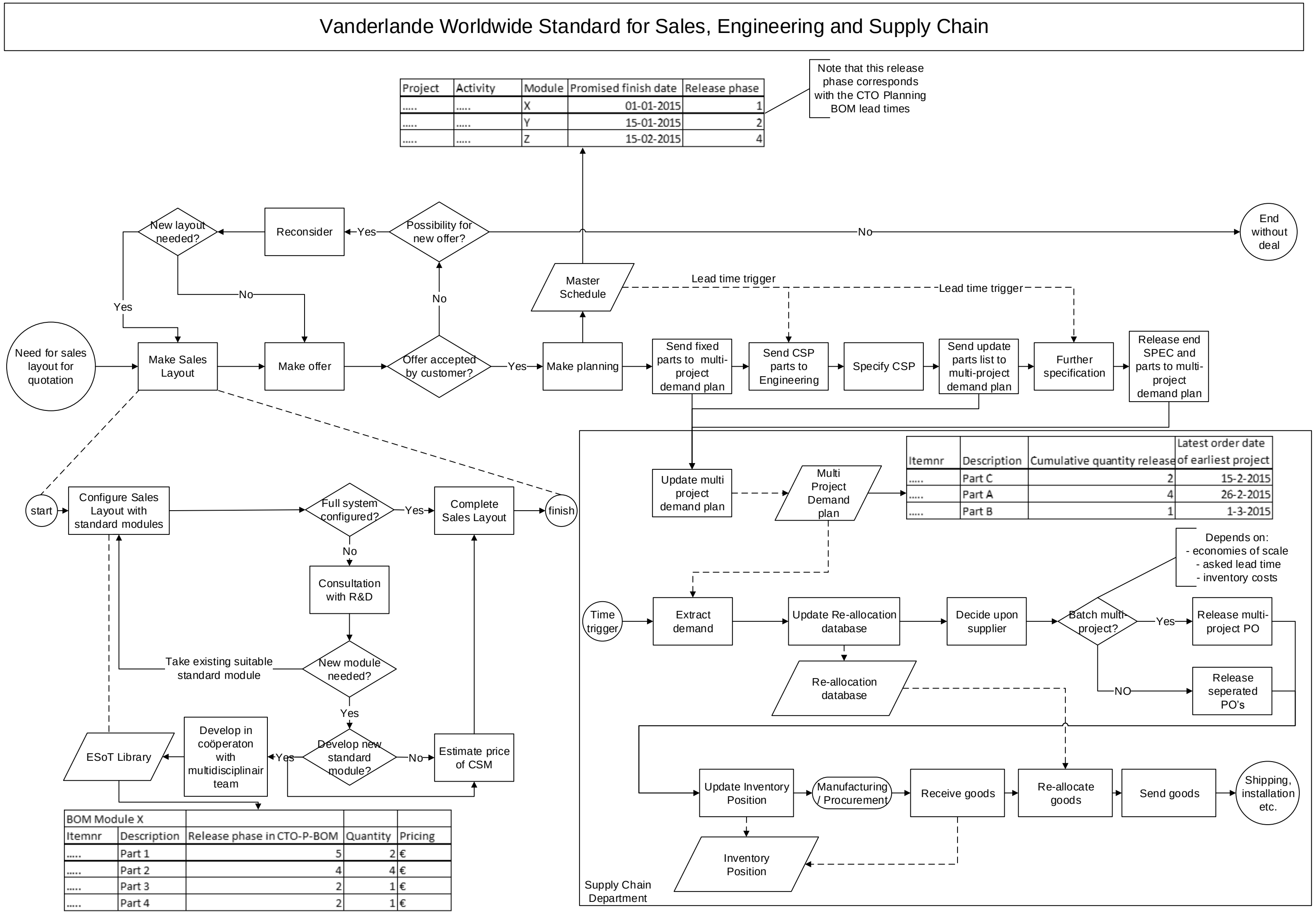
Baggage Handling	Europe				USA		Asia Pacific		
	VI Plant	West EU	East EU	Dinamic	USA	Dinamic	China	Grand	Dinamic
General									
EM Supports	x				x			x	
Stainless Steel Guards & Cladding	x	overload			x		x		
Transport									
Belt Curve (VI/Dinamic-Design)				CPP		develop			
Belt Junction	x			overload			x	x	
Belt Merge (=US Style BJ)					CPP	TBD			
BF 5.1 Drive + ETU	underload		x			develop		x	
BF 5.1 Side Guards	underload	x				develop		x	
BF 5.1 Floor Supports & Hangers	underload	x	x			develop		x	
BF 5.1 Bedsections	underload	x				develop		x	
BF 5.1 Connections & Miscellaneous	x					develop		x	
BF (Blueveyor)									
BF (US Style)					x				
Check In (Type A) (Standard)		x					x		
Check In (Type B) (Special)		x					x		
Cresplanar						x			
Gravity Roller Ø60	x	overload			CPP		CPP		
Triplanar Flat				x		x	develop		x
Triplanar Tilted				x		x	develop		x
Vertical Conveyor (Lift)	x	overload							
Vertical Switch Belt (Luffing)	x	overload					x	x	
Divert									
Divert Pusher Parallel	x	overload					x		
Sorter									
Baxorter Deck / Carrier	x								
Baxorter Track / Frames	develop			x					
Helixorter Carrier	x								
Helixorter Deck		x					x		
Helixorter Tilt Drive		x					develop		
Helixorter Track		x							
Helixorter Supports			x						
Traxorter									
High Capacity Divert						x			
Vertibelt	underload		x				x	x	
Verticross	underload		x						
Vertisorter / Vertimerge	underload		x			x	develop		
Viper Pusher					x				
Output									
Chute		x			x	x	x	CPP	
Baxup									
Tubtrax									
Tubtrax (Curves, Diverts, Etc.)	x			x					
Tubtrax / Twinbelt Conveyor	x			x					
Tubtrax Tub		x							
Bagtrax									
Bagtrax Track		x							
Bagrax Cart	x								
Bagtrax Loader	x			x					
Bagtrax Unloader	x								

Ready (No actions needed)
Develop (Is being developed)
Stop (will be stopped after the other source is available)

APPENDIX H. COST DECOMPOSITION

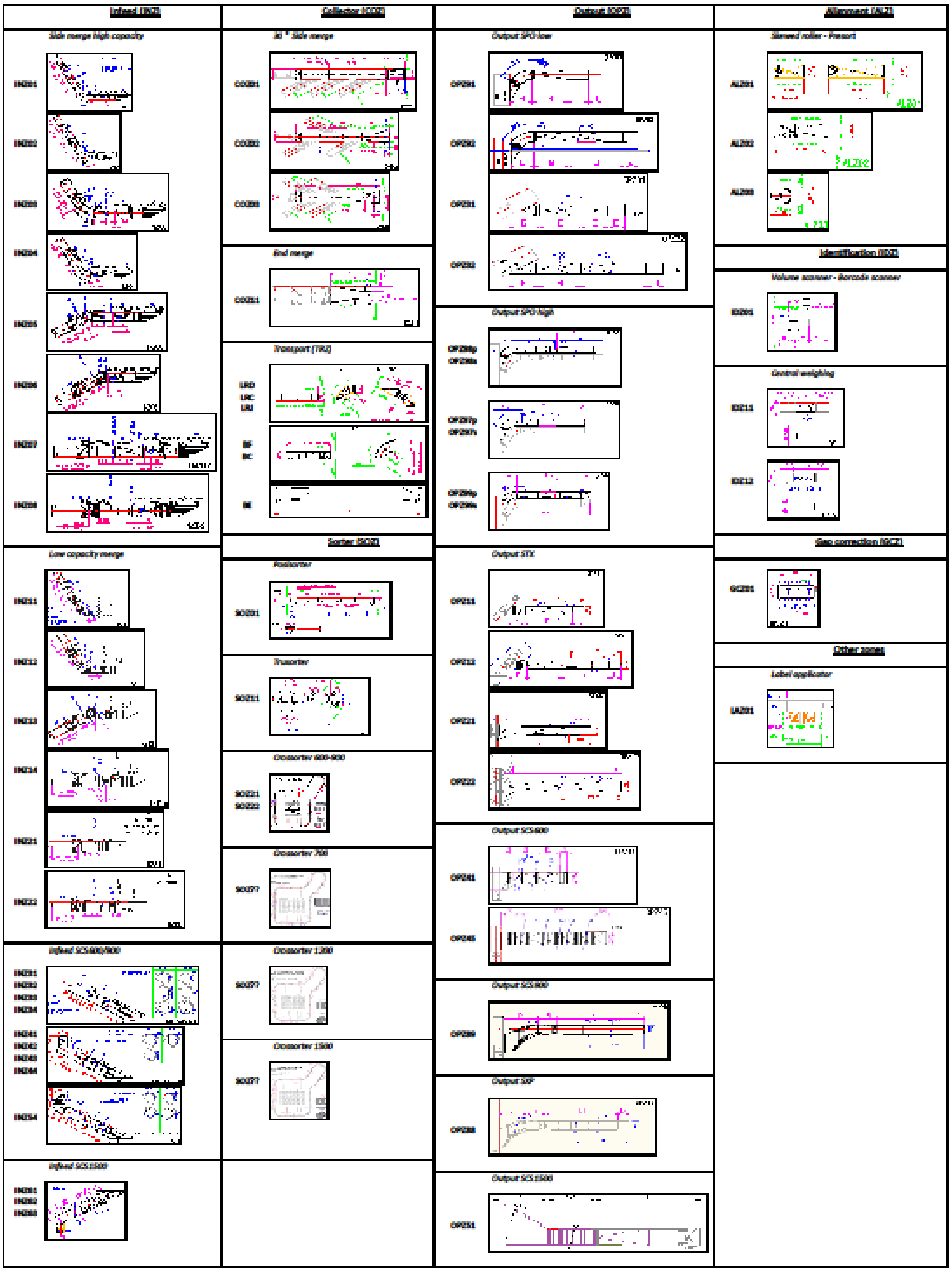


APPENDIX I. SUGGESTED IMPLEMENTATION ESOT AND CTO-PLANNING-BOM



APPENDIX J. STEP ZONE OVERVIEW

STEP Zone Overview



October 2011

APPENDIX K. RESPONSIBILITIES

Level	Decision or activity
Strategic	o Decision to ETO or CTO with clear intentions
	o Decide on core competences
	o Decide on focus markets
	o Decide to make or buy
	o Decide to outsource
	o Decide on MTO or MTS
	o Decide on standardization
	o Define Supply Chain configurations (production locations)
	o Integrate organizational philosophies
Tactical	**Sales**
	o Decide upon quotation or not
	o Decide on customization level
	o Determine customer needs
	Engineering and R&D
	o Decide upon product portfolio
	o Decide upon innovation projects
	Procurement
	o Select potential suppliers
	o Select strategic partners
	o Determine buy quantities
	o Determine wished lead times
	o Determine costs
	Production
	o Decide on production control
	o Decide on production capacity
	o Decide on production quantities
	o Determine production lead times
	o Determine production costs
	Shipping
	o Deciding upon transportation modes
	o Determine shipping costs
	o Select shipping partners.
Operational	**Sales**
	o Make quotations
	Engineering and R&D
	o Maintain product portfolio
	o Execute innovation projects
	Procurement
	o Execute buying
	o Control orders
	Production
	o Produce
	Shipping
	o Book orders
	o Pack orders
	o Ship orders