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Mapping and analysis of a distribution process in a make-to-order supply chain

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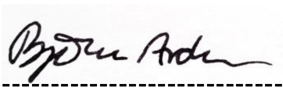
Preface

This master thesis was written during fall and winter 2012/2013 as the final part of our education in Industrial Engineering and Management at Lund University, Faculty of Engineering. The project was initiated and has been conducted for IKEA DS North Europe, Torsvik, in collaboration with the Department of Industrial Management and Logistics, Faculty of Engineering, Lund University.

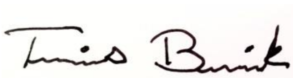
We would like to thank IKEA for giving us the opportunity to write this master thesis. It has been very interesting, informative and great fun to get an insight in the organization. We would like to thank all IKEA employees for your time, effort and great willingness to help us. A special thanks to Kicki Wettegård and Jakob Bertilsson for your support during the project. Moreover, we would also like to thank our supervisors, Dag Näslund and Hana Hulthén, at Lund University for your sharp and helpful comments.

Finally, we would like to thank our families and friends who have supported and helped us during nearly five years of studies at Lund University.

Lund, February 2013



Björn Andersson



Tobias Brink

Abstract

Title: Mapping and analysis of a distribution process in a make to order supply chain

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Background: Supply chains become more and more complex. Mapping can be a good way to understand a company's supply chain and its processes. IKEA's Direct Delivery Customer (DDC) process has a rather unique characteristic at IKEA. By using a make-to-order strategy are sofas, sofa covers and custom made worktops delivered to customers' home from the supplier. The material flow goes through IKEA's Customer Distribution Center (CDC). The DDC material flow has historically been very small and has therefore not received much attention. The volume of this material flow is continuously increasing.

Problem description: The CDC terminal in Torsvik perceives problems as lack of space and much manual administrative work due to the growing DDC material flow. The trend indicates that the impact of the perceived problems becomes more and more serious as the flow continues to grow. To fully understand the process and enable process improvements, it is requested to thoroughly map the process.

Purpose: The purpose of this study is to map the DDC process and investigate how it is managed. Another purpose is to identify problems in the process and suggest improvements.

Objectives:

1. Explain why a product is classified as DDC and why transshipment is made at the CDC terminal in Torsvik.

2. Create understanding of the DDC process by mapping from customer order to the point when the products are delivered at customer's home.

3. Identify and describe problems that occur in the part of the DDC process managed by the CDC terminal in Torsvik.

4. Suggest short-term and long-term improvements in the DDC process for the CDC terminal in Torsvik.

Method: The study is based on a system approach since synergy effects are expected between the different parts in the studied process. Improvement efforts require a system view to avoid sub optimization. The study was performed as a case study with single case design. Primary qualitative methods were used, as semi-structured, unstructured interviews and participating observations. Quantitative methods for collecting data also occurred, but to a minor extent.

The authors developed their own research procedure. After the literature review the research procedure was refined, in order to explain how the literature review would be used to answer the objectives. The refined research procedure contains the 6 steps; exploration, current state, identify and describe problems, analysis of problems and recommendations.

Conclusion: The mapping resulted in a description of the DDC process current state. Nine problems were identified through the mapping and analysis. Seven of these problems; lack of gate area, long lead time, no one responsible for the entire process, low efficiency in administrative work, missing goods, large amount of handovers, and custom related problems were further analyzed in terms of source, consequences and customer impact and potential solutions. From these seven problems it became clear that five depends upon low IT-support, one way or another.

In this case study it became clear that a growing material flow creates a more complex information flow. This information flow often requires to be managed with IT-support, which was missing in this case.

The analysis resulted in five short-term and two long-term recommendations. The short-term recommendations are; reduce lead time, share process maps, conduct a workshop with intention to increase efficiency in administrative work, inspection of loaded goods and modify the limit of orders in the IT-system. The long-term recommendations are; investigate possibility to implement IT-support and centralize process responsibility.

Keywords: Supply chain, process mapping, Value Stream Mapping, Swimlane flowchart, process analysis, process improvement, make-to-order, distribution

Glossary

3PL	*Third Part Logistics*. Outsourcing all or much of a company´s logistics operations to a specialized company. Among the services 3PLs provide are transportation, warehousing, cross-docking, inventory management, packaging, and freight forwarding.
CCD	*Central Customer Distribution*. Part of customer order flow delivered from stock at CDC.
CDC	*Customer Distribution Center*. Terminal managing both CCD and DDC material flow.
CDOS	*Customer Distribution Operation Support*. IKEA department placed in Helsingborg that monitors customer order.
CNS	*Cargo Network System*. IT-system that handles transport planning.
DC	*Distribution Center*. Terminal managing the DC material flow and refilling the stores. Products from the DC material flow are sold to customer through IKEA stores.
DDC	*Direct Delivered Customer*. Customer orders directly delivered from supplier as home deliveries to end customer, with transshipment at CDC terminal and hub.
Delivery schedule	IT-system including information about arriving and dispatching goods.
FY	*Fiscal Year*. IKEA is not following the calendar year. FY corresponds to the time period from 1st of September to 31th of August.
Gate area	Area in front of a gate in the terminal, can be either an inbound or outbound location
Hub	Terminal that is managed by 3PL companies which consolidate orders so they can be delivered to end customers home. The IKEA terminology for hub is Local Service Center (LSC.)
IKSC	*IKEA Service Center*. IKEA department, placed in Älmhult, handling customer support.
IKEA	An acronym for; Ingvar Kamprad Elmtaryd Agunnaryd

Inbound location	Gate area in the terminal which goods are received to.
IoS	*IKEA of Sweden*. IKEA department placed in Älmhult. The "heart" of IKEA that is responsible for creating designs, securing quality, low prices, planning availability and communicating the IKEA offer.
KPI	Key Performance Indicator
LSC	*Local Service Center*. The IKEA terminology for hub. LSC is called hub in this report.
MTS	*Make-To-Stock.* Manufacturing is based on forecasts and the products sold from stock.
MTO	*Make-To-Order.* Manufacturing is based on actual customer demand and triggered by a customer order.
Outbound location	Gate area in the terminal from where goods are dispatched.
VSM	Value Stream Mapping

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1. Introduction

In this chapter an introduction of the study will be presented starting with background. It will be followed by problem description, purpose, objective and delimitations which set the scope of this study. Thereafter it is declared which target group this study is directed to.

1.1. Background

Historically, it was common that one company handled the whole supply chain; from "farm-to-fork" (Goetschalckx 2011). Today, this is a rare situation and a supply chain is often a complex network consisting of many actors. Each company intends to focus on their core competence (Paulsson and Gammelgaard 2005). The complex structure makes the supply chain harder to understand and manage. Mapping can be a helpful way to understand and evaluate a company's supply chain and its processes (Gardner and Cooper 2003). A map can act as basis for redesign or modification, it helps to visualize the business and identify areas for further analysis and improvement.

IKEA, a Swedish home furnishing company established 1943, is an actor that participates in several different supply chains in order to provide a wide range of home furnishing products to their customers. IKEA´s original distribution strategy was to only operate as cash-and-carry, where the customer carried the products home at the same time as they bought them at the store. Today, IKEA also manage customer orders which means that the products are delivered to the customers' home at order. In this case the products are not held in stock at the stores (IKEA 2012a; IKEA 2012b).

Most of the products IKEA offers as customer order are held at stock in terminals and are ready for delivery. IKEA's Direct Delivery Customer (DDC) process has though rather unique characteristics at IKEA. DDC products are not held in stock at all by IKEA; instead a make-to-order system is used for those products. This means that the product is not ordered from the supplier before the customer orders the product from IKEA. Products handled as DDC products are; custom made worktops, sofa covers and a part of the sofa assortment.

DDC products were introduced in a small scale in the 80's. The material flow has historically been very small, especially on global level, and has therefore not received much attention. The volume of the DDC material flow is continuously increasing and in 2012 it represented a share of over 15 percent of the total customer ordered volume handled by IKEA's Customer Distribution Center (CDC) in Torsvik (IKEA 2012c).

Figure 1 illustrates the increase of DDC deliveries counted in total number of deliveries annually at the north European market.

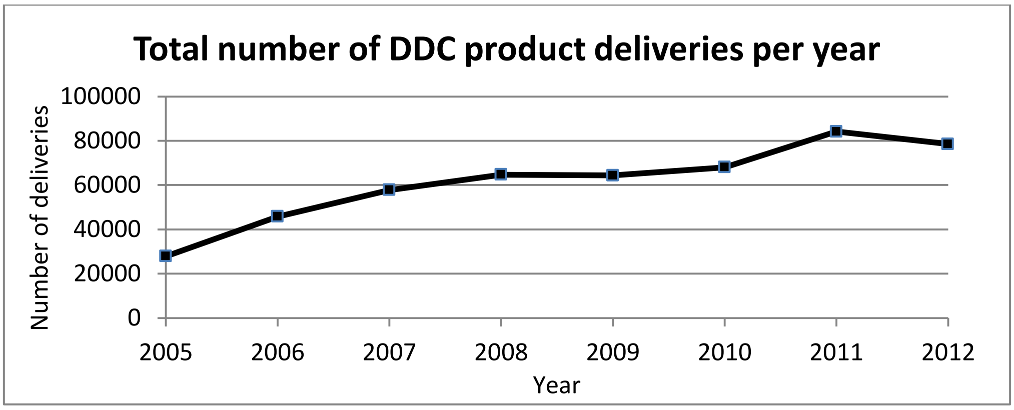


Figure 1. Visualizing the number of deliveries of DDC products per year, the trend is increasing. Based on IKEA (2012c)

In 2012 there were approximately 78,000 deliveries of DDC orders. This corresponds to a volume of approximately 110,000 m^3.

The actors in the supply chain handling the DDC process can be seen in Figure 2. There are several suppliers providing DDC products to IKEA. IKEA is responsible for transport to and from the CDC terminal and uses different third party logistic (3PL[1]) companies to manage the service.

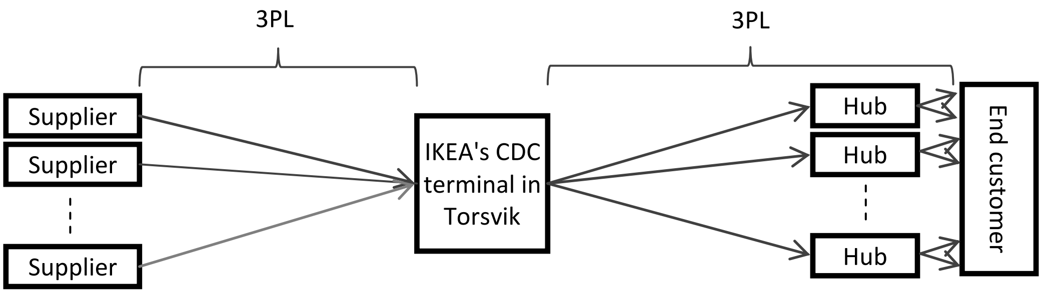


Figure 2. Overview of supply chain handling the DDC process

IKEA's CDC terminal in Torsvik receives and consolidates the goods before sending it on to different hubs.[2] The hubs consolidate the DDC products with possible remaining part of the customer order so they can send the complete customer order to the customer's home.

[1] Third party logistic (3PL) = A company specialized in logistics which handles other companies' logistics operations. (CSCMP 2010).
[2] Hub is at IKEA denoted as Local Service Center (LSC). This report will for simplicity use the word hub.

1.2. Problem description

The DDC material flow has grown rapidly the last ten years. IKEA’s CDC terminal in Torsvik perceives problems as lack of space and increased manual administrative work due to this growth. The trend indicates that the impact of the perceived problems become more and more serious in the CDC terminal, as the flow continues to grow. A hypothesis is that many of the perceived problems depend upon missing support from an IT-system.

The DDC process involves several actors in the supply chain and cross different departments inside IKEA. The different problems perceived at the CDC terminal, may be symptoms of problems existing in another part in the DDC process. To fully understand the process and enable process improvements, it is requested to thoroughly map the process. There is also a request to identify problems in the DDC process and investigate them to understand their source.

1.3. Purpose

The purpose of this study is to:

- Map the DDC process and investigate how it is managed.
- Identify problems in the process and suggest improvements.

1.4. Objectives

The objective is to:

1. Explain why a product is classified as DDC and why transshipment is made at the CDC terminal in Torsvik.
2. Create understanding of the DDC process by mapping from customer order to the point when the products are delivered at customer’s home.
3. Identify and describe problems that occur in the part of the DDC process managed by the CDC terminal in Torsvik.
4. Suggest short-term and long-term improvements in the DDC process for the CDC terminal in Torsvik.

1.5. Focus and delimitations

The object of this study is the DDC process regarding material and information flow. The process is managed in a supply chain with following actors; suppliers, 3PL companies, IKEA, hubs and end customers. The supply chain is studied from the perspective of IKEA´s CDC terminal in Torsvik.

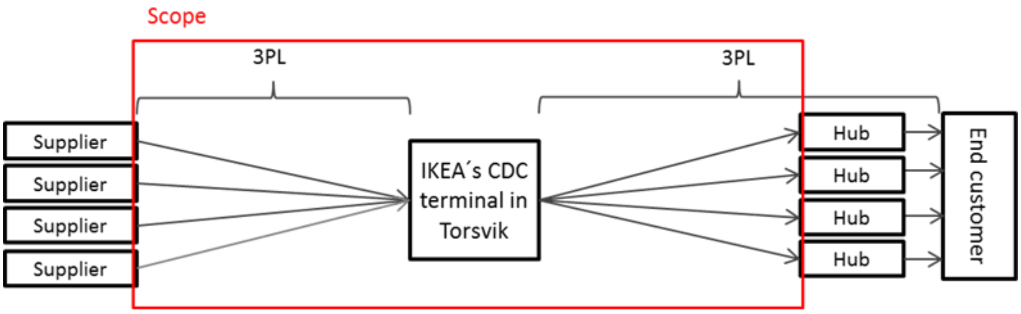


Figure 3. Illustration of the study´s scope in the supply chain. The mapping will be done from order creation to delivering product to end customer. The analysis will focus on the flow inside the red rectangle, from the supplier to the hub.

In Figure 3 the supply chain is shown, from first-tier supplier to end customer. The mapping and the analysis in this study will have different scopes regarding the start and endpoint of the supply chain. The mapping will be done from the point when a customer places an order to when the products are delivered at the customer's home. The analysis will have a narrower focus. The analysis will focus on the CDC terminal in Torsvik and include the part of the supply chain that is between the supplier and the hub, shown in Figure 3. The flows that will be included in the scope are the material flow and information flow. The material flow is studied downstream and not upstream, i.e. returns and claims will not be included which is handled in a separate process. The financial flow is set as a delimitation.

IKEA has a complex IT-system structure. Investigation of this structure will not be included in the scope even though the information flow is of importance.

Geographical delimitation is set to distribution in north Europe and to the material flow that is distributed through the CDC terminal in Torsvik, Sweden. Similar material flows at other IKEA CDC terminals in the world will be delimitations. The DDC material flow in north Europe is the largest one.

Products categorized as DDC are custom made worktops, sofa covers and a part of the sofa assortment. The handling of sofa covers, mainly delivered as parcels, differ from the rest of the DDC process and will be excluded from the scope of this study.

1.6. Target group

This report is aimed primarily to people involved with the DDC process at IKEA. The aim is to create understanding for the single person's role in the process. It should be of interest for management as basis to plan and address further actions. The second target group is students at technical university with interest of supply chain management.

2. Company introduction

IKEA is presented as a company in this chapter. IKEA's distribution channels, IKEA Distribution Service North Europe and the CDC terminal in Torsvik will be described.

2.1. IKEA

IKEA is a world-leading furniture company founded in Sweden. The IKEA Concept builds upon values and spirit of their founder, Ingvar Kamprad. The vision is *"to create a better everyday life for the many people"*. The IKEA concept includes the IKEA business idea to offer a wide range of well-designed, functional home furnishing products at prices so low that as many people as possible will afford them (IKEA 2012a).

2.1.1. IKEA at a glance

IKEA are via 338 stores, in 40 countries, distributing their range consisting of approximately 9,500 products. IKEA is presented in year 2012 numbers below (IKEA 2012d).

- IKEA stores had 690 million visits.
- IKEA websites had 1,100 million visits.
- The IKEA catalogue was printed in 212 million copies in 29 languages and 62 versions.
- The total number of co-workers was 154,000.

In 2012, IKEA's biggest markets where; Germany, USA, France, Italy, Russia and Sweden. IKEA's turnover in 2012 was 27.6 billion Euros. Figure 4 shows the total revenue trend between 2001 and 2012(IKEA 2012e).

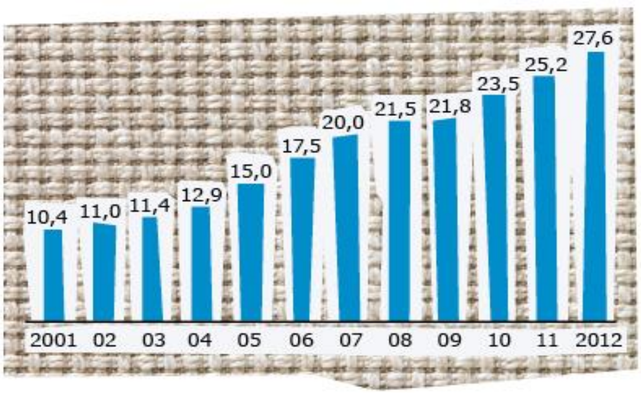


Figure 4. IKEA's total revenue in EUR billion from 2001 - 2012 (IKEA 2012e).

2.2. IKEA's distribution channels

This section aim to clarify IKEA's distribution channels and terms frequently used in this report as DDC, CCD, CDC and DC.

Products that the customers buy and bring home from an IKEA store are refilled from a Distribution Center (DC), and in few cases directly from the supplier. This material flow is visualized in the upper part of Figure 5, in grey color.

When customer order is distributed to customers home, a Customer Distribution Center (CDC) is used. This material flow is visualized in the lower part of Figure 5.

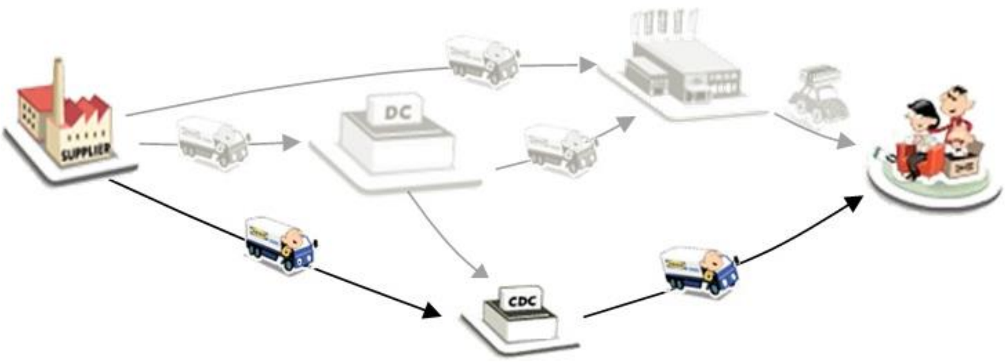


Figure 5. Illustration of distribution flows from supplier to end customer. The customer orders are handled in the CDC terminal.

The CDC terminal are managing two different distribution flows of customer orders; Central Customer Distribution (CCD) and Direct Delivered Customer (DDC), see Figure 6. The DDC process is the aim of this study.

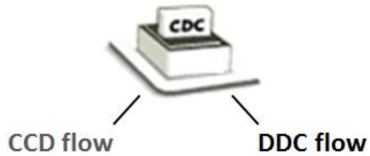


Figure 6. The material flows; CCD and DDC are both customer order flow that are handled in the CDC terminal. The DDC is the aim of this study.

The CCD products are stocked at the CDC terminal and delivered to end customers' home. DDC products are not held in stock at all by IKEA; instead a make-to-order system is used for those products. They are ordered from the supplier after a customer has placed an order to IKEA. The DDC products are then delivered directly from supplier to the customers' home, via transshipment at the CDC terminal.

2.3. IKEA Distribution Services North Europe

IKEA Distribution Services (IKEA DS) is divided in five distribution areas; North Europe, Central Europe, South Europe, North America and Asia Pacific (IKEA 2012f).

As mentioned in *1.5 Focus and delimitations* the scope of this study will be DS North Europe. Figure 7 visualizes the distribution areas in Europe and the location of DC- and CDC terminals.

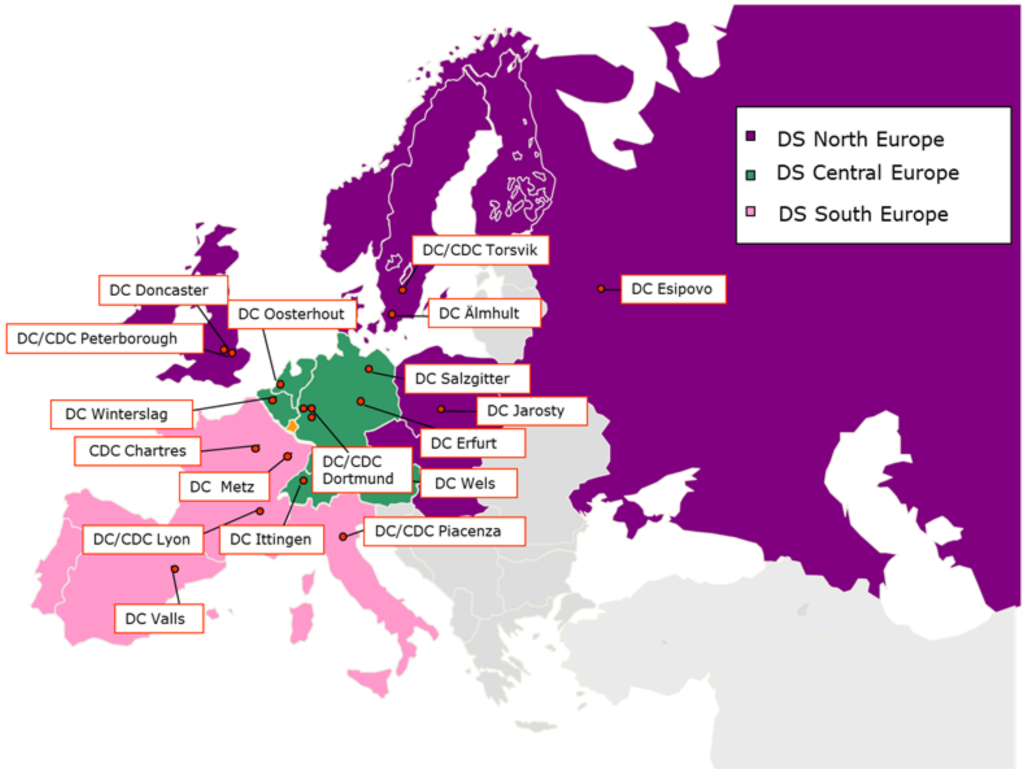


Figure 7. Distribution Service areas in Europe (IKEA 2012g)

There are, as seen in Figure 7, two CDC terminals that distribute customer orders in DS North Europe (IKEA 2012f). The CDC terminal in Peterborough supplies the British market and the CDC terminal in Torsvik supplies the remaining countries in the North Europe distribution area. This study is focusing on the DDC process managed by the CDC terminal in Torsvik. This terminal is therefore explained in following chapter.

2.4. CDC terminal in Torsvik

In Torsvik, both a DC- and a CDC terminal exist. These are shown in Figure 8 (IKEA 2012f). The nearest of the two white buildings, in the figure, is the CDC terminal. The

65,000 m^2 terminal has a storing capacity of 55,000 m^3. In 2012, the CDC terminal handled a volume of 724,000 m^3 which was divided over 4.5 million order lines.

Figure 8. Picture of IKEA's DC and CDC terminals in Torsvik seen from up above (IKEA 2012g)

Below the CDC terminal in Torsvik is presented in 2012 years facts and numbers (IKEA 2012f).

- 450 employees
- 5,500 articles in range including test range
- 300 million EUR in sales via CDC Torsvik which is 14% share of total Nordic sales

Daily volumes:

- Incoming deliveries with truck: 1,000 m^3
- Incoming deliveries with railway: 200 m^3
- Incoming deliveries from DC via tunnel: 70 m^3
- Number of trucks per day in/out: 100

3. Methodology

In this chapter the methodology for the study will be described. Different approaches, methods and strategies are explained. This is followed with a description of chosen research procedure and the different types of data collection methods used. The chapter ends by discussing the trustworthiness, authenticity and criticism of the sources.

3.1. Scientific approach

Researchers can have different views of reality which can influence the approach of the research (Arbnor and Bjerke 2008). The result of a research will therefore depend on the researchers' state of mind. To ensure that the thesis will be understood in the right way, it is necessary that the scientific approach is clearly defined.

Arbnor and Bjerke (2008) have created a methodological framework and formulated three scientific approaches; the analytical approach, the systems approach and the actors approach. Each approach explains a type of mindset and to some extent directs the choice of research method. In Table 1 an overview of these approaches is presented.

Table 1. Overview of different scientific approaches based on Arbnor and Bjerke (1997)

	Analytical approach	Systems approach	Actors approach
Theory type	Determining cause-effect relations. Explanations, predictions. Universal, time and value free laws	Models. Recommendations, normative aspects. Knowledge about concrete systems	Interpretations, understanding. Contextual knowledge
Preferred method	Quantitative (qualitative research only for validation)	Case studies (qualitative and quantitative)	Qualitative
Unit of analysis	Concepts and their relations	Systems: links, feedback mechanisms and boundaries	People – and their interaction
Data analysis	Description, hypothesis testing	Mapping, modeling	Interpretation
Position of the researcher	Outside	Preferably outside	Inside – as part of the process

3.1.1. Analytic approach

In the analytic view, reality is divided into small parts and investigated independently where patterns and casual relations between them can be disclosed (Arbnor and Bjerke 2008). When every part has been investigated and understood, all parts can be summarized by the idea that the whole is the sum of its parts. From this, concepts can be created which explains the systems behavior (Gammelgaard 2004). In this way it is possible to predict how the system will develop and behave in the future.

An important part in the analytic view is hypothesis (Arbnor and Bjerke 2008). In the analytical view theory contains models that should be general and valid for more than one reality case. Analytic studies can be explorative with an objective of creating a hypothesis, not to disclose a general pattern.

The researcher should observe from the outside (Gammelgaard 2004). It is important that the research object is not influenced by the researcher. Quantitative methods are dominating but qualitative methods could be used to validate the result.

3.1.2. System approach

From a system view, it is meaningless to divide reality into parts and investigate these independently (Gammelgaard 2004). In contrast to the analytic view, the whole is not the same as the sum of its parts. Synergy effects arise between the parts when they are summarized and a correct result can therefore not be obtained if parts are investigated independently. Instead it is necessary to identify the system’s parts, links, goals and feedback mechanisms to obtain a holistic view which enables the researcher to improve the system.

In comparison to an analytic approach is the search for a pattern or behavior of a system exchanged to a search for a solution to a real world problem (Gammelgaard 2004). The solutions tend to be much more case specific. According to Churchman (1979) are case studies the ideal research method when using a system approach, where both qualitative and quantitative methods can be used. The researcher should observe the object from the outside but is, in a system approach, allowed to influence the object with changes in order to improve it.

3.1.3. Actor approach

In the actor view, the reality is seen as a social construction. It is necessary to understand the human interactions and intentions to get the proper picture of the reality (Arbnor and Bjerke 2008). The whole is seen as the characteristics of the parts. Therefore is it important that the researcher is deeply involved in the research object to be able to fully understand it. Qualitative methods are primarily used in actor studies. The actor approach is rare in logistic researches (Gammelgaard 2004).

3.1.4. The scientific approach in this thesis

The DDC process can easily be divided into smaller parts and investigated independently. In this research it is necessary to study the process in detail, but at the same time is the holistic view essential. Synergy effects exist between the different parts in the process. An understanding of how the parts depend upon each other is required to figure out how the system reacts on changes in different parts. This is needed in order to not sub optimize the process.

The objective was to perform mapping of the entire process and a deeper analysis of identified problems. This should result in a case specific analysis and recommendations. With this in mind, a system approach was chosen for this study.

3.2. Qualitative and quantitative research

Qualitative and quantitative are terms that have been mentioned earlier but have not been explained. Qualitative and quantitative methods are two different methods that can be used to collect and analyze data (Denscombe 2009). Experiments and surveys are data collecting methods that are used in quantitative research. In a quantitative research, quantitative data is gathered. The definition of quantitative data is something that can be counted or classified and consist of numbers or numerical values. Statistics and mathematics are used to measure and analyze quantitative data (Höst *et al*. 2006).

Observations and interviews are methods that can be associated with qualitative research (Denscombe 2009). In a qualitative research, data which consist of words and descriptions is gathered (Höst *et al*. 2006). Qualitative data can for example be used to interpret observations.

Due to the nature of this study, primary qualitative methods for data collection were used as interviews and observations. Quantitative methods for collecting data also occurred when quantitative data was available, but in a minor extent.

3.3. Research strategies

A research strategy describes the fundamental way to work through a study (Höst *et al*. 2006). The nature and the objective of the study decide which research strategy that should be used.

Höst *et al*. (2006) has listed; survey, case study, experiment and action research as the four most relevant strategies for a master thesis. These are briefly explained below.

- ***Survey:*** A current state description is made of a research objective. The purpose of a survey can be, for example, to find out how many that uses a computer program. A survey often answers a broad question.
- ***Experiment:*** The purpose of an experiment is often to perform a comparative analysis of two or more options. As many parameters as possible should be stable while different options are tested. In this way it can be understood how the research object reacts on these options.
- ***Case study:*** A deep analysis is performed on one or more case objects with the intention to understand a phenomena and the cause of it. Conclusions that are made in a case study are often case specific and there is no aim of finding a general conclusion that can be used in other case studies.
- ***Action research:*** An action research can be compared with a case study. In addition from a case study, an action research also includes implementation of improvements. Therefore, the first step can be to do a survey or a case study, which will be followed up by a recommending solution to the problem and implementation of the solution.

Strategies can be divided into fix or flexible strategies (Höst *et al*. 2006). A fix strategy is well defined before the study is executed in comparison to a flexible that can be adapted if the conditions will change during the study. Case studies and action researches can often be classified as flexible strategies and surveys and experiments are mainly fix strategies.

As explained in *3.1 Scientific approach*, the result can vary depending of the used approach. A way to limit the variation is by using an approach called triangulation. It means that more than one strategy is used, data are collected in different ways or the same data are collected from different persons (Robson 2002). By doing this a better picture of the reality will be obtained.

Strategies have both advantages and drawbacks and it is important to choose the most suitable strategy for the study (Yin 2007). In Table 2 Yin (2007) has tried to differentiate the strategies to make it easier to select.

Table 2. Overview of different research strategies. Based on Yin (2007)

Strategy	Type of research question	Requires control of behavioral event	Focuses on contemporary events
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Case study	How, why?	No	Yes

Yin (2007) does not mention action research and it is therefore not included in Table 2. Höst *et al.* (2006) explains that action research sometimes is explained as a variant of a case study.

A case study can have a single or multiple case study design (Ellram 1996). A single case design is used when an examination is made on one unit; a company for instance. When a multiple case design is used, the same examination is made on multiple units.

3.3.1. The research strategy used in this thesis

The objective for the study aimed to answer questions as "how" and "why". The study focused on a contemporary event with the purpose to understand a phenomenon and why it occurs. This matches well with how a case study is described above.

The objective was also to further investigate problem areas, analyze the source of the problems and its consequences. An action research includes the implementation of solutions and improvements (Höst *et al*. 2006), which is out of scope for this study. With this in mind a case study was chosen as research strategy. Case study as research strategy is recommended by Churchman (1979) when using a system approach, which strengthens the selection of this strategy. A single case design was used due to the fact that the case was performed at one case company, IKEA.

To sum this up; a flexible research strategy in form of a case study was performed. This was done with a single case design. Primary qualitative methods were used but quantitative methods also occurred. This was performed with a systems view perspective.

When a research strategy been selected the next step is to form a research design (Yin 2007). According to Yin (2007) the researcher has to form his own research design because there are no general research designs to choose from when it comes to case studies. A research design could be defined as a plan for how to get from the research questions to the conclusions. A research design contains processes like collection, analysis and interpretation of data. In this study the research design is called research procedure.

3.4. Research procedure

This section will explain the research procedure of the study that has been divided in two sections; pre-study and case study.

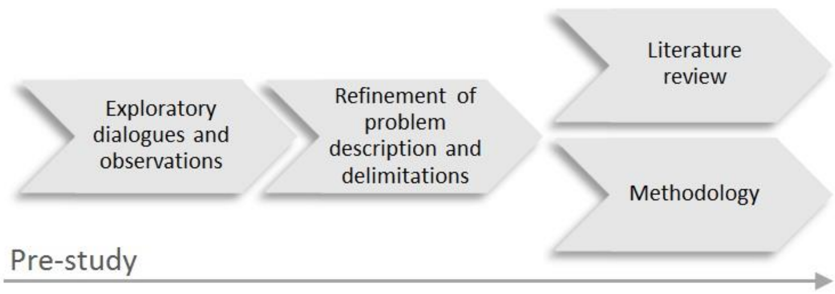


Figure 9. Illustration of the pre-study

The pre-study is illustrated in Figure 9 and started with exploratory dialogues and observations to get an understanding of the DDC process and the operations. This was performed at the case company at several departments which participates in different parts of the process. The new information served as a basis for refinement and adjustment of the problem description, objectives and delimitation of the study. When the problem description, objectives and delimitations were settled, the methodology was described and a literature review performed.

Literature review and methodology review was carried out in parallel, which finalized the pre-study. The purpose with the literature review was to get a deeper knowledge in the field.

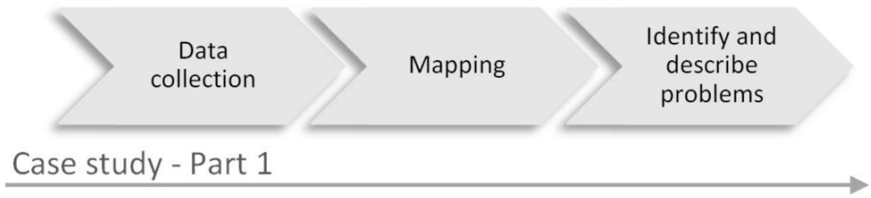


Figure 10. Illustration of case study – part 1

The case study, partly illustrated in Figure 10, started with data collection. The data collection is further discussed in *3.5 Data collection*. After collecting necessary data, the DDC process was mapped. The maps were used to understand the process. They were also used as basis in order to identify problems in the DDC process and during analysis of this process. Problems were identified through interviews and observations. The maps were then further analyzed in order to find additional problems. All identified problems were thereafter described.

Figure 11. Illustration of case study – part 2

The second part of the case study, illustrated in Figure 11, started with analyzing the identified problems in terms of their sources and consequences. This step included a workshop with managers at IKEA's CDC terminal in order to discuss these problems. Potential solutions were developed and investigated in term of suitability. Based on this, recommendations were made to IKEA, both in long- and short-term.

3.5. Data collection

This study mainly used interviews and observation as data collection methods, which according to Höst et al. (2006) are common methods to collect data in case studies. In addition to above methods, archival data was also gathered.

3.5.1. Primary and secondary data

To ensure the quality of the study, the data needs to be current, relevant, reliable and accurate (Rabianski 2003). The data could be primary or secondary and it is important to know which type of data that is used and understand its characteristics and limitations. Primary data is defined as information directly gathered by the researcher. It is obtained from the original source through direct observations or by explicit questioning of people, as interviews or surveys.

Secondary data is defined as information from a secondary source, i.e. not directly compiled by the researchers (Rabianski 2003). In general, secondary data is obtained from published materials. Secondary data has been gathered by others for their own purposes. This purpose is usually not known and it is therefore important to check for errors to validate its accuracy. Source criticism is important when using secondary data to avoid using irrelevant data that could lead to incorrect conclusions.

Primary data is preferred and was in this study gathered through interviews and direct observations at the departments. Secondary data that was used are archival material and data gathered by IKEA employees from IKEA's IT-systems. Archival material is material collected from the company like statistics, reports and documentations (Yin 2007). Company specific data was gathered from IKEA's information systems. This is unaffected raw data generated from the actual business flow and are therefore considered as reliable. Public publications and internal documents provided by IKEA were assessed as credible due to the comprehensive review the document has completed before publication. Quantitative data was gathered from IKEA's IT-systems in those occasions it was available and considered as useable during analysis.

3.5.2. Interviews

An interview is a questioning of a person regarding a problem or a specific topic. Interviews can be made face to face or via telephone (Höst *et al.* 2006). According to Yin (2007) interviews are one of the most important information sources when performing a case study. Denscombe (2009) have listed three different types of interviews; structured-, semi structured- and unstructured interview.

In a structured interview the researcher has large control over the interview (Denscombe 2009). Questions have been formed and the interviewed person can only answer with predefined answers made by the researcher. This type of interview is common in surveys.

In a semi structured interview the researcher has also formed a number of questions (Denscombe 2009). There is no predefined answer which enables the interviewee to answer more in detail. The researcher should also be flexible when it comes to the sequence of the questions and let the interviewee develop their ideas and opinions.

In an unstructured interview the researcher only prepare the topics that should be discussed i.e. no questions are formed (Denscombe 2009). The researcher should try to start the interview by introducing a topic and then let the interviewee talk and share thoughts, ideas, and opinions.

The majority of the empirical information in this study is based on interviews. During the pre-study, unstructured interviews were used in order to complement the observations. In part 1 of the case study, semi structured interviews were primary used. In several occasions during part 1 was the semi structured interview followed by an unstructured interview in order to discuss a specific topic further on.

The interview guide for the semi structured interview can be found in Appendix A. The length of the semi structured interviews was approximately 30 minutes. The length of the unstructured interview varied between 15 to 100 minutes. Notes were taken during all interviews and compiled in structured documents after each interview. All main issue and information of great importance were communicated to the interviewees for verification.

To be able to receive a holistic view, it was important to interview people from the different departments handling the DDC process. It was also important to interview persons at both an operational and strategic/tactical level in the company. Following persons were therefore interviewed. They have been categorized after which IKEA company they belong to.

IKEA DS North Europe CDC/DC Torsvik

Name	**Job title**	**Department**	**Years at IKEA**
Anton Thai	Warehouse Co-worker	Goods In CDC	12 years
Jakob Bertilsson	Associate warehouse manager	CDC	6 years
Jonas Tingrud	Warehouse Co-worker	Flow Co-ordination CDC	11 years
Kicki Wettegård	Operational support manager	Operational support Mgmt	14 years
Lena Fallkvist	Operational support Co-worker	Administration	13 year
Linda Eriksson	Operational support Co-worker	Administration	1 year
Linda Sonestedt	Flow planner	Administration	13 years
Nina Josefsson	Custom specialist	Administration	5 years
Olov Norberg	Business navigator	Business Navigator	1 year
Richard Thorell	Site manager	CDC/DC Mgmt Torsvik	16 years
Sandra Jonsson	Operational support	CD Transport	12 years
Stefan Eng	Flow planner	Administration	14 years

IKEA IoS, Älmhult

Håkan Holm	Sourcing developer	Category Upholstery	32 years

IKEA DS North Europe, Älmhult

Conny Persson	WMS Responsible	IT-support	14 years
Ola Johnsson	Business developer	DC	33 years

IKEA CDOS, Helsingborg

Christian Müller	CDOS Co-worker	CDOS	23 years
Viktor Lööf	CDOS Co-worker	CDOS	4 years

IKEA DS South Europe, Paris

Said Abdelouadoud	WMS Responsible	Warehouse Logistics	7 years

IKEA IKSC

Rose-Marie Ivarsson	Head of department	Contact Center Sweden	3 years

3.5.3. Observations

Observation is a data collection method which is not totally relying on what people are saying or thinking (Denscombe 2009). It is based on the researchers own perception of what actually is happening in real situations at the field.

It is possible that two researchers that observe the same phenomenon might draw different conclusion (Denscombe 2009). This depends upon the human ability of memory and perception. The memory has limitations and most of what is observed will be forgotten. A lot of information that is received through our mind is filtered by our brain and gives us a restricted picture of what actually happened. What is perceived can also be influenced of our emotional mind and feelings as anger, frustration, hunger etc.

There are two main types of observation methods; systematic and participating observation (Denscombe 2009). Systematic observation tries to overcome the problematic mentioned above and minimize the variations that occurs based upon individual perception. To do this, the observer is using an observation schedule to register data in a systematic and standardized way. The goal is that the resulting data observed by the researcher, will be consistent with other researchers´ observations of the same data.

If participating observation is used, the observer participates in the environment a certain time period during the study and observes what happens, listening to what is being said and ask questions (Denscombe 2009). It is important to maintain and not affect the natural environment of the studied object.

This study uses participating observations as an important and significant data collection method. Observation is one of the methods that were used to study the DDC process and its sub processes. Field notes were taken to document the field observations. By directly document what was observed, the documentation was not affected by memories and perceptions. If suspicions existed concerning information gathered through observations, this information was verified through additional observations or through interviews. Most observations were done in the CDC terminal in Torsvik. Beyond this, observations were made at one hub.

3.6. Trustworthiness and authenticity

To verify the research is important. Without verification, research is meaningless and therefore the trustworthiness of the research must be proven (Denscombe 2009).

For a research to be considered as trustworthy, the sources used in the report also have to be trustworthy. The used literature has been controlled in term of trustworthiness by the authors during the whole study. In majority, books and articles has been used as sources which in large extent has been found through searches in the data bases; Summon, LUBsearch and Lovisa.

The validity, reliability and objectivity can determine how trustworthy a research is. These concepts are presented below.

3.6.1. Validity

To accomplish high validity in the collected data the method of collecting it must be accurate and correct (Denscombe 2009). Validity means that the right data has been collected and that it has been collected in the right way.

High validity has been achieved through triangulation. Different types of data collection methods have been used as unstructured interviews, semi structured interview, observations, workshops and quantitative data collection from IT-systems. This has been achieved by using both qualitative and quantitative data.

In order to avoid personal opinions and inaccurate information, interviews have been held with as many people as possible. By doing so, the information has been gathered from several people with different points of view. Unfortunately, it was not possible to gather all the information from different sources and the risk that information is inaccurate exists.

Information that could have been misunderstood was communicated to the interviewees for verification.

3.6.2. Reliability

Reliability is about the repeatability of the research (Denscombe 2009). High reliability is achieved if the outcome of the research would be the same if the research had been performed once more.

A clear research procedure has been explained. If the research should be performed again, the researcher could follow the same research procedure. By using the interview guide and protocol together with a database including interviews- and field notes, the data collection can be performed in the same way again. This increases the reliability.

Interviews have been held with as many people as possible to insure that the authors have gained the whole picture. This has increased the reliability.

The DDC process develops constantly. Changes can be made which improves the process and solves problems. Consequently, these problems may not exist if the research is performed again, at a later point of time.

The reliability could have been higher if more data were used. Due to lack of resources were some of the analyses carried out with a low amount of data. Some of the analyses outcome may therefore differ if they were repeated.

3.6.3. Objectivity

Objectivity means that the researcher has been impartial and neutral (Denscombe 2009). The data collection and the analysis of the data should be neutral and not influenced by the researcher.

The objectivity of the literature is considered as high since the data has been gathered from multiple sources. Choices done by the authors have been clearly motivated in order to ensure objectivity.

4. Literature review

This chapter presents the literature review. It starts off with discussing the concept supply chain which will be followed of process approach, mapping and analysis tools.

The literature review is divided in four main parts (see Figure 12); supply chain, process approach, mapping and analysis tools.

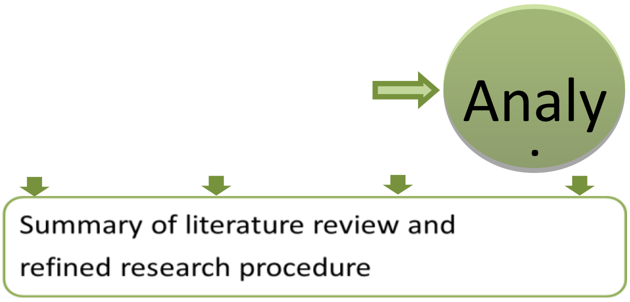


Figure 12. Focus in literature review.

The first part of this chapter will discuss supply chain at an overall level, taking its starting point in the definitions of supply chain and supply chain management, to then examining the configuration of specific make-to-order supply chains. In the second part, literature on process approach is reviewed as it is a central way to describe businesses. It is also supportive to, and often mentioned in connection with mapping and analysis. Third part will go through mapping, it will include reasons to map, problems with mapping and describe different ways to map processes. Fourth part will present different analysis tools that can be used to analyze the conducted map. Finally, the literature review will be summarized and a refined research procedure presented. This research procedure is first presented in general to be used for similar case studies as this one. Then it is explained how the literature review will be used in order to fulfill the objectives of this case study.

4.1. Supply chain

All companies participate in a supply chain, from the raw materials to the end consumer (Lambert and Cooper 2000). In literature there are several definitions of supply chain. This study adopts the definition of supply chain given by Mentzer *et al.* (2001b):

“*a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer”* (p.4).

4.1.1. Supply Chain Management

Historically, it was common that one company handled the whole supply chain; from “farm-to-fork”. Today, this is a rare situation and a supply chain is usually not a single or simple chain but a complex network (Goetschalckx 2011).

Since the expression Supply Chain Management (SCM) was introduced in the 1990´s many different definitions has occurred (Gibson *et al*. 2005). Global Supply Chain Forum (GSCF) defines it as:

“Supply Chain Management is the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders.” (Lambert & Cooper 2000, p.66)

A larger focus on core competencies from many companies has resulted in more complex supply chains with many actors. To be able to give a competitive offer to the end customer, the single company depends on the other actors in the supply chain (Paulsson and Gammelgaard 2005). Paulsson and Gammelgaard (2005) argues that competition has previously been between individual companies but nowadays the competition is between supply chains that offers similar products to the end customer. This was also claimed by Lambert and Cooper (2000):

“Instead of brand versus brand or store versus store, it is now suppliers-brand-store versus suppliers-brand-store, or supply chain versus supply chain” (p. 65)

Lambert and Cooper (2000) argues that successful supply chain management requires cross-functional integration within the company and across the companies included in the supply chain. An objective with supply chain management is to be cost effective across the whole supply chain (Basu and Wright 2012). Optimizing one part in the supply chain can lead to cost reductions in this part but affect the whole supply chain negatively.

Unsuccessful supply chain management can be characterized by sub optimization, where each part is optimized independently. To be able to avoid sub optimization and succeed with supply chain management a holistic view of the supply chain is essential (Basu and Wright 2012).

4.1.2. Focal company in supply chain

The supply chain network structure consists of the member companies and the links between these companies (Lambert and Cooper 2000). Figure 13 illustrates a supply chain structure model adopted from Paulsson and Gammelgaard (2005).

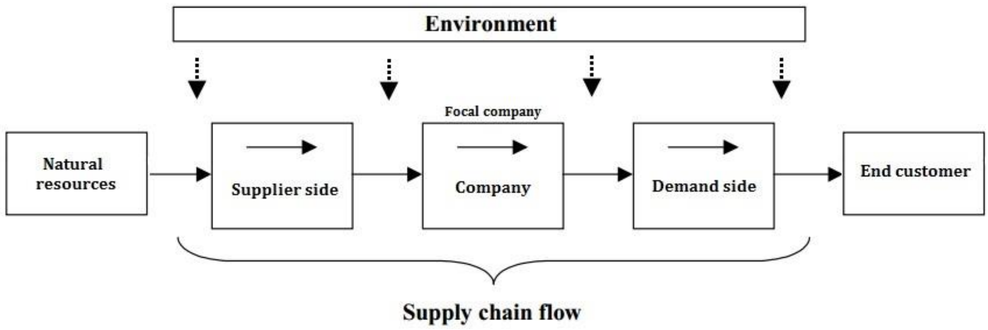


Figure 13. Basic structure of a supply chain including a supplier side, a focal company and a demand side. Based on: Paulsson and Gammelgaard 2005.

This model is divided into three different parts; a supply side, a company and a demand side (Paulsson and Gammelgaard 2005). It is all seen from the perspective of a specific company, called the focal company. If the perspective had been changed and the supply chain had been seen from the perspective of a supplier instead, the supply chain had been different containing other customers and suppliers. It is therefore important to define the focal company. The focal company is a definition just saying "it is from this company's perspective we choose to look". The company itself could be any actor in the supply chain.

4.1.3. Make-to-order supply chain

This section will shortly present make-to-order supply chain and compare it with other chain strategies.

In a pure Make-To-Order (MTO) supply chain, the receiving of a customer order triggers all activities from procurement of materials, part and components, to production and assembly, until final delivery (Li and Womer 2012). Companies using MTO, produce to orders on actual customer demand instead of forecast. This means no inventory, but customers instead need to wait for delivery (Kaminsky and Kaya 2009). MTO is closely related to the philosophy of just-in-time. It enables every order to be unique and low in quantity (Li and Womer 2012).

MTO is often contrasted to more traditional push system as Make-To-Stock (MTS). Both systems have their relative advantages, related to various manufacturing environments (Olhager and Östlund 1990). Key characteristic differences between a

Make-To-Stock supply chain and Make-To-Order supply chain can be seen in Table 3.

Table 3. Differences between Make-To-Order and Make-To-Stock supply chains. (Gunasekaran and Ngai 2005; Vidyarthi et al. 2009; Verdouw et al. 2011)

	Make-To-Stock (MTS)	**Make-To-Order (MTO)**
Mechanism	Push	Pull
Basis for production planning	Demand forecast	Customer order
Production schedule	Stable	Flexible
Economics of scale in production	Yes, possible	No
Distribution	Non differentiated mass approach	Fast, reliable, customized
Managing uncertainty	Inventory buffers	Information management, flexibility
Finished goods inventory	High	None
Supplier selection criteria	Cost, quality	Responsive, collaborative
Supplier lead time	Long	Short
Order promising	Based on availability finished products, distribution capacity and distribution lead time	Based on input material availability, capacity and lead times of fabrication, assembly and distribution
Customer order response time	Fast	Slow
Market response time (e.g. to market trends or volatile demand)	Slow	Fast

Beside MTS and MTO, other so called hybrid supply chain strategies exist, which combine push-pull strategies. Literature distinguishes the following main strategies (Verdouw *et al*. 2011; Gunasekaran and Ngai 2005; Olhager and Östlund 1990):

Make-To-Stock (MTS) **-** Products are entirely produced according to forecast and customers are served from available stock of finished goods.

Assembly-To-Order (ATO) **-** Sometimes also called Build-To-Order (BTO). Components are produced according to forecast and held in stock. The products are then assembled from the stocked components at customer order. One of the first successful ATO companies was Dell Computers, which gained market shares by building customized computers from components (Gunasekaran and Ngai 2005).

Make-To-Order (MTO) - The products are entirely produced based on customer orders.

Engineer-To-Order (ETO) - The products are engineered and designed according to customer order, e.g. aircrafts or houses.

The supply chain classification above is achieved by separating the supply chains according to the placement of the Customer Order Decoupling Point (CODP). Sharman (1984) describes that the CODP separates the supply chain into an upstream, forecast-driven, and a downstream demand-driven section. The upstream section from the CODP follows a traditional push-mechanism where production planning is based on a forecast of future customer orders (Wouters 1991). The downstream section follows a traditional pull-mechanism where the production planning is based on real customer orders. Thus, the CODP works as a buffer between the stable upstream processes and the fluctuating downstream processes driven by customer orders (Verdouw *et al*. 2011). Figure 14 illustrates the main strategies based on the placement of the CODP.

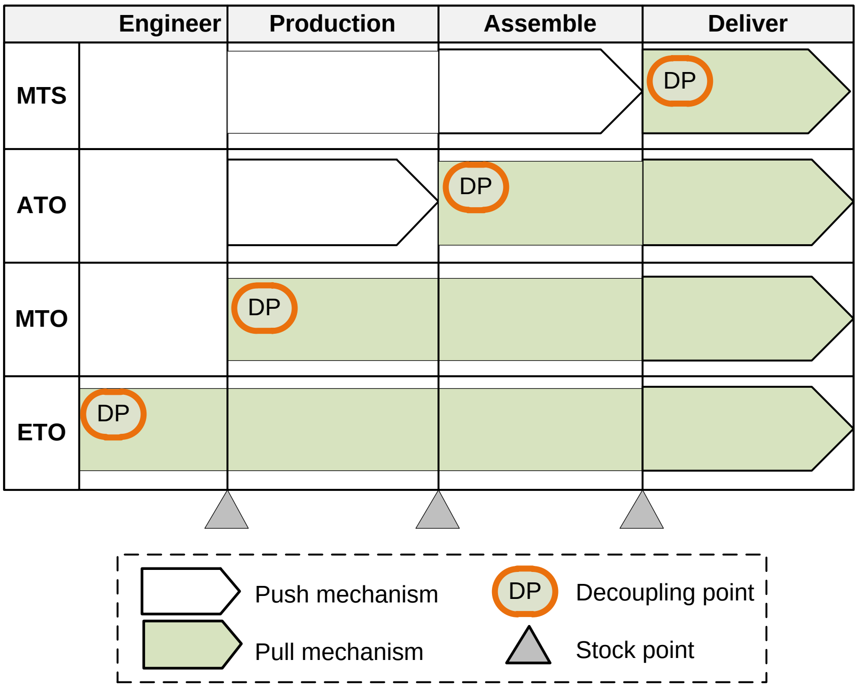


Figure 14. Illustration of main supply chain strategies based on the placement of the customer order decoupling point. Based on figures and information from (Sharman 1984; Wouters 1991; Olhager and Östlund 1990; Mason-Jones et al. 2000)

4.2. Process approach

The concept of processes and Supply Chain Management are related per definition, since a Supply Chain Management earlier has been defined as *"the integration of key business* ***processes*** *from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders."* (Lambert and Cooper 2000, p.66).

Process approach means that the business is not viewed, structured and improved in terms of function or products, but in terms of processes (Davenport 1993). The company primarily consists of processes, not products or services. In other words, managing a business means managing its processes (Škrinjar *et al*. 2008).

4.2.1. Process definition

According to Davenport (1993) p.5, a process is defined as:

"a structured, measured set of activities designed to produce a specified output for a particular customer or market, (...)a specific ordering of work activities across time and space, with a beginning, an end, and clearly identified inputs and outputs: a structure for action"

This definition is widely used and accepted (e.g. (Aguilar-Savén *et al*. 2004; Lin and Shaw 1998; Lambert *et al*. 2005). It will therefore be adopted in this study. Many other definitions of a process exists, but they all have the same essential content: processes are relationships between inputs and outputs, where inputs are transformed into outputs using sequence of activities, which add value to the inputs for a specific customer.

4.2.2. Type of processes

Business processes are classified in different ways in theory. For instance, business processes can be classified into core and supportive processes (Porter 1990; Davenport 1993; Aguilar-Savén *et al*. 2004). Management process is added to this classification by some literature e.g. Ljungberg and Larsson (2001) and Harmon (2010).

Another classification is hierarchically according to the level of detail, see Figure 15. Each core business process (level 1) consists of a number of sub processes (level 2). Each sub process consists of a number of activities (level 3), which are further divided into tasks (level 4) (Kalman 2002). These multi-level structures are used in most process literature and integrated in frameworks such as e.g. the Supply Chain Operations Reference (SCOR) model and Business Process Re-engineering (BPR).

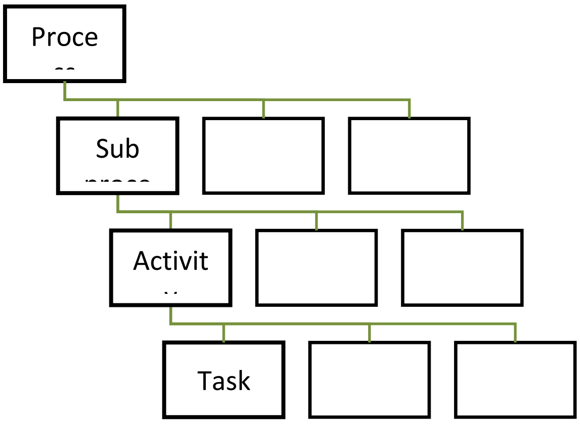


Figure 15. A process can be described in different level of details. A process consists of sub processes which in turn consist of activities, which in turn consist of tasks. Based on Kalman (2002).

4.2.3. Process responsibility and roles in a process oriented organization

A traditional hierarch and function based organization has a shape of a pyramid. Work areas are formed by putting people together with similar competence and those who are performing similar work. A manager of a department is responsible for the people and the work that is performed in a specific part of the process. With other words the manager of a department is responsible for three relatively different areas (Ljungberg and Larsson 2012):

- Management of the operational work
- Co-workers development
- Development and maintenance of a specific part of the process

The three areas do not have much in common, and different managers prioritize the three areas differently and one area may be forgotten. In a process oriented organization, there is a different perspective of organizing the business. Operations personnel work in cross-functional teams that have far-reaching responsibilities throughout the process. Managers' traditional role as coordinators and policy makers is therefore amended to focus more on supporting the teams so the work is carried out as smoothly as possible (Ljungberg and Larsson 2012).

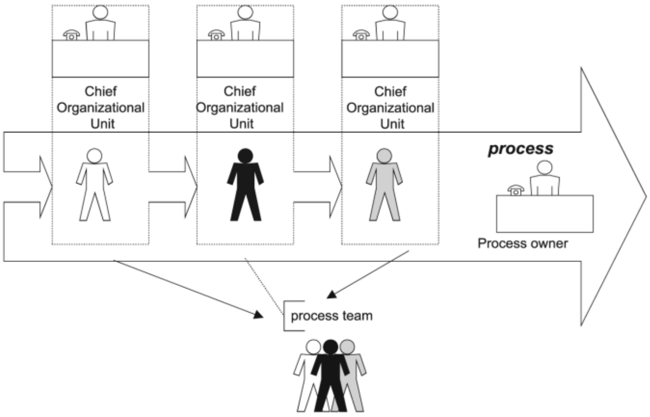


Figure 16. A process owner is responsible for the performance of the process and the work is performed by cross-functional teams. (Ongaro 2004)

To successfully develop a process in a process oriented organization, it is important to appoint process responsibility. The process owner is responsible for a holistic approach to coordinate and lead the development of the assigned process. The process owner is often situated at the top management level and defines the process goals so they are aligned with the corporate goals (Becker *et al*. 2003). The process owner is responsible for achievement of the process goals. The functional manager will lose the right to make changes in his part of the process and he will instead be seen as resource owner (Ljungberg and Larsson 2012).

The resource owners will be responsible for developing qualities and competences in the organization. They need to ensure that the individuals in the organization are allocated to the appropriate processes. The resource owner has the long-term responsibility in providing necessary competence and will therefore be the one that hires people (Ljungberg and Larsson 2012).

4.3. Mapping

Mapping means creation of a map which represents a true reflection of the current business process (Damij 2007). The purpose of the mapping is to provide a basis for analyzing a process (Savory and Olson 2001). The making of the map is not a solution in itself, but provides a compact picture that can facilitate for continuous improvement of a process.

When organizations grow and adapt to changing business environment, it is common that the processes becomes obsolete (Ljungberg and Larsson 2012). Work routines and methods, that once were logic and natural, has been adjusted after changing conditions. Those changes are often done within each department and seem logic in this smaller part of the organization. But activities in one department affect other departments. It is therefore important to understand the connection between activities along a process to avoid problems. It is often first when the process is mapped that connections between different departments is discovered and understood (Ljungberg and Larsson 2012).

A map should in an easy way illustrate how value is created in the business (Ungan 2006). As an example, a process map of a manufacturing process show how the product or service is created through operations. It must clearly show the relations between activities, information and the objectives in the given work flow. According to Gardner and Cooper (2003) a good map is interpretable, recognizable and has a format that makes it easy to spread.

4.3.1. Terminology

In literature, several terms exist when referring to mapping. The terms *process mapping* and *process modeling* are often used synonymously. Ungan (2006) uses the term *process documentation* with the same meaning. He refers to creation of a graphical representation of the process, which could either be done as a process flowchart/diagram or as a process map.

Another term which can be found is *supply chain mapping*, which in many aspects is similar to process mapping. The differences will be explained later in the section about process mapping in chapter *4.3.4 Mapping tools.*

4.3.2. Why mapping?

There are several reasons to map processes. A map can act as basis for redesign or modification, it helps to visualize the business and identify areas for further analysis and improvement (Gardner and Cooper 2003). A map can be used as a communication tool across firms and departments and will lead to common understanding of the process. The map can also be used as an education tool for new people involved in the process so they can be oriented of their role in the process.

As discussed earlier, the making of the map is not a solution in itself, but provides a picture that can facilitate for improvement of the process. According to Savory and Olson (2001) and Kalman (2002) following benefits can be obtained by mapping:

- Processes that need to be reengineered or improved can be identified.
- Processes can be streamlined and improved by eliminating non value-added tasks, or eliminating entire steps in processes and thereby reduce cost.
- Process work flows can be simplified (often by eliminating unnecessary checking and transport steps).
- Communication and cooperation across functional boundaries can be improved.
- Root causes of problems can be identified

- The integration of a supplier's role into the business can be enhanced.
- Job satisfaction can be improved when employees understand their jobs better.
- Quality can be improved and variability decreased since fewer steps mean fewer opportunities to introduce error.

A lot of benefits come with mapping but there are also difficulties with mapping. Those are discussed in the next chapter.

4.3.3. Difficulties with mapping

Different mapping tools have different difficulties and drawbacks. These are later elaborated under each mapping tool section. General difficulty in mapping is limited availability of data. It may be difficult to gather data outside the focal company, often due to a lack of visibility along the supply chain (Hines *et al*. 1997). Even inside the focal company there may be limited data, this is particularly true for cost-related data, when defining cost along a process. Costing systems are often designed after a functional organizational structure, e.g. there are budgets for departments but not for processes. Cost accounting systems such as Activity-based costing (ABC) intend to overcome these issues. However, one cannot assume that a system like that have been implemented in all companies. Farris II (2010) therefore suggest relying on estimated numbers and secondary sources of information if primary data is not available.

Another general difficulty with mapping is to determine the level of detail. Ungan (2006) propose that the level of detail depends of the purpose of the mapping. The map should be enough detailed to allow for substantial improvements or to get understanding of the process, if that is the purpose. The level of detail is also an economic trade-off between the cost to gather the details, and the benefit received (Farris II 2010). It is often recommended to begin at a high level and then drill down. However, some mapping tools may be suitable for strategic purposes and then not suitable to use when it is wished to drill down and map with high level of detail. Gardner and Cooper (2003) warns that strategic supply chain maps must maintain a strategic emphasis, any users with a desire to drill down to an operational level should utilize alternative mapping tools such as flow mapping. Farris (2010) therefore gives the recommendation to keep the strategic maps at a high, strategic level and avoid undue complexity.

4.3.4. Mapping tools

Processes can be mapped in different ways, levels and with different purposes. Five mapping tools are described and compared. Those are; Value stream mapping, process mapping, flowchart, swimlane flowchart and activity table.

Value stream mapping

A value stream can be defined as a collection of activities currently required to bring a product from raw material to the customer (Rother and Shook 2003). Both the material and information flow is considered in these activities (Abdulmalek and Rajgopal 2007).

Value streams can be mapped and analyzed using a tool known as Value Stream Mapping (VSM) (Arbulu and Tommelein 2002). In VSM, which is called a pencil and paper tool, a map of the value stream is created using pre-defined symbols (Abdulmalek and Rajgopal 2007). The objective of VSM is to identify all types of waste in the value stream in order to eliminate these and improve the value stream. An example of a value stream map is illustrated in Figure 17.

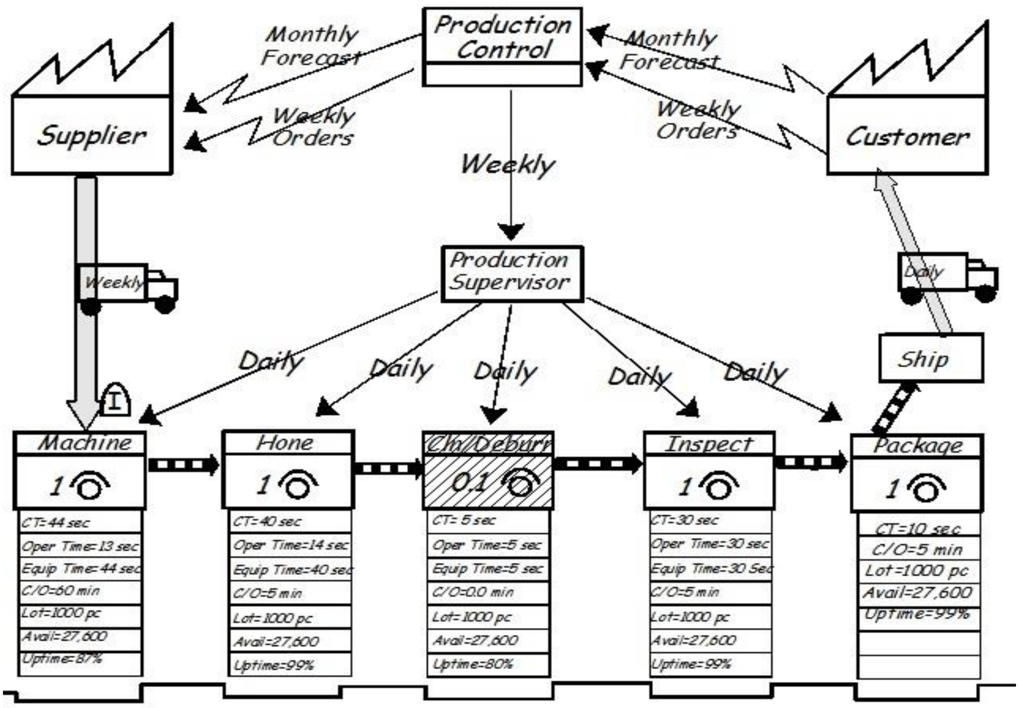


Figure 17. An example of a Value stream map. (Arbulu and Tommelein 2002)

Value stream maps usually focus on a specific facility, from external supplier to external customer (Strategos 2012). After succeeding with a Value stream map of this kind, an extended Value stream map can be done with a broader perspective which often includes suppliers and customers in the second tier (Strategos 2012; Rother and Shook 2003).

Even if the VSM perspective is broad, a value stream map is a "one page picture" (Rother and Shook 2003). This means that the actual map should fit onto one page which provides a good overview of the value stream in a simple way.

While performing VSM certain steps should be followed. Firstly, a product or product group has to be chosen (Abdulmalek and Rajgopal 2007). Thereafter a map should be drawn illustrating how things currently are performed in the facility. This map can be called As-Is map. This is accomplished by following the process. The As-Is map acts as a basis for the analysis of the process where weaknesses and problems can be identified. Several tools and techniques have been developed in order to analyze the VSM map. The analysis of the As-Is map is called Value Stream Analysis (VSA). From the analysis, suggestions of improvement are formed. Thereafter a future state map is drawn which illustrates how the process shall look like after the suggestions of improvements have been implemented. This map can reveal difficulties in implementing the changes and acts as a basis for making the necessary changes in the process. Finally, an action plan is developed which includes a plan of how and when the suggestions of improvements should be implemented (Rother and Shook 2003).

Different mapping techniques fit different situations. Strategos (2012) recommend using VSM for high-production, low-variety product mixes with few components and subassemblies and dedicated equipment. In other situations Strategos (2012) recommend process mapping as a suitable tool.

Process mapping

By describing the business and its operations through process maps, it is easy to explain how the different parts in the organizations relates to each other and how they interact to create value for the customer (Ljungberg and Larsson 2012). Process maps often cross different functional areas in an organization and could also include customers and suppliers (Sanders *et al*. 1999). A process map enables to see all the critical interfaces, handovers, the time to complete various sub processes and identifies disconnects (illogical missing and extraneous steps) in the process (Rummler and Brache 1995).

Process mapping is a way to graphically illustrate the processes and can be done with several different sets of notations and symbols. The graphical symbols Ljungberg and Larsson (2012) uses to conduct process mapping is shown in Figure 18.

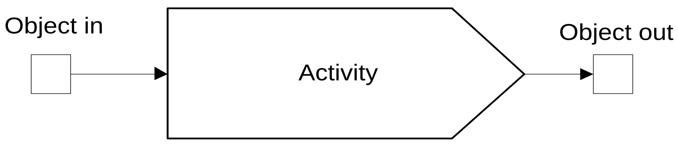


Figure 18. A process consists of an object in, one or several activities and an object out. Based on Ljungberg and Larsson (2012).

The *object in* is what starts or triggers the process. The process is initially triggered by a customer need. The process consists of activities that add value to the incoming object and transform it to an outgoing object. The *object out* is the result of the activities in the process and can be a trigger for the next process activity. The final object out should satisfy the customer need.

Process maps are hierarchical in nature. A process map describes the major activities. It is possible and often necessary to divide the high-level process map into several more detailed sub process maps (Sanders *et al*. 1999).

A business can be described with a system of processes. A process can consist of several sub process which in turn may consist of several activities, see Figure 19.The process map visualizes the processes and its sub processes. A sub process map visualizes the sub process and its activities.

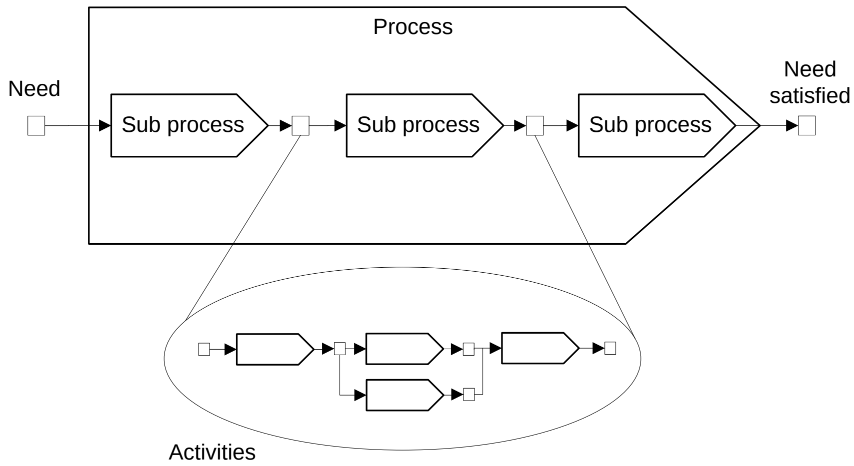


Figure 19. A process consists of sub processes which in turn consist of activities. Based on Ljungberg and Larsson (2012)

As mentioned earlier, the term supply chain mapping also exist, which to great extent is similar to process mapping. However, Gardner and Cooper (2003) distinguish between the terms in three main areas; orientation, level of detail and purpose. In their view, supply chain mapping has an external focus mapping the flows both outside and within the company in the supply chain. It takes an overall perspective of how processes work together between the companies and puts emphasis on “high-level measures such as volume, cost, or lead-time". These maps contain a low to moderate level of detail, and serve strategic purposes.

Process mapping, on the other hand, is internally focused and has the primary attention within the company, even though suppliers or customers may appear in the map. However, some process mapping approaches tend to analyse beyond the firms borders, e.g. SCOR (The Supply Chain Council, Inc. 2001). Process mapping often breaking down a process into activities and therefore contains a high level of detail.

Process mapping is typically tactical rather than strategic. It is often created with the goal to make changes in the current operations within the firm as addressing a problem area or to improve operating efficiency (Gardner and Cooper 2003).

Flowchart

Flowchart is a graphical way to map processes by using symbols which represents things as activities, information, decision points and flow directions (Aguilar-Savén 2004). A flowchart is illustrated in Figure 20. It visualizes actions in a chronological order and gives an overview of the activities. It does not support any breakdown of activities.

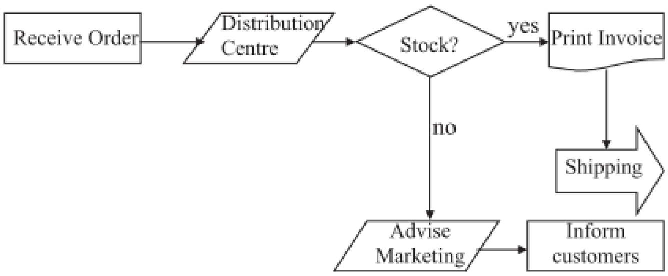


Figure 20. Example of flowchart (Aguilar-Savén 2004)

The main advantage with usage of flowchart is the flexibility (Aguilar-Savén 2004). A process can be described in a wide variety of ways by combining the different symbols as building blocks. Symbols that are commonly used are shown in Figure 21.

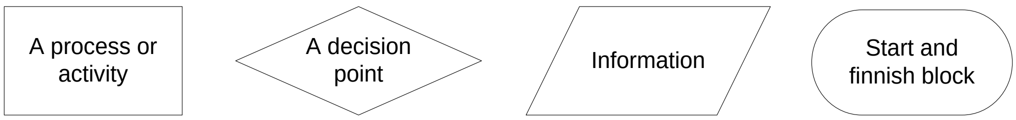


Figure 21. Symbols that can be used in a flowchart (Aguilar-Savén 2004; Fitzgerald et al. 2005)

The weakness of the flowchart is that it is too flexible. The boundary of the process may not be clear. There is no difference between main and sub process or activities. Since there are no sub-layers it is hard to read and navigate in the chart (Aguilar-Savén 2004).

According to Ungan (2006) process maps are preferred compared to flowcharts. Aguilar-Savén (2004) argues that flowcharts are easy to use but Ungan (2006) claims that flowcharting may be more difficult to use effectively. Another reason is that flowchart does not map interactions between activities. It does not assign attribute data such as input and output to each process step. This is a serious missing, because interactions are one of the most significant areas for improvement efforts (Hammer and Champy 1995; Savory and Olson 2001). Other disadvantages of flowcharts are; limited vocabulary, imprecision about details and concurrency, only listing activities that occur if everything works perfectly, no reveal of waste work due to errors and defects and no visualization of cost and quality. Process maps overcome these disadvantages (Savory and Olson 2001).

Swimlane flowchart

Swimlane flowchart can be seen as an extended version of flowcharts (Fitzgerald *et al*. 2005). The same symbols can be used to illustrate activities, decision points etc. In a swimlane flowchart activities are drawn in different horizontal or vertical lanes where each lane represents a business function, department or person (Burns 2007). By keeping each role in one lane, each activity is linked to the performer of the activity. The activities are usually drawn in time sequential order and connected by arrows (Fitzgerald *et al*. 2005). The chart visualizes what is done, by whom and in what sequence. A swimlane flowchart is visualized in Figure 22.

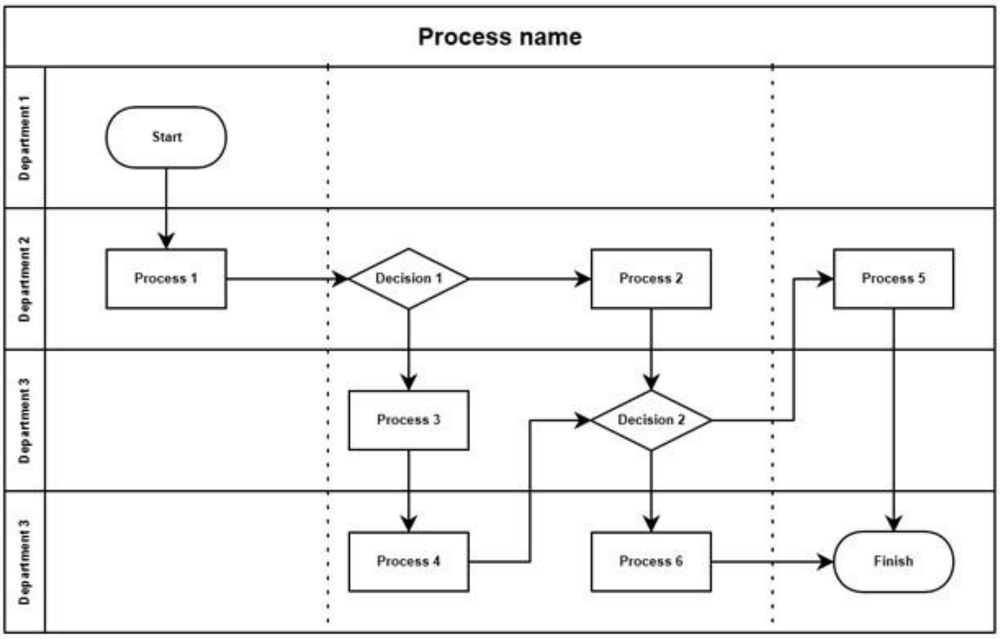


Figure 22. Example of a swimlane flowchart (Grapholite 2012).

In a swimlane flowchart it is illustrated when the responsibility is transmitted to another participant in the process (Fitzgerald *et al*. 2005). When the responsibility is handed over to another participant there is a risk of errors (Smith 2012; Hammer and Champy 1995; Savory, Olson 2001).

A problem with swimlanes can be that it becomes hard to draw on higher level due to the fact that it must contain high level of detail (Favre 2003).

Activity table

One way of carrying out mapping is by developing an activity table. As the name tell, the activity table presents an As-Is map of the process in table form (Damij and Grad 2006).

		Department	Sales		Warehouse			
					Entity			
Business process	Work process	Activity	Sales claim clerk	Sales clerk	Warehouse cla. clerk	Manager of dispatch D	Stock keeper	Customer
Sales_Claim	1. Reception of		T_6					
	Sales_Claim	1. Receive Claim_Note	P_1					S_6
			S_1					
		2. Register Claim_Note	U_1					
			S_1					
		3. Print Claim_Form	U_1, P_3					
		4. Collect claim	S_1					
		documentation	U_1, P_4					
			S_1					
		5. Send claim documentation	U_3, U_4, P_5	T_1				
		6. Determine claim solution		S_2				
		path		U_5, P_6				
		7. Return claim		S_2				
		documentation	T_2	U_6, P_7				
	2. Under-received	8. Forward claim	S_1					
	products	documentation	$U_7^{*} P_8$		T_1			
		9. Analyse quantity of			S_3			
		products			U_8, P_9			
					S_3			
		10. Approve the claim			$U_9^{*} P_{10}$			
					S_3			
		11. Reject the claim			$U_9^{*} P_{11}$			
		12. Return claim			S_3			
		documentation	T_3		U_{10}, U_{11}, P_{12}			
			S_1					
		13. Check approval	P_{13}, U_{12}					
			S_1					
		14. Issue credit-note	U_{13}^{*}					T_1

Figure 23 Example of an activity table; sales-claim business process (Damij 2007)

An example of an activity table can be seen in Figure 23. The first column in the activity table represents the business process. It is composed of sub processes, second column, which in turn consist of activities, listed in the third column. The columns to the right tell which department and persons within the company that perform the activity. Each activity is usually connected with two departments, the one that starts the activity and the one that receives the output from the activity. The vertical sequence shows the order in which the activities are performed. To describe the activities in detail, a property table is developed. This property table contains information for each activity about description, needed resources, required time for the execution, the input/output and cost of the activity (Damij and Grad 2006).

To use activity table as a mapping tool is not as easy as using flowchart. It may be hard to gather all needed information to make a complete activity and property table and it requires a deep understanding of the process (Damij 2007).

A weakness with activity table is the visibility and ability to understand the process. The reason is that the activity table not visualizes the process in graphical way as flowchart and process map does, it can be hard to get an overview by looking at a table. However, the activity table is better when the process contains hundreds of activities. The reasons for this are that the whole business process is presented in one table, which make it easier to track the paths of the discussed process (Damij 2007).

4.3.5. Categorizing of mapping tools

The described mapping tools differ from each other. One thing that is especially varying is the level of detail. This makes them suitable in different levels of the organization and can be used for different purposes. For instance, if the purpose is to use the map in order to illustrate how the process is designed or to create documentation, a high level detail is needed. If the map instead should be used as a basis for analyzing the overall businesses, a lower level of detail is appropriate. But how should one pick between these mapping tools?

The authors compared the mapping tools by categorized them in three levels; strategic, tactical and operational, depending on which level in the organization the tool seems appropriate to be used in.

Strategic, tactical and operational levels are described below (Schmidt and Wilbert 2000; Bacon 2012):

- ***Strategic level*** **–** At a strategic level, the entire organization is in consideration with a focus of long term development. Long term means a time horizon of at least 1 year. High-level managers are often responsible for this development.

- ***Tactical level*** **–** At this level, the focus is set on improvements of the different parts of the organization. The time horizon in the tactical level is between 6 and 12 months. Mid-level managers are often responsible for this level.

- ***Operational level*** **–** The operational level focus on a high level of detail and in the lowest level of the organization i.e. tasks. Operational managers are often responsible for this level. The time horizon to perform development is 6 months or less.

In Figure 24 the categorization of the mapping tools is shown.

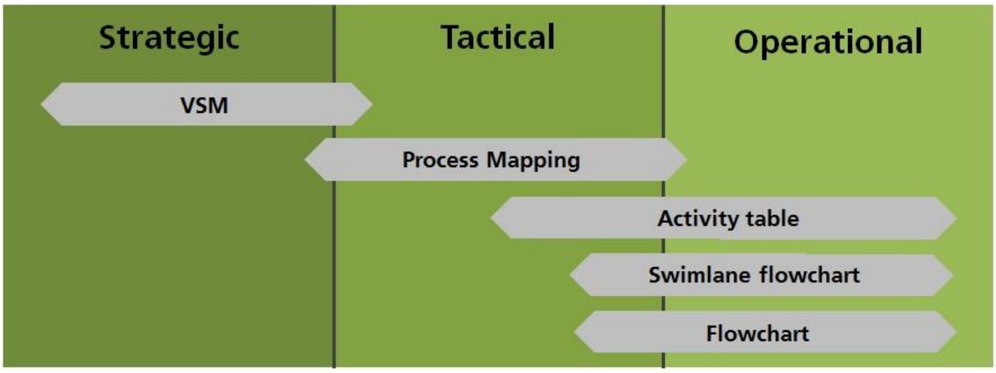


Figure 24. Illustrating the categorization of the mapping tools

As seen in the figure, the distinction between the levels is vague and a tool can be appropriate in more than one level. The flexibility in the tools contributes to that the mapping tools can be appropriate over a wider span. For instance, process mapping can be done in the span from mapping strategic core processes to mapping the sub processes, activities or even tasks with a high level of detail. The level of detail in the mapping increases the further right one come in the figure.

As mentioned earlier it is often recommended to begin the mapping at a high level and then drill down if it is possible (Farris II 2010). Gardner and Cooper (2003) warns that strategic mapping tools should stay strategic and if it is wished to map with high level of detail, alternative more operational mapping tools should be used. The authors will therefore use this technique, starting on a higher level and then change to lower level mapping tools if the map needs to be more detailed.

4.3.6. Mapping approaches

This section will describe different approaches of how to map processes.

Interview based method of mapping

Jacka and Keller (2002) present a methodology for mapping processes with the tool process mapping. This approach can, to a large extent, also be used if maps are mapped with mapping tools as flowcharts, swimlane flowchart and activity tables.

The method begins with identifying the end and starting point of the process. With the basic understanding of the process and the gathered information at hand the researcher can start creating the map. Next step is to carry out interviews, which is a central part of the methodology. First, interview is held out with the manager or supervisor of the process. This is done to get an overview of the process, task and individuals involved in the process. Second, interviews are held with the individuals working with the process. The interviews will add events to the process map, which will be developed as it reveals more details. At the end of each interview a significant step is to walk the interviewee through the map and ask if there is anything to add or change (Jacka and Keller 2002).

When all interviews are completed, a final map should be created. All activities gathered from the interviews are moved around, added and removed until a final map is created (Jacka and Keller 2002).

As-Is and To-Be mapping

Becker *et al*. (2003) provides another approach. In this mapping approach both an *As-Is* situation and a *To-Be* situation is mapped.

First, the As-Is state of the process is mapped. There is a focus on weaknesses and problem areas when creating the As-Is map. As-Is mapping consist of the following steps:

1. Preparation of As-Is mapping.
2. Identification and prioritizing of problem areas.
3. Collection and documentation of As-Is maps.
4. Consolidation of As-Is maps.

The first step, preparation, is to determine the level of detail and what mapping tool that will be used. The next step is to identify problem areas in order to prioritize those in the mapping. In the third step, collection of data and documentation of prioritized problem areas should be done which will be used as the input. The collection and mapping is preferably conducted in successively workshops. Finally, the maps created in the workshops are consolidated.

Based on the As-Is map, the weaknesses and potential improvement identified during the analysis of it, a To-Be map is conducted. The To-Be map should improve the As-Is map and lead to better efficiency or effectiveness.

Efficiency improvements may be; increased profit, cost savings, streamlining of process, lead time reduction, updated view of the organization and better communication.

Effectiveness improvements may be; higher product quality, increased customer satisfaction and higher process transparency towards the customer.

Eight step of how to map processes

Ljungberg and Larsson (2012) suggest an eight step approach of how to map processes with the tool process mapping. The steps are following:

1. Define the purpose of the process and its start and ending point.

2. Conduct a brainstorming session and think of all activities that might be a part of the process. Write the activities on post-it notes. The purpose of the brainstorming session is that this is an easily way to get started.
3. Arranging the activities in the right order by moving the post-it notes around until a description of the process is found.
4. Merge and add activities. Activities that are duplicates of one another are merged and missing activities are added.
5. Define object in and out for each activity, this will connect the activities and form a process with a united purpose.
6. Make sure that all activities are linked together by the objects. In this step it will be very clear if any activity is missing, if not each activity's object out will be the next activity's object in.
7. Make sure all activities have a common level of detail and that the activities has accurate names. The name should reflect how value is created and the purpose of the activity (why performing the activity), rather than saying what and how something is done.
8. Make adjustments of details the process map until a satisfactorily description of the process is obtained.

4.4. Analysis tools

After completing the mapping of the process an analysis can be made. Several tools for analyzing exist, some will briefly be explained.

4.4.1. Root cause analysis

Root Cause Analysis (RCA) is designed for identifying and categorizing the root causes of problems (Rooney and Vanden Heuvel 2004). RCA is used in purpose to correct the root cause, instead of fix the symptoms of problems. The importance in RCA is therefore to identify why a problem occurred, not only what happened and how it occurred.

A benefit with root cause analysis is that it is a time effective method (Rooney and Vanden Heuvel 2004). The method consists of a standard set of tools which are easy to use. Anyone with sufficient training is able to perform the analysis near where the problem occurred. There are different methods and tools developed to perform root cause analysis which are further described in following subchapters.

5 why

Five whys is a method used to find the root causes of problems (Latino 2004). By repeatedly asking "Why did this happen?" the root cause will finally be identified. The method does not require the analyst to ask this question exactly five times. The purpose is to find the root cause and the question should be asked until no further answer is forthcoming. The method relies that the last answer, or answers, are linked to a solution to the problem (Latino 2004). The root cause will then be identified but not solved.

Example of problem: The vehicle will not start.

1. Why? - The battery is dead.
2. Why? - The alternator is not functioning.
3. Why? - The alternator belt has broken.
4. Why? - The alternator belt was beyond its useful service life
5. Why? - The vehicle was not maintained according to the recommended service schedule. (a root cause)
6. Why? - Replacement parts are not available because of the extreme age of the vehicle. (optional footnote)

Solution:

- Start maintaining the vehicle according to the recommended service schedule. (possible 5th Why solution)
- Purchase a different vehicle that is maintainable. (possible 6th Why solution)

Fishbone diagram

The fishbone diagram is also known as the Ishikawa diagram or the cause and effect diagram (Latino 2004). The fishbone diagram is a way of visualizing the relationship between different causes and a problem. A graphic illustration of a fishbone is used to illustrate this relationship. The head of the fish represents the problem, or the effect of the problem. The causes to the problem are visualized as spines. Smaller bones can be added to the spines if each cause is explained in more detail. An example is shown in Figure 25.

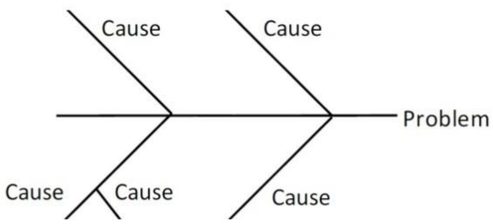


Figure 25. Illustration of the fishbone diagram.

The 5 Whys can be used as a part of the fishbone diagram. Once all causes (spines) are established on the fishbone, the 5 Whys method can be used to find the root causes.

Pareto charts

The Pareto principle states that in many cases, a few causes contribute to the most of the problems and many causes contribute relatively little to the problems (Fawcett 1995). This principle is also known as the 80/20 rule. This states that 80 percent of the trouble comes from 20 percent of the problems.

Pareto chart is a bar chart where each bar represents a category of problems (Fawcett 1995). The problems are categorized by a specific cause. The tallest bars represent the categories/causes contributing to the most of the problems. Pareto chart therefore makes it easier to focus the efforts where they will have the biggest effect.

4.4.2. Value analysis

In a value analysis each activity or sub process is classified as value adding, non-value adding or waste (Hines *et al*. 1997). A value adding activity is an activity that contributes in satisfying the customers need in a direct way. For instance, *Forging* can be a value adding activity in the process *Produce products*.

A non-value adding activity is an activity that does not create value for the customer but is needed for the functioning of another process or the organization. An example of a non-value adding activity could be *Handle production orders*.

An activity that is classified as waste is an activity that does not satisfy the customer or any other stakeholder. Production of defect products can for instance be classified as waste. The Lean concept classifies seven types of waste in the production that constitutes areas for process improvements (Liker 2004):

1. ***Overproduction*** – Means producing items which there are no orders, which generates such wastes as overstaffing, storage and transportation costs because of excess inventory. In a distribution center it can mean that documents are kept in both paper and electronic form.
2. ***Waiting*** – Workers waiting for next process step etc., or plain having no work because of stock outs, processing delays, equipment downtime and capacity bottlenecks. IT can also mean that staged goods are waiting to be picked up or shipped.
3. ***Unnecessary transport*** – Moving material into or out of storage or between processes. Another example can be that employees are sharing tools which are hunted and moved several times during the day.
4. ***Over processing or incorrect processing*** – Taking unneeded steps to process parts. Inefficiently processing due to poor tool and product design can cause unnecessary motion and production of defects. Waste is also generated when producing higher quality than necessary. In a distribution central, over processing can mean that a truck is double checked to verify that another employee's work.

5. ***Excess inventory*** – Excess raw material, work in progress, or finished goods causing longer lead times, damaged goods, transportation cost, storage costs, and dely. Also extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime and long setup times.
6. ***Unnecessary movement*** – Any waste motion employees have to perform during their work, such as looking or reaching for tools etc. Also, walking is waste.
7. ***Defects*** **–** Production of defect parts or correction. Repair or rework, scrap, replacement production and inspection mean wasteful handling, time and effort.
8. ***Unused employee creativity*** – Losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to the employees. This type of waste is added by Liker (2004) to the original seven wastes defined in the Lean concept.

There is a specific and simple strategy for each category of activity; value-adding, non-value adding and waste (Ljungberg and Larsson 2012). Value adding activities should be developed, non-vale adding activities should be minimized and waste should be eliminated.

According to Ljungberg and Larsson (2012) there has been a large focus on eliminating processes and activities classified as waste during the last years. Value adding processes and activities are essential for the company's performance and are therefore receiving a lot of attention. Non-value adding processes and activities do often receive lowest attention from top management, hence there are often potential to improve these.

4.4.3. Analysis of handovers

A handover occurs when the process is handed over from one participant to another. Smith (2012) stated that handovers increase the risk of errors in the process due to translation problems from one participant to the next. Madison (2012) describes it as following: "Consider every handover as an opportunity for error". By analyzing the handovers existing in a process, risk of errors can be identified (Madison 2012).

4.4.4. Analysis of lead time

Customers today want their products faster which make the lead time very important (Mentzer *et al*. 2001a). By shortening the lead time, the company will be more competitive on the market (Tersine and Hummingbird 1995). An analysis of a process lead time is recommended in order to find potential in reducing it.

Time analysis

This is a lead time analysis which is based on the value analysis. Time analysis is performed with the intention to analyze the potential of reducing lead time (Ljungberg and Larsson 2012). The time spent on value adding activities is often a small share in comparison to the total lead time for the process. A lot of the time is therefore unproductive. A measure that compares the time spent on value adding activities in comparison to the total lead time can indicate the potential in reducing the lead time. Therefore, this analysis starts off with identifying value adding activities.

The time that is spent on value adding activities is divided with the total lead time, which results in a quota (Ljungberg and Larsson 2012). This quota is often small but it can be become infinitely large i.e. if value adding processes is performed in parallel the quota can be larger than 1. In Figure 26 an example of a time analysis is illustrated.

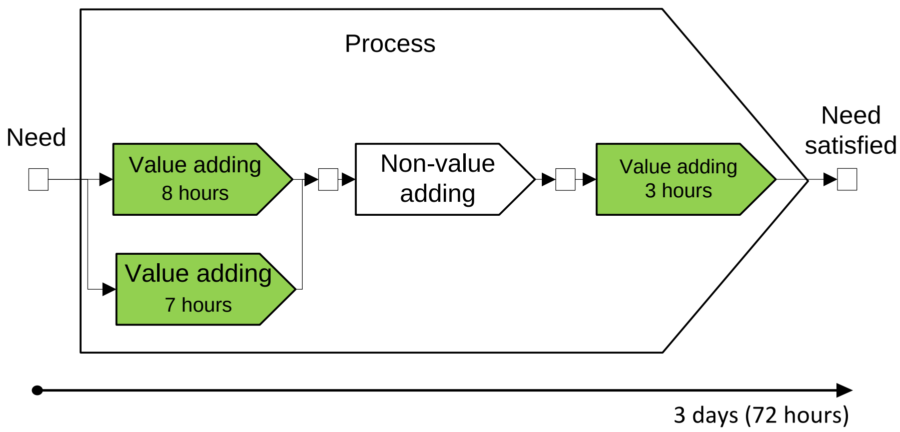


Figure 26. A process with a quota equal to 0.25. (18/72=0.25)

This analysis challenges the need of having activities in linear (Ljungberg and Larsson 2012). If activities can be placed in parallel activities can be performed simultaneously and the lead time can be reduced.

4.4.5. The seven Value Stream Mapping tools

Hines and Rich (1997) have defined seven well-known VSM tools for analyzing processes. These tools are developed with the intention to analyze Value stream maps and are strongly connected to the seven different wastes which are defined in *4.4.2 Value analysis*. The seven tools are listed below:

- Process activity mapping
- Supply chain response matrix
- Production variety funnel

- Quality filter mapping
- Demand amplification mapping
- Decision point analysis
- Physical structure volume/value

All tools will be described but in different extent due to the variety in suitability for this study.

Process activity mapping

This tool creates understanding of the different activities within the process and can be used as a basis for future analysis and subsequent improvement (Hines and Rich 1997).

Hines and Rich (1997) have defined five steps in this general approach:

1. The study of the flow of processes
2. The identification of waste
3. A consideration of whether the process can be rearranged in a more efficient sequence
4. A consideration of a better flow pattern, involving different flow layout or transport routing
5. A consideration of whether everything that is being done at each stage is really necessary and what would happen if superfluous tasks were removed.

When this tool is used a sequential list is created of all activities in the process including information of each activity (Hines and Rich 1997). An example is illustrated in Figure 27.

#	STEP	FLOW	MACHINE	DIST (M)	TIME (MIN)	PEOPLE	OPERATION	TRANSPORT	INSPECT	STORE	DELAY	COMMENTS
1	RAW MATERIAL	S	RESERVOIR				O	T	I	S	D	RESEVOIR/ ADDITIVES
2	KITTING	O	WAREHOUSE	10	5	1	O	T	I	S	D	
3	DELIVERY TO LIFT	T		120		1	O	T	I	S	D	
4	OFFLOAD FROM LIFT	T			0.5	1/2	O	T	I	S	D	
5	WAIT FOR MIX	D	MIX AREA		20		O	T	I	S	D	
6	PUT IN CRADLE	T		20	2	1/2	O	T	I	S	D	
7	PIERCE/POUR	O	MIX AREA 12		0.5	1	O	T	I	S	D	
8	MIX (BLOWERS)	O			20	1/2	O	T	I	S	D	BASH MATERIAL, BLOW & ADDITIVES
9	TEST #1	I			30	1 + 1	O	T	I	S	D	SAMPLE/TEST
10	PUMP TP STORAGE TANK	T	STORE TANK	100		1	O	T	I	S	D	DEDICATED RESEVOIR
11	MIX IN STORAGE TANK	O	STORE TANK		10	1	O	T	I	S	D	
12	I.R. REST	I			10	1+1	O	T	I	S	D	STAMP APPROVE
13	AWAIT FILLING	D			15		O	T	I	S	D	LONGER IF SCREEN LATE
14	TO FILLER HEAD	T		20	0.1	1	O	T	I	S	D	
15	FILL/TOP/TIGHTEN	O	FILLER HEAD		1	1+1	O	T	I	S	D	1 UNIT
16	STACK	T	PALLET	3	0.1	1	O	T	I	S	D	1 UNIT
17	DELAY TO FILL PALLET	D			30		O	T	I	S	D	
18	STRAP PALLET	O			2	1	O	T	I	S	D	
19	TRANSFER TO STORE	T		80	2	1	O	T	I	S	D	
20	AWAIT TRUCK	D	STORE		540		O	T	I	S	D	BATCH 360/ QUEUE 180
21	PICK/MOVE BY FORKLIFT	T		90	3	1	O	T	I	S	D	FORKLIFT
22	WAIT TO FILL FULL LOAD	D	LORRY		30	1+1	O	T	I	S	D	1 OPERATOR, 1 HAULER
23	AWAIT SHIPMENT	D	LORRY		60	1	O	T	I	S	D	1 HAULER
	TOTAL		23 STEPS	**443**	**781.2**	**25**	6	8	2	1	6	
	OPERATORS				**38.5**	**8**						
	% VALUE ADDING				**4.93%**	**32%**						

Figure 27. Example of a list developed with the tool process activity mapping (Hines and Rich 1997)

Each activity is classified as an operation, inspection, transportation, delay or storage activity (Hines and Rich 1997). Operations represent the only form of value adding. The others are seen as non-value adding activities or waste.

At the bottom line the total lead time is summarized. The sum of the value adding activities' cycle times is also summarized. By expressing the value added time as a fraction of total time, it is shown how much of the time that a product spends in the process is value adding (Deloitte 2012). Similarities can be recognized between this tool and the time analysis tool explained earlier in chapter 4.4.4.

Supply chain response matrix

A diagram is created which creates an understanding of where in the supply chain inventory and lead time can be reduced (Hines and Rich 1997). Reducing inventory will not be an objective for this study and due to the fact that there are other more suitable tools to analyze lead time will this tool not be further described.

Production variety funnel

The product variety funnel is used to understand where product variety is added along a supply chain (Hines and Rich 1997). The principle is that variety should be added as late as possible. Adding variety too early creates lower responsiveness, adds inventory, and reduces flexibility. This tool is mainly suitable for a producing company and will not be further discussed.

Quality filter mapping

Quality filter mapping is based on a map that points out the quality performance throughout a supply chain. It identifies where in the supply chain quality defects occur (Hines and Rich 1997). Hines and Rich (1997) defined three types of defects:

- ***Product defect*** **-** Product defects is defined as the products that is damaged when delivered to customer i.e. the defect has not been detected by in-line or end-of-line inspections.
- ***Service defect*** - An example of a service defect is when the product is delivered too early or too late. A service defect is thus not directly connected with the goods.
- ***Internal Scrap*** – Internal scrap is a defect on the product that, in opposite to product defects, is detected by in-line or end-of-line inspections.

These defects are measured in each part of the supply chain and the result is illustrated in a diagram (Hines and Rich 1997). An example of a diagram is shown in Figure 28.

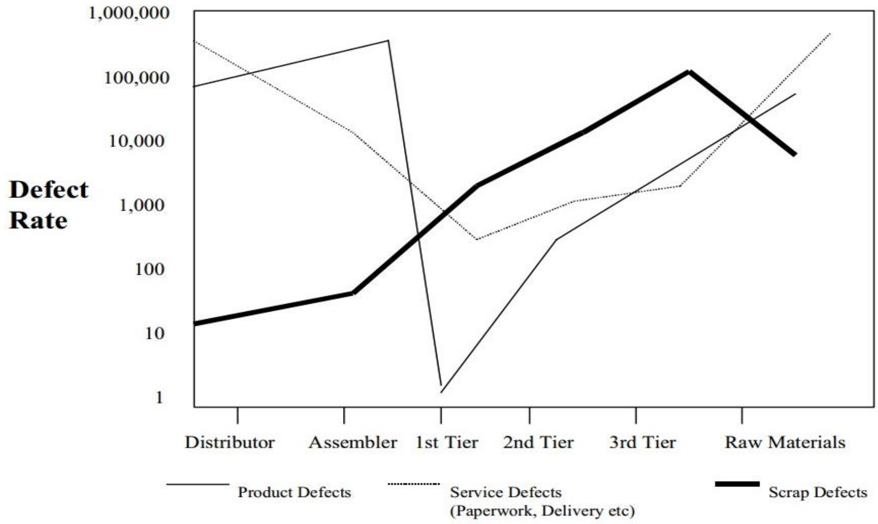


Figure 28. Example of a quality filter map (Hines and Rich 1997)

It will be addressed where defects arise and it can be pointed out where focus should be placed in order to improve the quality performance.

Demand amplification mapping

This is a tool that compares historical data regarding forecasts, purchases and sales (Deloitte 2012). By analyzing this it is visualized how the variability of consumer sales often is far lower than it is for supplier orders. This effect is known as the bullwhip effect.

Demand amplification mapping is an analysis with the intention to show how demand changes along the supply chain. Though, this study analyses a make-to-order supply chain, this tool is not suitable.

Decision point analysis

A decision point can be defined as the point where the production stops producing against forecast and instead starts to produce against orders and actual demand (Hines and Rich 1997). This point is the same point that has been discussed earlier in chapter *4.1.3 Make-to-order supply chain* by Sharman (1984). Sharman (1984) then defined this point as the Decoupling point (CODP). In Figure 29 the different production system options are shown.

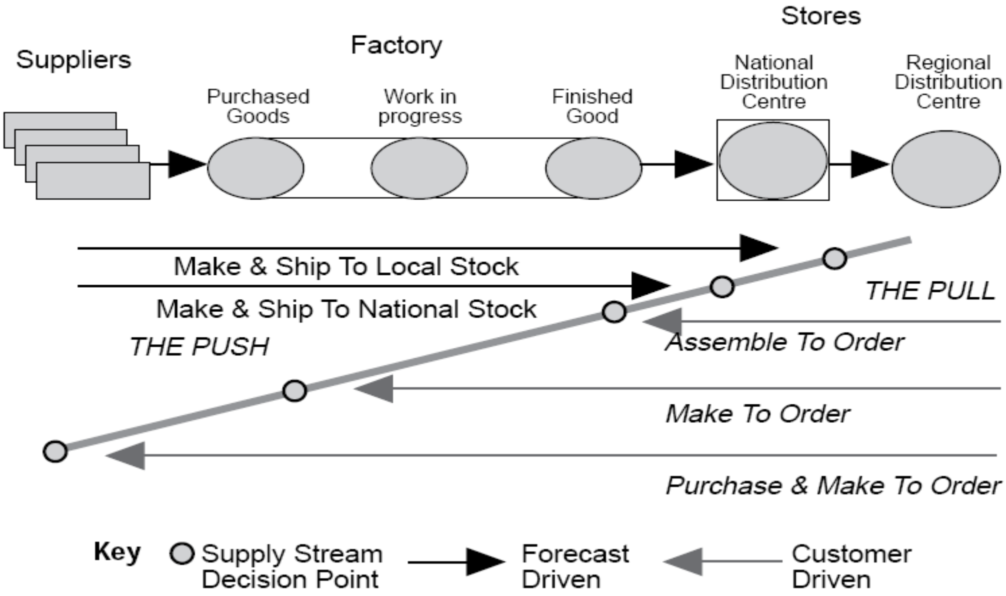


Figure 29. Illustration of different decisions points. (Hines and Rich 1997)

After identifying where the decision point is placed an analysis can be made by asking the question “What if?”. This means that it should be questioned “What if the decision point would be placed one step to the left or to the right?”. By building up different scenarios and analyzing advantages and drawbacks with moving the decision point may lead to a better design of the value stream itself.

Physical structure volume/value

This tool can be used in order to understand the supply chain (Hines and Rich 1997). The tool presents the supply chain in a basic graphical way and creates understanding in how the supply chain operates and where value is added. It addresses where in the supply chain focus for improvements should be placed. The analysis and improvements efforts of this study are delimited to the terminal in Torsvik and therefore will this analysis tool not be further discussed.

4.4.6. Categorizing of analysis tools

Similar to the mapping tools, the analysis tools are differing from each other. The analysis tools could also be considered as suitable in different levels in the organization. The analysis tools are therefore categorized in the same categories as the mapping tools; strategic, tactical and operational level, depending on which level in the organization the tool seems appropriate to be used in. In Figure 30 the categorization of the analysis tools is shown.

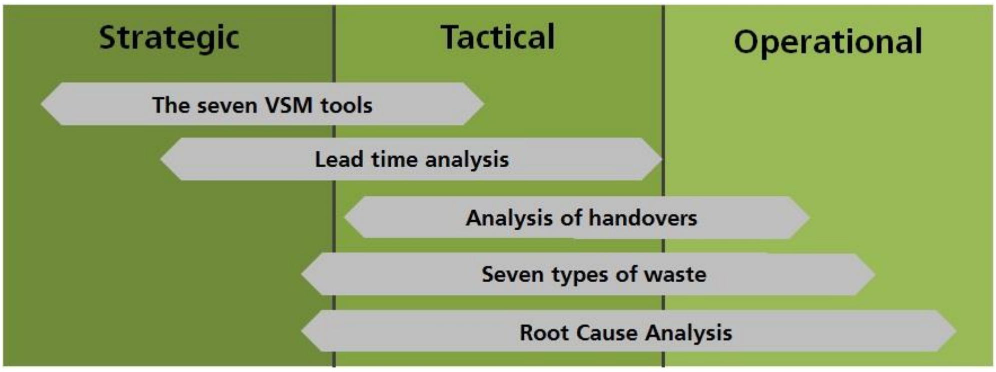


Figure 30. Showing the categorization of the analysis tools

As seen in the figure, the authors consider the analysis tools to be even more flexible than the mapping tools. The described tools can often be modified in a minor way in order to be usable over a wider span.

4.5. Summary of literature review

Table 4 summarizes the content in literature review which seems usable for the case study in order to fulfill the objectives.

Table 4. Summary of content from literature review that suitable for the case study to fulfill objectives

Supply Chain

- Focal company in a supply chain
- Make-to-order supply chain

Process approach

- Type of processes
- Process responsibility

Mapping

- Why mapping?
- Difficulities with mapping?
- Value stream mapping
- Process mapping
- Flowchart
- Swimelane flowchart
- Activity table

Mapping approaches

- Interview based method of mapping
- As-Is and To-Be mapping
- Eight step of how to map processes

Analysis tools

- Root cause analysis
- Seven types of waste
- Analysis of lead time
- Analysis of handovers
- The seven value stream mapping tools

The literature presented will serve as a basis to fulfill the objectives of the case study. In next section (4.5.1) a general research procedure is developed which could be applicable for similar case studies as this one. In the second section (4.5.2) the research procedure is further examined in relation to the objectives of this study. It will be explained which theory that is relevant for the different steps and in which step the objectives attempt to be answered.

4.5.1. Development of a general research procedure

As mentioned earlier and according to Yin (2007), the researcher has to form his own research procedure because there are no general research procedures to choose from when it comes to case studies. With the literature review as basis, the research procedure described in *chapter 3.4* has been refined and designed so it can be used in case studies of this nature. Below it is going to be described in a general way, applicable for similar case studies as this one. This research procedure is divided into 5 steps:

Step 1 - Exploration

The case study should start off with exploratory dialogues and observations to get an understanding of the problem and the operations. This is done in order to refine the problem description, objectives and delimitations for the study.

Step 2 - Current state through As-Is maps

Information is gathered in order to create an overview and map the current state. Following information is recommended to be gathered:

- Product characteristics
- Supply chain characteristics
- Characteristics of the chosen flow of the study (material-, information- or financial flow)

When above information is gathered, which are relevant to understand the processes, is it possible to describe the current state through process maps. First, mapping tool/tools has to be chosen. Thereafter, inspired from the mapping approaches *As-Is and To-Be mapping* by Becker *et al*. (2003) and *Interview based method of mapping* by Jacka and Keller (2002), As-Is maps are created. It is recommended to start interviewing the manager or supervisor of the process. This is done to get an overview of the process, task and individuals involved in the process. Second, interviews should be held with the individuals working along with the process. With interviews and observations as basis, the process can be mapped.

Step 3 - Identify and describe problems

Throughout interviews and observations, problems can be identified. Additional problems could be identified by analyzing the As-Is maps. Relevant data should be gathered for each problem which results in a description of the identified problems.

Step 4 - Analysis of problems

The identified problems are in this step analyzed in term of source of the problem, its consequences and potential solutions. Analysis tools should be used in order to support this analysis.

Potential solutions are identified and analyzed. To-Be maps are created in order to illustrate the changes the potential solutions would lead to.

Step 5 - Recommendations

Finally, recommendations are made in both short- and long-term, which is the last step in this case study's research procedure.

4.5.2. How research procedure should answer this study's objectives

The authors will use the research procedure described above. In this section it will be explained how the research procedure and the choices made by the authors will attempt to answer the objectives of this study. In Figure 31 the refined research procedure is illustrated for this study. This illustration shows which theory will be relevant for the different steps and in which step the objectives attempt to be answered.

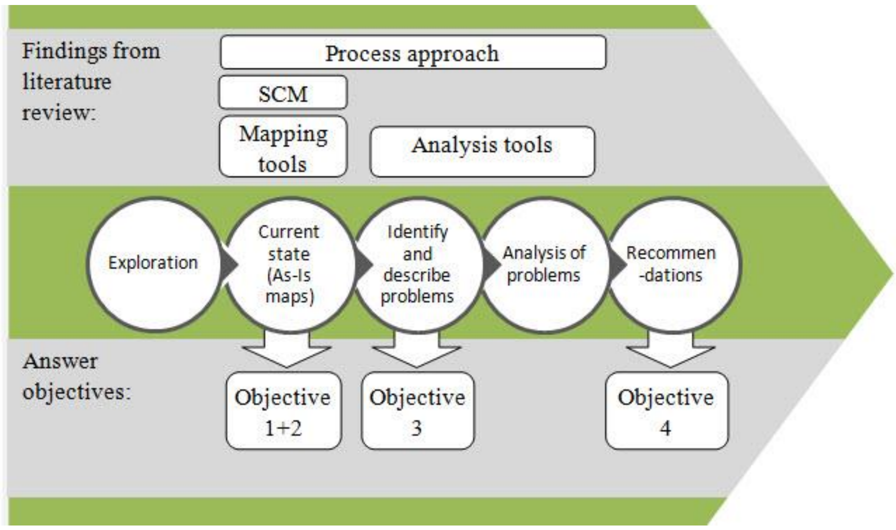


Figure 31. Model of the research procedure showing how the theory will be used to fulfill the study's objectives

The first step, *Exploration*, will be performed at CDC terminal in Torsvik in order to refine the problem description, objectives and delimitations for the study with the supervisors at IKEA.

Thereafter the second step, *Current state*, will be described. Process approach, SCM and Mapping tools are theory that seems useful when accomplishing this step. Gathering information about product-, material flow- and supply chain characteristics will serve as a basis to answer objective 1;

1. *"Explain why a product is classified as DDC and why transshipment is made at the CDC terminal in Torsvik."*

Description of current state will be finalized by creating As-Is maps. The maps have the purpose to both create an understanding of the process and also be used as a basis for process improvement. In order to fulfill these purposes, process mapping will be chosen as an appropriate mapping tool to map the process and its sub processes. VSM will not be chosen because the level of detail is considered too low due to the fact that the mapping should fulfill the purpose of creating an understanding of the process. If activities within the sub processes need to be mapped, swimlane flowchart should be used. Swimlane flowchart will be chosen because the tool both visualizes the process in a good way and in the same time addresses which department that performs the activity. This part of the step *Current state* will answer objective 2;

2. *"Create understanding of the DDC process by mapping from customer order to the point when the products are delivered at customer's home."*

The third step in the procedure is *Identify and describe problems*. Observe that this step is limited to only focus on problems occurring in the part of the DDC process managed by the CDC terminal in Torsvik. This step will be performed in order to fulfill objective 3;

3. "*Identify and describe problems that occur in the part of the DDC process managed by the CDC terminal in Torsvik."*

In the fourth step, *Analysis of problems*, the problem will be analyzed with support from the analysis tools described in the literature review. The mapping will be performed at a tactical level and all analysis tools are, in chapter *4.4.6 Categorizing of analysis tools*, pointed out as usable at this level. The analysis tools may not fit directly in this study, but could then be adjusted or used as inspiration in the analysis. Potential solutions will be created and even if the analysis is delimited to the CDC terminal, a supply chain perspective will be considered in order to eliminate the risk of sub optimization.

Finally, short- and long-term recommendations will be provided. This step will fulfill objective 4;

4. *"Suggest short*-*term and long-term improvements in the DDC process for the CDC terminal in Torsvik."*

5. Current state

This chapter will go through the empiric of this study and describe the current state. It will start with describing the products-, material flow- and supply chain characteristics and the actors of the supply chain. It will also explain why a product is classified as DDC[3] and why transshipment is made at the CDC[4] terminal in Torsvik. Then, the DDC process will be described through As-Is maps. Lastly problems identified through interviews and observations will be described.

The current state will be described by As-Is maps. According to theory, these maps can be used in order to create understanding and a holistic view for the participants in the different parts of the process. The respondents have been asked how valuable a holistic picture of the DDC process would be for them, in a scale between 1 and 10, where 10 is most valuable. The result was an average of 8.5. This indicates the need of mapping the process. In order to understand the maps, information about the products' characteristics, supply chain actors and the characteristics of the material flow is needed. This information is therefore provided first and thereafter the process maps are presented and described.

5.1. Product description

Figure 32. Picture showing packages of worktops to the left in and packages of sofas to the right.

Custom made worktops, sofa covers and a part of the sofa assortment is classified as DDC products. As mentioned in *1.5 Focus and delimitations*, sofa covers is set as delimitation. In following sub chapters the worktops and sofas will be described.

5.1.1. Worktops

The range of DDC worktops is called PERSONLIG. PERSONLIG is a total customized product, produced according to the individual customer preferences.

[3] Distribution process of customer orders direct delivered to customer.
[4] Distribution terminal managing customer orders

Unlike the standard pre-cut worktops that IKEA also offers, these worktops are premium and designed by customer which makes every single worktop to a unique product.

The customer can choose material, color and dimensions of the worktop. The customer can also order other features as a kitchen-sink mounted on the worktop when delivered. All customization options are shown in Table 5:

Table 5. Options for a DDC worktop

Dimensions	
Length:	10-400 cm
Thickness:	3.8, 4.0 or 7.6 cm
Depth:	10-124 cm
Materials	
Laminate	19 prints
Solid wood	3 kinds of wood (Oak, Beech, Birsch)
Stone	8 types
Acrylic	2 colors
Additional options	
Cut-outs	e.g. rounded corners, cut-outs for sink/ tap holes etc.
Joints	to connect multiple worktops
Edges	available in different materials, colors, shapes, thicknesses

These options can be combined into a countless range of customized products. The customized worktops differ from other IKEA products when it comes to article numbers. Usually, one article number means one product. For the customized worktop, every customer option corresponds to an article number. As an example, ordering a laminate worktop with options as two edges and a sink with cut-out for sink, consist of five article numbers even if only one worktop has been ordered. In this way every operation (as cut-outs) and physical option (as a sink) gets chargeable. Complete customized worktops always consist of at minimum two article numbers.

There is no imbedded length specified for each article number since length is an option for the worktops. When specifying the length in an order, the column for quantity is used. As an example, when ordering a worktop with length of 2.61 meters, the quantity is set to 2.61. Thus, only one worktop can be ordered per order line.

5.1.2. Sofas

IKEA offers a range of 17 different sofa models. Each model series contain different number of functions. Examples of functions are; armchair, two seated sofa, three seated sofa, bed sofa, corner settee and footstool. Each function could be ordered with several different colors. The ranged of functions and colors offered differ between different countries and markets. Table 6 shows a summary of IKEA's global range of sofas.

Table 6. IKEA's range sofas. Showing number of functions, colors and materials for each model.

Sofa model	No. of functions	No. of colors	Combinations	Material
ARILD	3	2	6	Leather
EKTORP	5	11	55	Fabric
HÄRNÖSAND	3	3	9	Fabric
KARLFORS	4	3	12	Leather
KARLSTAD	4	9	36	Fabric
KIVIK	8	12	96	Fabric, Leather
KLIPPAN	2	12	24	Fabric, Leather
KLOBO	1	1	1	Fabric
KNISLINGE	2	2	4	Fabric
PS	1	2	2	Fabric
STOCKHOLM	2	7	14	Fabric, Leather
SANDBY	2	3	6	Fabric
SKOGABY	2	1	2	Leather
SÖDERHAMN	6	7	42	Fabric
SÄTER	1	1	1	Leather
TIDAFORS	4	6	24	Fabric
YSTAD	2	1	2	Leather
ÄLVROS	5	3	15	Leather
Total			**351**	

Besides above 351 sofa article numbers the range also include 28 bed sofas, 22 armchairs and 13 footstools. In total is there 414 article numbers in IKEA's global range of sofas.

The CDC terminal in Torsvik handles 279 different sofas. 157 of these sofas are categorized as DDC products and 122 sofas are categorized as CCD products. The sofas are supplied from five suppliers located in east Europe. The goods are transported to the terminal in Torsvik by truck or train.

5.1.3. Why is a product classified as a DDC product?

All DDC products are bought via customer order and delivered as home delivery. When a customer order is placed the product is order from the supplier which in turn starts the production of the order. This is thereby classified as a make-to-order system. The worktops have a pure make-to-order supply chain, which is the only make-to-order supply chain at IKEA. The sofas are either made or assembled to order at the supplier. Make-to-order characterizes the DDC products. This is very different from rest of IKEAs supply chains, which mostly uses make-to-stock.

There are several reasons why these products are classified as DDC products. The worktop is a fully customized product where different material, sizes and additional options as cut-outs for sinks, rounded corners etc. is available. The nature of the worktop makes is impossible to store. The worktops cannot be produced before the customer has ordered them. This is the simple reason why worktops are categorized as a DDC product.

Regarding the sofas, the reason is not that easy. IKEA want to offer sofas to the many people and to do that, a large assortment of sofas is needed. The sofas are delivered through three different distribution solutions. The most popular and high-flow sofas are sold and stocked in the stores. Thus, they are handled as cash-and-carry. Sofa is an article that requires large volume and the stores are not big enough to handle the full range of sofas. Some products therefore need to be offered as customer order.

All sofas offered as cash-and-carry in stores are also stocked in CDC terminal as CCD and can be ordered as customer order. The question is why all customer order sofas not are stocked (as CCD) in the CDC terminal? Why are some made to order and delivered directly from supplier (DDC)?

Today IKEA offers 414 different sofas globally, 157 of them are distributed as DDC in North Europe. There are several reasons to why all sofas not are stored and why DDC is used, which are explained below.

- ***Need of storage space*** **-** Keeping stock of all sofas would require large storage space in the CDC terminal and occupy many pallet positions in the AS/RS[5].
- ***Picking locations*** **-** Each article need an own picking location from where picking is done which is refilled from the storage by the AS/RS. Picking location is a capacity limitation in the warehouse. Storing all sofas would occupy many picking locations.
- ***Flexibility*** **-** It is easier to change and phase out a product from the range if there not is any stock to get rid of.

[5] Automated storage and retrieval system.

- ***Inventory and handling cost*** - By not storing the products in the CDC terminal, the inventory and handling costs will be lowered. Capital cost would also be avoided which occurs for all stocked articles. The cost of tied up capital for DDC products are low since the customer are paying in advance.

A test has been performed by IKEA at the CDC terminal in Peterborough (Great Britain) in order to compare the cost of handling a customer order of a sofa as CCD in comparison to DDC. The sofa model *EKTORP*, which is sold in store, was replaced from being handled as a CCD product to instead be handled as make to order in the DDC process. The result showed that it in total was 11 percent cheaper to handle the products as DDC, by avoiding large inventory and handling cost. With these arguments is it better categorize low-volume sofas as DDC products.

However, there is a drawback with having the sofas as DDC. The lead time for the customer order is longer in comparison to if sofas had been stocked at the terminal. The lead time for a CCD sofa stocked at the terminal is 7-10 working days. The lead time for a DDC sofa is 13-29 working days. The variation depends of suppliers' production time, localization and chosen transport mode.

Historically, the suppliers had very long lead times for providing sofas. Then it was necessary for IKEA to hold stock. But as the supplier managed to reduce their production time, it became possible to instead order when customer asks for it and still deliver it in a reasonable time.

5.2. The supply chain and its actors

The products in the DDC process is produced by different suppliers and distributed through the CDC terminal in Torsvik. The CDC terminal acts as a cross docking terminal for the DDC material flow and perform activities as receiving, consolidating and shipping. The DDC goods are shipped further on to hubs from the CDC terminal. 3PL[6] companies manage the hubs and the transport to the end customers. Figure 33 visualizes the supply chain of the DDC process from a perspective with the CDC terminal in Torsvik as the focal company.

[6] Third party logistic (3PL) = A company specialized in logistics which handles other companies' logistics operations. (CSCMP 2010).

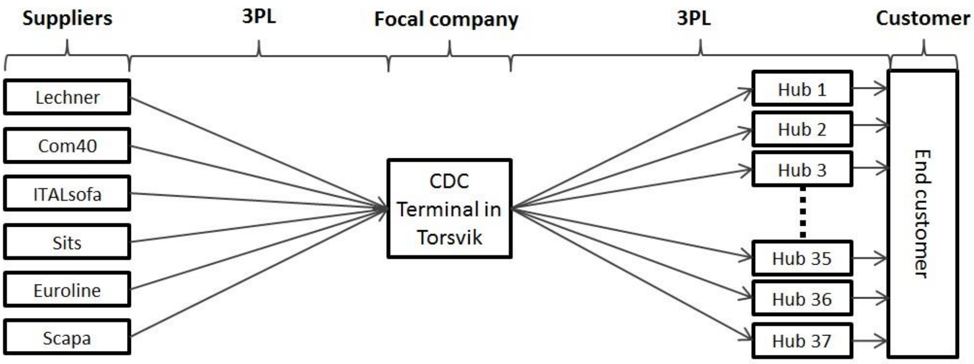


Figure 33. Basic illustration of how the CDC terminal in Torsvik consolidates shipments from different suppliers.

5.2.1. Actors

Suppliers

Six different suppliers provide IKEA with the DDC products. Information about the suppliers is presented in Table 7.

Table 7. Information about DDC products suppliers answering the questions; what they are supplying, from where and how.

Supplier	Product	Located	Transport mode
Lechner	Worktop (wood)	Sweden	Truck
Lechner	Worktop (stone)	Germany	Truck
Com40	Sofa	Poland	Truck/Train
ITALsofa	Sofa	Romania	Truck
Sits	Sofa	Poland	Truck
Euroline	Sofa	Poland	Truck/Train
Scapa	Sofa covers	Lithuania	Truck

The German company Lechner is the supplier of the worktops. Lechner supplies worktops from two production sites, one located in Germany and one in Sweden (Strömsnäsbruk). The German factory supplies worktops made in stone materials and the Swedish factory supplies worktops in wood material. One supplier, SCAPA, provides sofa covers, which is set as delimitation. The other four suppliers provide sofas.

Third Part Logistics (3PL)

Different 3PL companies are involved in the supply chain. IKEA hire 3PL companies to manage the transportation between the suppliers and the CDC terminal. The 3PL companies also manage the home delivery transport from the CDC terminal to the end customer including managing of the hubs. Example of used 3PL companies are Bring and DHL.

IKEA - Retail stores

At the stores, sales personnel are responsible advising and creating an offer to the customer. This includes, for example, help in drawing and order worktops.

IKEA - CDC terminal in Torsvik

The terminal acts as a cross-docking terminal for the DDC material flow. The terminal has 67 gate areas divided over 32 inbound locations and 35 outbound locations. In the beginning, only one inbound and outbound location was required to manage the DDC goods. Today between 9 and 12 gate areas are required, depending on the material flows variation. When the DDC goods need more area, an outbound location is changed to be used as an inbound location for the DDC goods.

In Figure 34 a layout is shown for the CDC terminal. As seen in the figure there are different sized of the inbound locations. The ones at the top have a size of 100 square meters each. The locations at the bottom each have a size of 150 square meters.

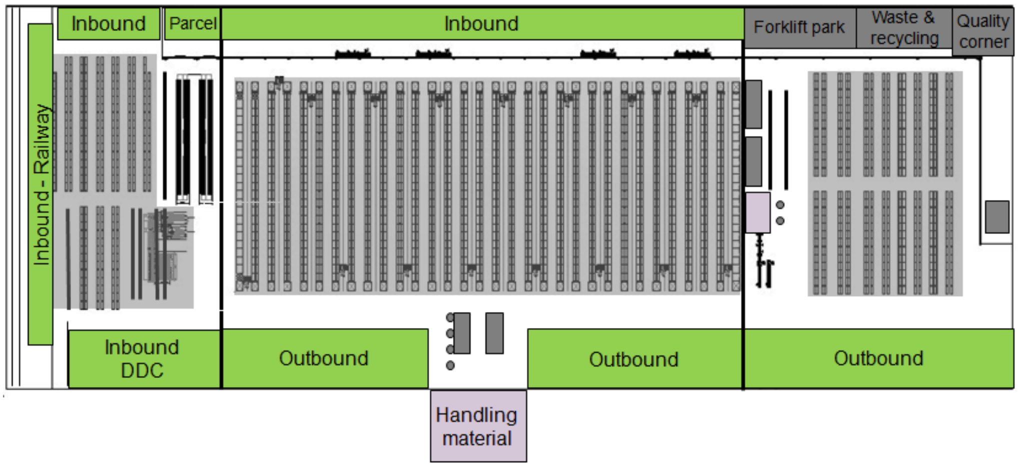


Figure 34. Layout of the CDC terminal in Torsvik showing inbound and outbound locations

IKEA - Customer Distribution Operation Support - CDOS

CDOS is an IKEA department which is responsible for facilitating delivery of customer orders and for securing stock availability at CDCs. To do so, they monitor orders and manage deviating orders. CDOS is located in Helsingborg.

IKEA – IKEA Service Center (IKSC)

IKSC is an IKEA department managing the contact with the customer. IKSC informs the customer about delivery dates and makes sure that the customer is able to receive the goods at the specific date. IKSC also handle claims.

Hubs

The DDC goods are distributed to 37 hubs from the CDC terminal. Those are managed by the different 3PL companies that also handle the home delivery transportation to the customers' home.

The sizes of the hubs vary and they are spread out geographically in Sweden, Denmark, Norway and Finland. Figure 35 show where the hubs are located.

Figure 35. The red markers indicate where the hubs are located which the CDC terminal (blue marker) distributes the DDC goods to.

5.2.2. Why transshipment of DDC products is made at the CDC terminal

The six different production sites supplying sofas and worktops classified as DDC are spread out geographically in northern Europe. IKEA has a large amount of different customers ordering DDC products. If neither the terminal in Torsvik nor the hubs had existed countless connections between suppliers and customers would be needed.

If the flow would not be handled by a CDC terminal, the suppliers would need to send the goods directly to the hubs. Connection between every production site and all hubs would be needed. With 6 suppliers and 37 hubs this would correspond to 222 transport relations. With a CDC terminal that functions as a node in the middle of the distribution system, only 43 transport relations are needed.

Without using CDC terminal for transshipment of DDC following drawbacks would occur:

- ***Low fill-rate in transport units between supplier and hubs*** **-** By sending a transport from every supplier to every hub means that the fill-rate in trucks would be extremely low, which leads to high cost and high environmental impact.

- ***Longer lead times due to suppliers attempt to increase fill-rate by dispatching rarely*** **-** The supplier would probably try to send shipments less often in order to improve the fill-rate, which would cause longer lead times and the customer would have to wait even longer for the products. This is a disadvantage that only could be avoided with larger material flow, so the suppliers could send full truck to every hub.

- ***Low control*** **-** A test was performed by IKEA four years ago where suppliers sent direct deliveries to the largest hubs with highest volumes. This test was not successful because the suppliers did not take any responsibility for the supply chain's best. When the DDC products not were delivered through the CDC terminal, IKEA did not had any control if the supplier delivered the goods in right time. The suppliers were sending the products as soon as they were finished with their production in order to lower their own inventory. This resulted in that the DDC products arrived to early and had to be stored at the hubs. After 4 days, IKEA has to pay for the storage of goods at the hubs. The result was overfilled hubs and increased cost due to longer storage at the hubs.

- ***Capacity at hubs*** **-** There is a capacity limit in how much goods a hub can handle at the same time. Direct deliveries from suppliers to all hubs would only be possible to perform with low frequency (once or twice a week) and the hub would have to receive larger shipments. The size of the hubs differs and many of the hubs would face problem if all deliveries that today is divided over the week would instead be delivered at once, one day per week.

The drawbacks mentioned above are avoided by using the current distribution setup with a terminal between the suppliers and the hubs. By using the terminal in Torsvik each supplier only have to have one connection to the terminal. In turn, the terminal needs one connection to each hub.

5.3. Characteristics of material flow

5.3.1. Size

The volume of the DDC material flow is continuously increasing with exception of 2012, visualized in Figure 36.

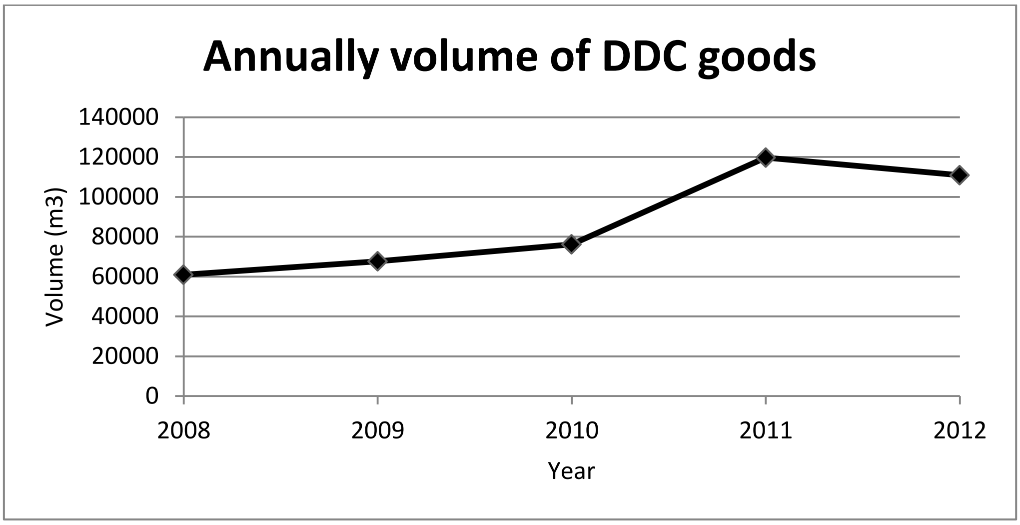


Figure 36. Annually volume of DDC goods

In 2012, the volume of DDC goods handled by the CDC terminal in Torsvik was approximately 110,000 m^3. This represented a share of more than 15 percent of the handled volume in the CDC terminal (IKEA 2012c). This volume was in 2012 distributed via approximately 78,000 deliveries. 29 percent of the deliveries were sofas and 71 percent were worktops.

The material flow is expected to grow. A forecast regarding the total handled volume in the CDC terminal exists i.e. including both the DDC and the CCD material flow. This forecast is shown in Figure 37.

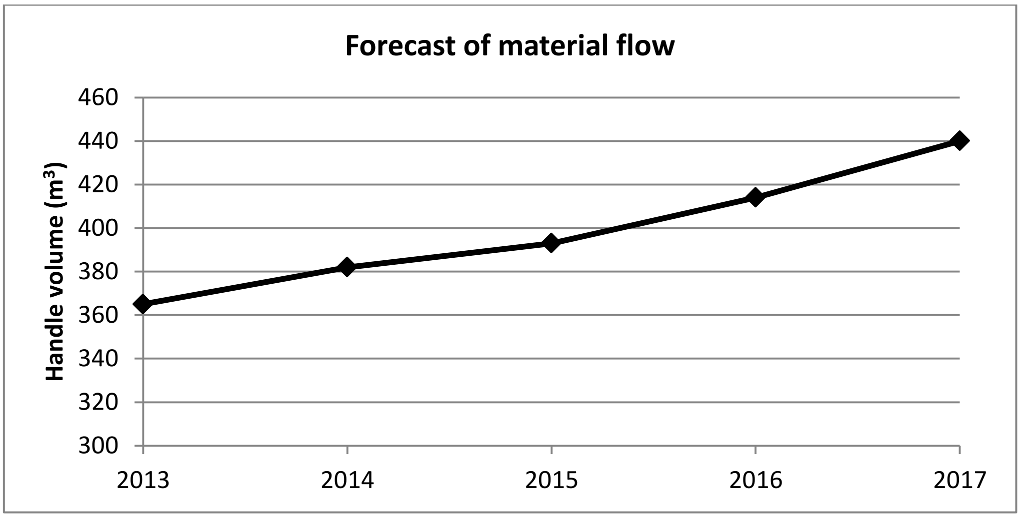


Figure 37. Forecast the growth of the material flow running through the CDC terminal.

DDC today contributes to 17 percent of the handled volume of the CDC terminal. Site manager at the CDC terminal predicts that the DDC share will increase in the future. If this is the case will the material flow of the DDC goods grow faster than Figure 37 visualizes.

5.3.2. Variations

In Figure 38 the variations in DDC material flow can be seen on a daily basis over a working week. The variation refers to volume of outbound deliveries from the CDC terminal. A little peak can be seen at Wednesdays but overall the variations can be seen as low and the flow is stable on a daily basis.

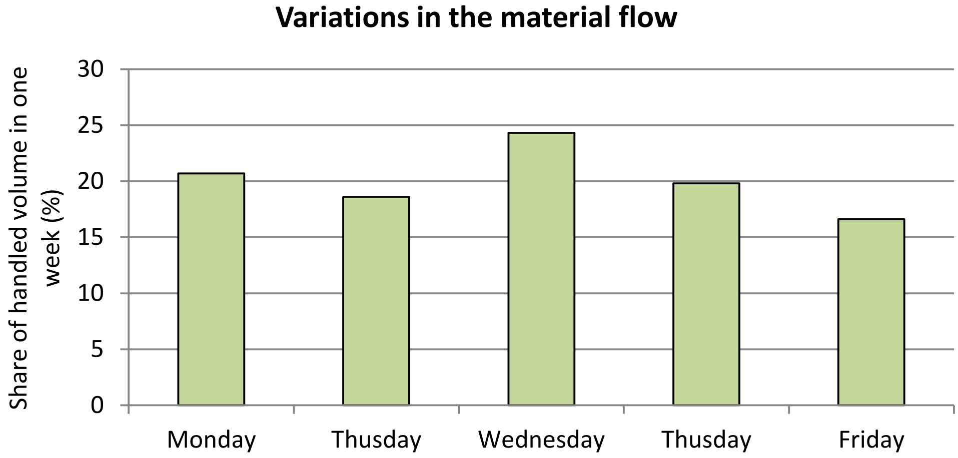


Figure 38. Variations of the DDC material flow over one working week. The variation refers to volume of outbound deliveries from the CDC terminal.

Campaigns and seasonality creates variations seen over a year. A kitchen campaign, as an example, has a large effect on the volume of the DDC material flow. The required amount of inbound and outbound locations for the DDC goods therefore varies.

5.3.3. Delivery performance

The delivery performance is measured in number of customer claims. Statistics for claims exist for worktops but not for sofas. The statistics for worktops is provided below.

Delivery performance of worktops

The delivery failures of worktops are classified as sales failure, transport damage, missing goods or supplier failure.

- ***Sales failures*** - When sales personal not succeed to sketch and order according to customer's preferences e.g. wrong length (50 percent of the sales failures), wrong measurement of cut-outs, wrong pattern etc. The origin of this problem is related to the stores.
- ***Transport damage*** - The goods got damaged in the transportation, e.g. chipped, scratched, cracked, crushed or damaged sink. These damages can occur everywhere in the supply chain, including at the CDC terminal.
- ***Missing goods*** - The worktop was not delivered to customer and got lost somewhere. A new have to be ordered. The worktops could be lost in every part of the supply chain, including at the CDC terminal.
- ***Supplier failure*** - Errors that can be blamed on the suppliers manufacturing, e.g. edging or bonding fall off, patches on the surface, crack arise after a while. The origin of this problem is related to the suppliers.

The number of failures for each category can be seen in Figure 39.

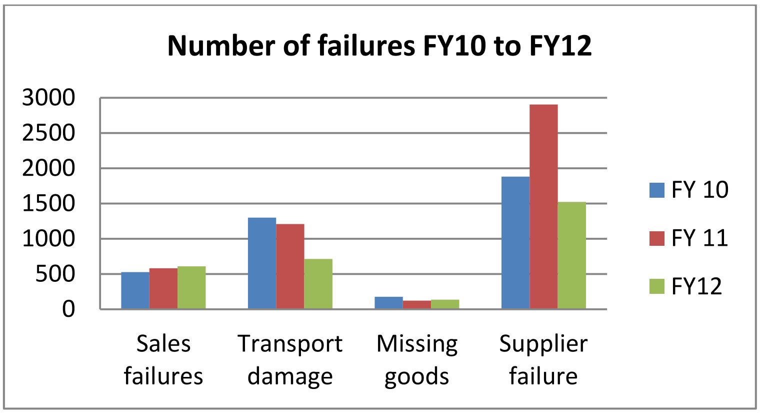


Figure 39. Number of failures in the delivery of worktops for FY10 to FY12.

In total, 27,800 worktop deliveries were performed in FY 2012[7], 2,974 of them failed, which mean that 12 percent of the total number of deliveries of worktops failed in FY 2012. Of these 12 percent, 2 percent were sale failures, 3 percent transport damages, 1 percent missing goods and 6 percent supplier failures. Figure 40 shows the distribution of the failures between the different categories.

[7] FY 2012. IKEA are not following the calendar year. FY 2012 corresponds to the time period from 1st of September 2011 to 31th of August 2012.

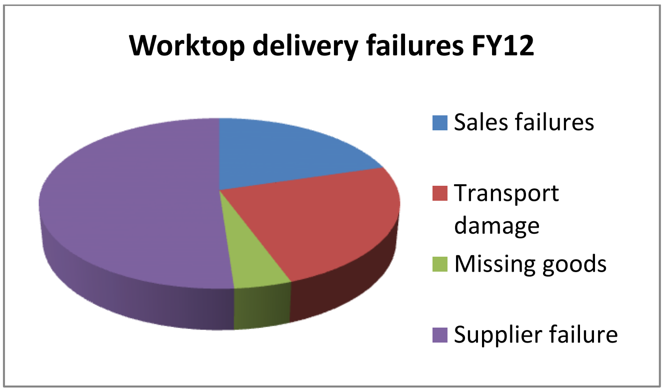


Figure 40. The fraction of each failure category.

5.3.4. Handling material

Handling material means material required to handle the goods, as pallets for example. Handling material is an area that receives large focus at IKEA though it affects factors as transport efficiency, filling-rate and transport damages.

In the CDC terminal in Torsvik are the DDC goods handled on different types of pallets. A pallet is the lowest level of SKU (Stock Keeping Unit). This means that the products that a pallet contains are never moved or sorted, the terminal only handle DDC goods at pallet level.

Worktops

The worktops are transported vertically, standing on its edge. The worktops in stone material are transported on wooden pallet with a wooden frame as protecting cover. The wood worktops are delivered on metal platforms that were introduced in February 2012 with intention to reduce damages and increase the fill-rate. The metal platform can in height be stacked in two layers to increase fill-rate. Unfortunately, double stacking of metal platform is not used by all transport providers due to safety issues.

One steel platform can carry up to 16 wooden worktops, depending on the size of the worktops. Stone worktops have more protective packaging which requires more space and less worktops fits onto a pallet

Sofas

70-80 percent of all sofas are transported on pallets in corrugated cardboard (in Swedish: wellpapp) Rest of the sofas are transported at so called loading list in plastic. It is an IKEA initiative to move away from using wood pallets due to the high cost and low fill-rate they bring. Corrugated cardboard pallets and loading list requires less transport volume and lead to better fill-rate than wood pallets.

However, many hubs had problem to handle the loading list and pallets in corrugated cardboard though it requires special equipment as forklifts with thinner forks. Therefore are the arriving goods at the CDC terminal lifted up on a wood pallet. The goods are thereafter handled on wood pallets in the CDC terminal, during the transport, and at the hub. This means that the goods stand on double handling materials.

Work has been done to get hubs to invest in equipment so they can manage handling material as loading list and corrugated cardboard pallets. This work is in progress with the intention to eliminate the need of handle goods on double handling materials. The CDC terminal also needs to make investment in handling equipment before this works completely.

5.3.5. Transport volume

Transport volume of worktops

All worktops transported to one hub, are loaded at the same pallet at the supplier, if all fits. Each pallet only has one hub destination which means that worktops for different hubs are not consolidated at supplier. In consequence, this means that in worst case one pallet carries only one worktop. This pallet need same amount of space in a truck as if it were full and contained 16 worktops.

The volume specifications of the goods are required when performing the planning of outgoing goods. The given volume from the IT-system, Delivery Schedule, is the net volume, i.e. only the volume of the product. When a product is transported it often requires more space. For example, if two worktops with a length of 5 meters are placed at one pallet, the pallet requires approximately 5 cubic meters. In the IT-system Delivery Schedule the volume for these worktops, which is the net volume, may be 0.2 cubic meters.

The volume is due to this instead measured when the goods arrive at the terminal. The volume of pallets containing worktops is estimated using guidelines based on the length of the worktops, presented in Table 8. The longest worktop sets the length for the estimation.

Table 8. Guidelines for estimating of the transport volume based on the length of the worktop.

Length of the pallet's longest worktop	Estimated volume
0-2 m	2 m^3
2-4 m	4 m^3
> 4 m	6 m^3

Transport volume of sofas

The volume specifications provided in IT-system, Delivery Schedule, is more accurate for sofas, but is not accurate enough to be useable. The volume for sofas is therefore also estimated. According to one employee at *Goods in* is one pallet calculated as 3 cubic meters. If the sofa extends beyond the pallet, the volume is calculated as 4 cubic meters. However, this guideline is not used by the next respondent at *Goods in.* After exploring this further it became clear that a standardized way to estimate the volume doesn't exist.

Test of using volume from IT-system as transport volume

A test is performed with the purpose to see if there are any correlation between the given volume in the IT-system Delivery Schedule and the estimated volume for the sofas. The test is performed at a consignment level i.e. comparing the volume of each shipment sent from one supplier to a specific hub. The test was performed by IKEA co-workers, working at the *Planning*, with instructions and periodic monitoring from the authors. Data were gathered under a time period of 16 days, including 407 consignments. All suppliers providing sofas was included in the test.

The data was provided through an excel-document. The document contained following information for each consignment:

- Consignment number
- Volume measured by *Goods in*
- Volume given in the IT-system Delivery Schedule
- Supplier
- Which hub the consignment should be delivered to

5.4. As-Is process map

Information about the products' characteristics, the supply chain actors and the characteristics of the material flow is now given. Following is the current state of the DDC process described through As-Is maps. The process has been mapped in three different levels. In the first and second level process mapping has been used as mapping tool. At the third level swimlane flowchart has been used. Following sub chapters will describe the process and their sub processes one by one.

The first level consists of an overview of the DDC process which is illustrated in Figure 41. The DDC process contains of 7 sub processes and starts from the object in, where a customer places an order. The DDC process ends at the object out, where the end customer receives the goods.

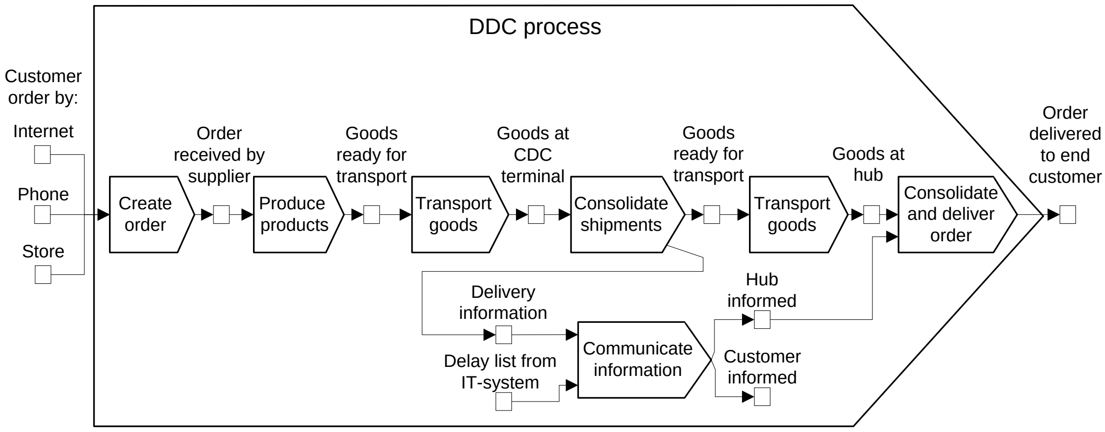


Figure 41. General overview of the process from customer order to satisfied customer.

Each sub processes in the DDC process will be described in following sub chapters. This is seen as the second level of the mapping.

5.4.1. Create order

The sub process *Create order*, which is shown in Figure 42, starts with an incoming customer order.

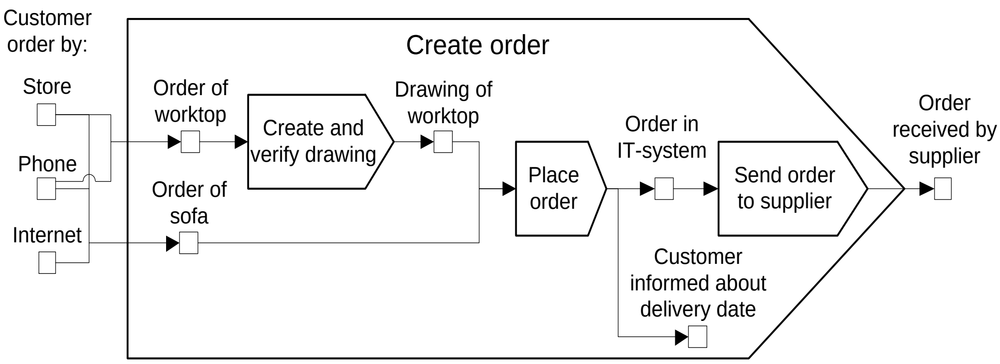


Figure 42. Overview of the sub process Create order.

Sofas can be ordered in a store, by phone or internet. Worktops can only be ordered by phone or in a store, not via internet

If a worktop is ordered, a drawing of the worktop must be made. The worktop is designed in an IT-program, PlanIt. PlanIt will provide a drawing that can be used by the supplier. The finished drawing will be connected to the order.

During the activity *Place order*, the order is placed in the IT-system, I-Sell. I-Sell is an IT-system handling orders. If the order is placed in a store or by phone, IKEA co-workers will place it manually in I-Sell. If the order is placed by internet it will be placed in I-Sell automatically. When an order is placed, I-Sell will provide the expected delivery date which is communicated to the customer. In the end of each day, all orders that are placed in the IT-system are automatically placed as an order to the supplier.

The orders are monitored by the IKEA department called Customer Distribution Operation Support (CDOS) which follow up deviations.

5.4.2. Produce products

Next sub process is *Produce products* which is handled by IKEA's suppliers exclusively. The sub process is illustrated in Figure 43 and starts with an incoming order from IKEA.

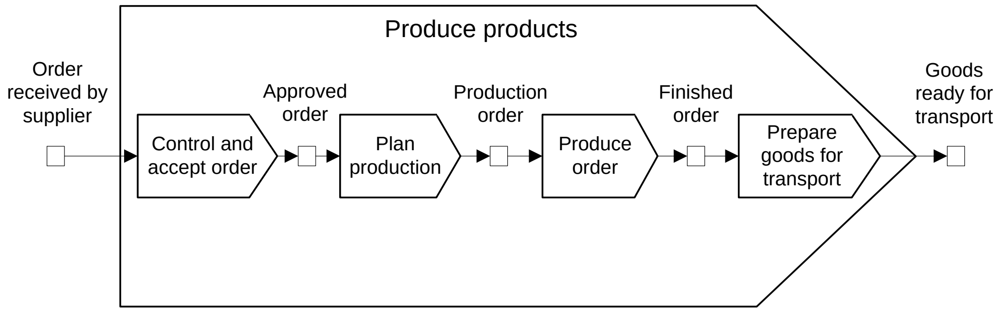


Figure 43. Overview of the sub process Produce products.

The supplier will receive the orders through their IT-system. If a worktop is ordered, the supplier first control that the drawing is right performed and that all needed information is received. If not, IKEA has to gather and send the correct information.

Thereafter the supplier starts to plan their production. Next, the product is manufactured and controlled. When the goods have been produced, the supplier prepares the goods for delivery to the CDC terminal in Torsvik. Transport documents are created by the supplier and sent along with the shipment. The transport documents consist of consignment notes and custom documents. The consignment notes contain article and delivery information about the goods delivered in that specific consignment. One consignment consists of all goods the supplier sends to one hub. Thus, the supplier sends one consignment for each end destination i.e. each hub. Therefore, several consignment notes are often submitted in each shipment to the CDC terminal.

5.4.3. Transport order

The sub process *Transport order* is trigged by the object *Goods ready for transport*. IKEA's transport department contracts 3PL companies in order to transport the finished goods to the CDC terminal. The goods are transported by truck or train. The object out of from this sub process is *Goods at CDC terminal*. The sub process is not illustrated through a map due to its simplicity.

5.4.4. Consolidate shipments

The sub process *Consolidate shipments*, visualized in Figure 44, is triggered by the object in; *Goods at CDC terminal*.

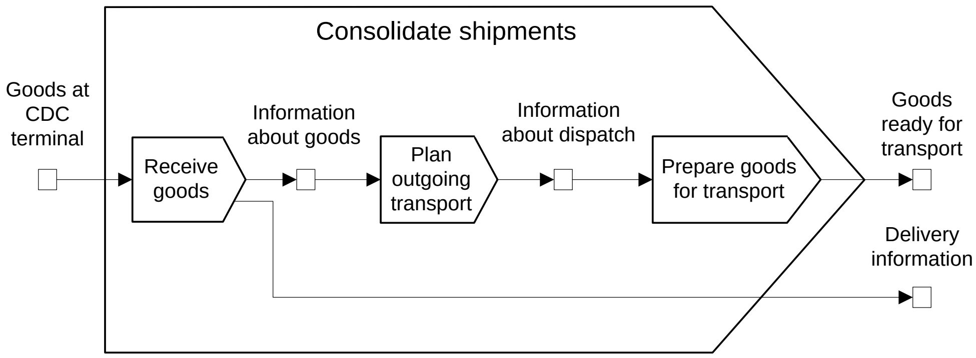


Figure 44. Overview of the sub process Consolidate shipments.

This sub process is exclusively handled by the CDC terminal. From this sub process, two out objects is created; *Goods ready for transport* and *Delivery information*.

The analysis of the study will focus on this sub process which therefore will be further explained through illustrations of its activities. These illustrations are seen as the third level of the mapping and the maps are based on the mapping tool swimlane flowchart.

Receive goods

The first activity in *Consolidate shipment* is *Receive goods*. This activity is illustrated in Figure 45.

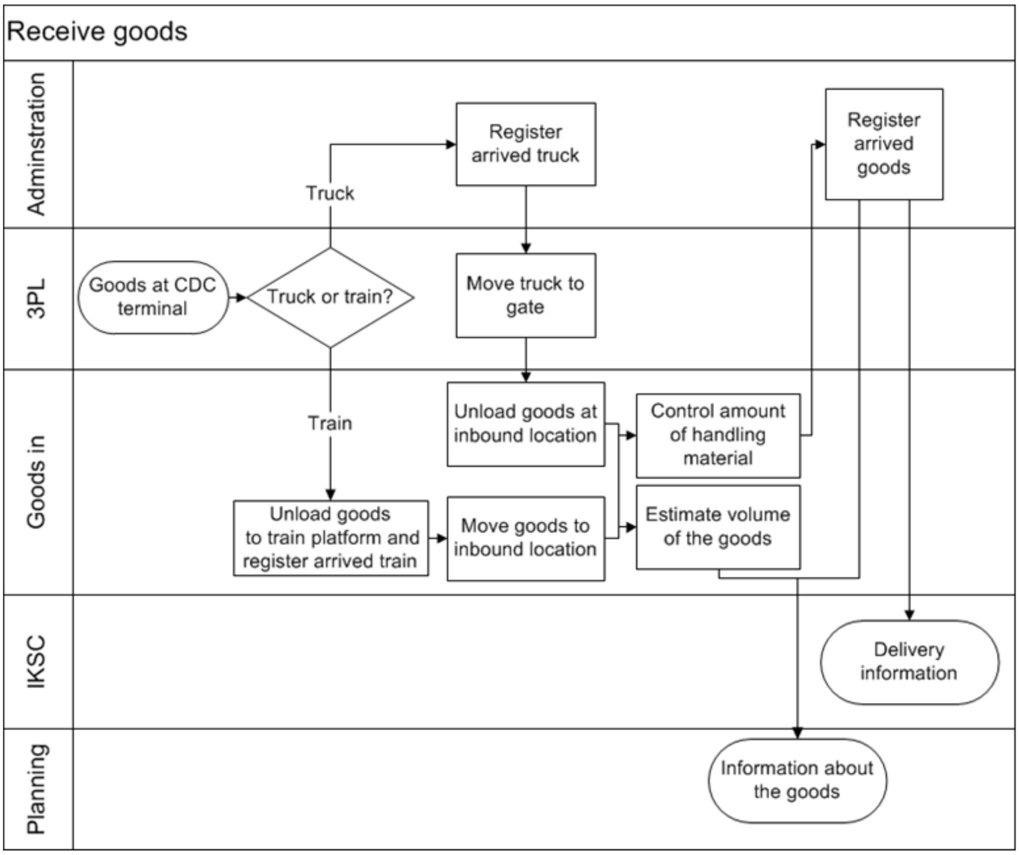


Figure 45. Overview of the activity Receive goods

The activity is trigged by the object *Goods at CDC terminal*. Goods can be delivered by train or truck. If goods are delivered by truck, the driver hand over transport documents to the reception. The reception is placed in a building called *Grindstugan* which is operated by a department called *Administration*. The *Administration* register that the truck has arrived. The consignment notes are copied and the original is returned to the driver. The driver receives information about where and when the goods should be unloaded.

The driver moves the truck to the correct gate at the scheduled time and prepares the truck for unloading. The driver hands over the consignment notes to the IKEA co-workers at *Goods in*. The co-workers unload the truck and place the goods at the inbound location.

If goods are delivered by train the driver will drive the train set directly to the train platform. Consignment notes are submitted with the goods arriving with the trains and are collected by co-workers at *Goods in.* They are also unloading the train. They will in the same time register that the train has arrived in a booking list, existing in the IT-system Access (which is a data base management system). The goods are unloaded at the train platform and thereafter are the goods moved to an inbound location. If the amount of goods delivered by train is low the goods can be stored at the train platform instead, but this is seldom.

The department *Goods in* has the responsibility to control that the amount of pallets in a truck or train matches amount given in the consignment notes. All incoming consignment notes are thereafter delivered to the *Administration* in the end of the day.

Next, *Administration* will compare their stored copies of the consignment notes with the ones received from *Goods in*. The consignment notes from the train are missing and can easily be sorted out. The consignment notes from the train are also copied so copies exist of all consignment notes which then are archived. The originals will later on be handed over to the driver transporting the goods from the CDC terminal to the hubs.

The *Administration* also registers all incoming goods as arrived in the IT-system CNS. A list is compiled containing consignment number, supplier and destination for all consignment notes that has arrived during the day before. This is sent to the departments *Planning* and *IKSC*. This list will act as an object out, *Delivery information*, and the list sent to *IKSC* will later on trigger the sub process *Communicate information*.

After all goods are unloaded, *Goods in* is also estimating the volume of the goods and is gathering information about the goods final arrival destination. This information is compiled in an excel document during the arrival day for all deliveries of DDC goods. The document is after each day sent to the department called *Planning*. Together with the compiled list from the *Administration*, this document acts as an object out; *Information about the goods*. This information tells how much volume the DDC goods will require in the trucks when it should be transported to the different hubs.

Plan outgoing transport

Information about the goods is a trigger for the next activity, *Plan outgoing transport*. This activity is visualized in Figure 46.

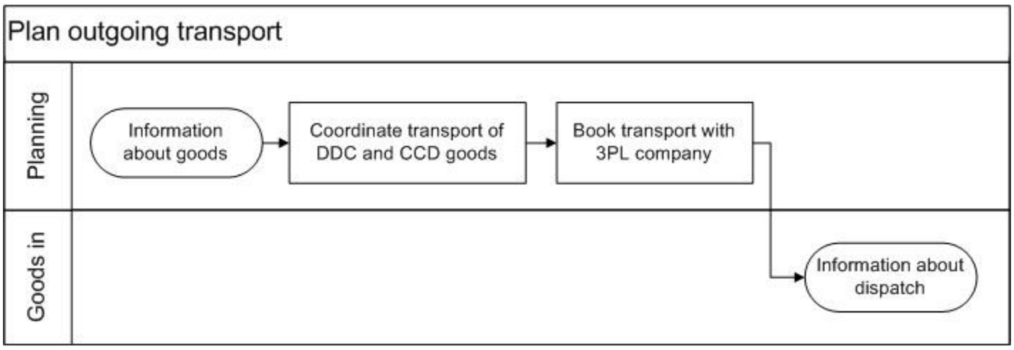


Figure 46. Overview of the activity Plan outgoing transport.

To be able to book outgoing transport, from Torsvik to the hubs, the information about goods volume and destination is needed. This information is received from *Goods in.*

The transportation is coordinated with the transport of the CCD flow. This is handled by a department called *Planning.* The volume required for the DDC goods is added to the volume required for the CCD goods. Information about the CCD goods is received from the IT-system ViCO, (Virtual Customer Orders) which is a warehouse management system in the CDC.

The transports must be booked before 12 o'clock the day before departure. The transport is booked the day after the arrival day, when knowing the volume of the received goods. The goods are therefore stored at the inbound location during the second day at the CDC terminal. To clarify, day 1; the DDC goods arrive and volume is estimated, day 2; transportation is booked and goods wait at inbound location, day 3; the DDC goods are dispatched.

The *Planning* manually register which consignments that should be transported in which truck by connecting the consignment number with the shipment number in the IT-system CNS. This information is a trigger for the next activity *Prepare goods for delivery*.

Prepare goods for delivery

Prepare goods for delivery is the last activity in the sub process *Consolidate shipment*. An overview of this activity is shown in Figure 47

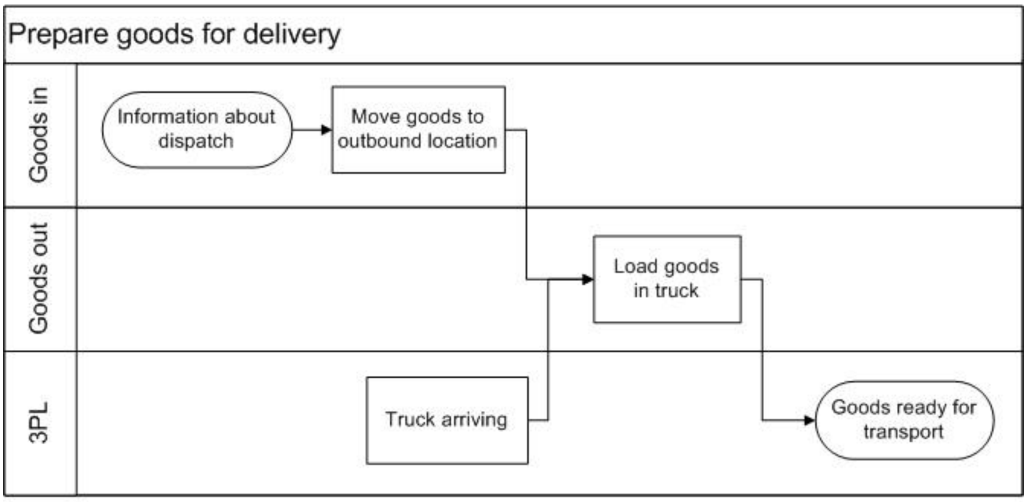


Figure 47. Overview of the activity Prepare goods for delivery

At this point of time the goods are waiting at the inbound location. The goods have not been sorted since the time of unloading i.e. the goods stands at the inbound location as it was unloaded.

The activity is triggered by the object in *Information about dispatch. Goods in* will receive this information via a booking list from the IT-system Access (which is a data base management system). *Planning* is manually adding the information in IT-system Access after they have ended the transport booking for each day. This information tells which goods should be placed at the different outbound areas, depending on which hub that should receive the consignment. It also contains information about when the drivers will arrive. By knowing this information, the co-workers at *Goods in* can move the goods to the correct outbound area at the right time. The CCD and DDC are consolidated and share outbound locations.

When the trucks arrive, the goods are loaded into the truck and are then ready for delivery. This is handled by the department *Goods out*. The object out *Goods ready for transport* acts later on as a trigger for the sub process *Transport goods*.

5.4.5. Communicate information

The sub process *Consolidate shipment* has an object out named *Delivery information*. This information is sent by the *Administration*. This object acts as an object in to the process *Communicate information*. Every day IKSC also receives a list from an IT-system including all delays regarding the goods in the DDC process, which acts as another trigger. *Communicate information* is illustrated in Figure 48.

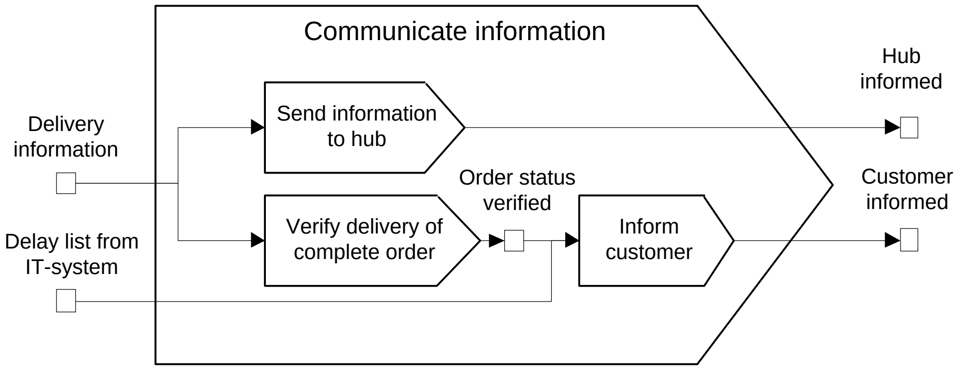


Figure 48. Overview of the sub process Communicate information

The delivery information is received by IKSC and contains information about which day the goods will be delivered to the hub and end customer. IKSC sends the information further on to the hubs. This is performed two or three days before the hubs receives the goods.

IKSC will in parallel manage the activity *Verify delivery of complete order*. IKSC verifies that there are no delays of the CCD products included in the orders existing in the list from *Administration*. This is done because a customer order including a DDC product also could include CCD products. If a kitchen is ordered can for instance the whole kitchen be CCD products except from the worktop, which is a DDC product. Thereafter IKSC calls the customer, either to confirm the delivery date that the customer received when ordering the products or to inform that the products are late. IKSC is informed about delays regarding the DDC products through the delay list received from the IT-system GPS. GPS stands for Global Purchasing System.

From this process, two object outs are created; *Customer informed* and *Hub informed*. *Hub inform* acts as one of the triggers to the sub process *Consolidate and deliver order*.

5.4.6. Transport order

The sub process *Transport order* is trigged by the object *Goods ready for transport*. This sub process is handled by 3PL companies. It starts off with that the driver receives the consignment notes and, if there are any, custom documents from the *Administration* when leaving the CDC terminal. Then, the driver will transport the goods to a hub. If goods are transported to a hub outside EU, the driver will leave the custom documents to the Custom Service at the border.

The goods are always dispatched by truck from the CDC terminal. In some cases the goods are first transported by truck and thereafter transshipped and distributed by train to the hub.

The sub process is not illustrated through a map due to its simplicity. The object out of from this sub process is *Goods at hub* which is a trigger for the sub process *Consolidate and deliver order*.

5.4.7. Consolidate and deliver order

The last sub process is *Consolidate and deliver order*, shown in Figure 49.

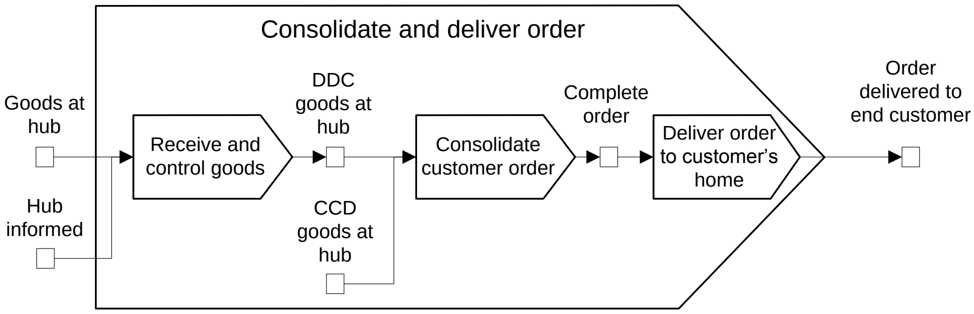


Figure 49. Overview of the sub process Consolidate and deliver order.

This process is exclusively handled by 3PL companies. The process is trigged by the object *Goods at hub*. Firstly, the hub receives the goods and controls the content which is compared with the list that has been sent to the hub by IKSC.

The DDC goods are then consolidated with the CCD goods in order to complete customer orders. The worktop is for instance consolidated with the rest of the kitchen. The completed orders are thereafter delivered to the customers´ homes.

5.4.8. Lead time perspective

The total lead time is counted from the point where the customer places an order to the point where the products are delivered to the end customer. The total lead time is between 13 and 29 working days. The large variation depends on supplier and end destination. In Figure 50 is the lead times of the sub processes visualized. The sub process *Communicate information* is removed in this figure because it is performed in parallel to the other sub processes and does not affect the lead time.

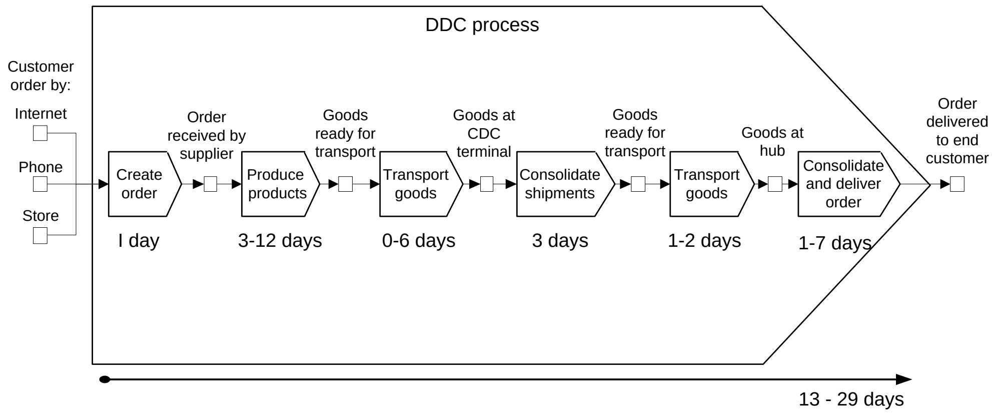


Figure 50. Visualizing lead time in the DDC process.

The lead time starts when a customer places an order. All customer orders that are placed during the day are automatically sent to the supplier during the night. This means that it will take 1 working day for the supplier to receive the order.

Thereafter the supplier's production time starts. The production time differs between the suppliers and is between 3 and 12 working days. The production time, in which the goods have to be produced and made ready for delivery, is pre-decided for each product. The suppliers' different production lead time and transport lead time is showed in Table 9.

Table 9. Production and transport lead time counted in days for respective supplier.

Supplier	**Production lead time (days)**	**Transport lead time (days)**
Lechner Sweden	10	0
Lechner Germany	10	2
Com40	5	2 (truck) 5 (train)
ITALsofa	9	6
Sits	3	5
Euroline	5-12	2 (truck) 4 (train)

The supplier Sits has the shortest production time, which is 3 working days. The supplier Euroline has the longest production time, which is 12 working days.

Transporting the goods from supplier to the CDC terminal takes all from 0 to 6 working days, depending on location of the supplier's production site and transportation mode. Slowest (6 working days) is to transport from the supplier

ITALsofa located in Rumania. The fastest deliveries come from Lechner´s production site located in Strömsnäsbruk, which supplies wooden worktops.

The end customer has the right to cancel the order up until 48 hours after the order was placed. This means that the customer can cancel the order during the first day of the supplier's production time. The supplier is therefore not able to start producing the order until the second day in the production time.

The lead time of consolidating the shipments at the CDC terminal is defined as 3 days by IKEA. This process will be described in more detail in following subchapter.

From the time when the goods are dispatched from the CDC terminal, it takes 1 to 2 working days for the goods to be transported to the hub.

It takes between 1 and 7 working days from the time the goods has arrive to the hub until it is delivered to the customer's home. The variation depends upon the delivery schedule for the postcodes. Some post code has deliveries every day and some only once a week.

Lead time of the process Consolidate shipment

IKEA defines the lead time of the sub process *Consolidate shipment* as 3 working days. The sub process is handled over a 3 working days period, but the actual average lead time is 48 hours. Arrivals from the supplier are spread out during the first day. The first goods arrive at 05.30 o´clock and the last goods are unloaded at 23.00 o´clock. The goods are dispatched during the third day from 05.30 o'clock until 23.00.

The actual time to perform the tasks (cycle times) within the activities has been identified and can be seen in Appendix C. The cycle times of the tasks within an activity has been summarized and is visualized in Figure 51. The unit of analysis is one full truckload.

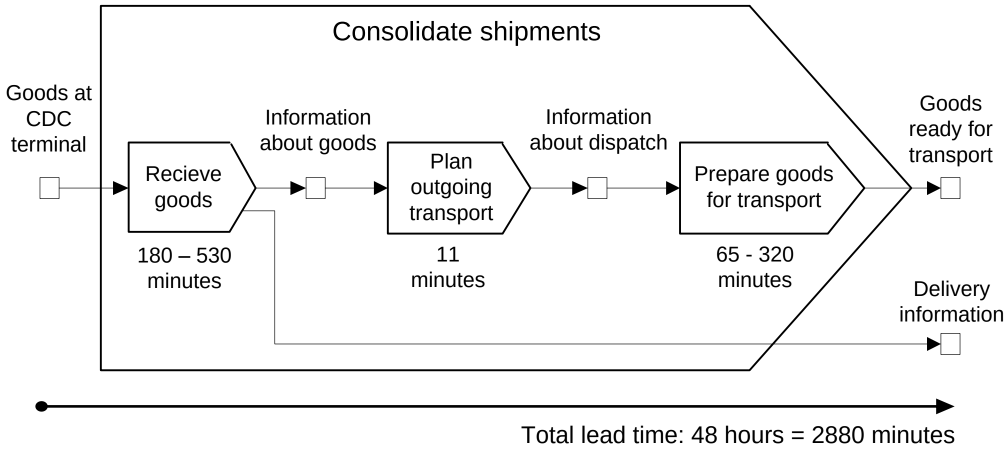


Figure 51. Illustration showing the summarized cycle times for the tasks within each activity in the sub process Consolidate shipment.

The large variation in cycle time mainly depends on the route distance between the inbound and outbound locations that is used. To move one pallet can vary from 1 to 10 minutes depending on which inbound and outbound location is used. The cycle times for the tasks can be found in Appendix B.

5.5. Problem identification

The mapping exposed problems in the process. Problems were also identified through interviews and observations. The identified problems are summarized in Table 10.

Table 10. Summary of identified problems in the DDC process.

Problems
Low efficiency in administrative work
Transport damages
Missing goods
Lack of gate area
Limited way to follow up performance
Custom related problems

These problems will be shortly described in following sub chapters and then further investigated in the analysis chapter.

5.5.1. Low efficiency in administrative work

The handling of the DDC process at the CDC terminal means a lot of manual work, especially regarding the administrative work. The information often travels in form of physical paper documents and handling of those takes a lot of time. This requires many labor hours which lead to low efficiency.

Low efficiency, in terms of time consuming manual work, has through observations been identified in the activity *Receive goods*. Manual work is particularly identified in the tasks; *Register arrived truck, Register arrived goods* and *Estimate volume of the goods.* The activity *Plan outgoing transport* also contains manual work which is seen in the task *Coordinate transport of DDC and CCD goods.*

5.5.2. Transport damages

By referring to *5.3*.3 *Delivery performance* it is obvious that delivery failures are a large problem in the supply chain. Transport damages are declared as one of the categories of failures. These damages can occur everywhere in the supply chain, including in the CDC terminal. Transport damages refer to that the goods get damaged in the handling e.g. chipped, scratched, cracked, crushed or damaged sink. 712 worktops were claimed as transport damaged in FY12, this is about 3 percent of all worktops delivered. There is no such statistic for sofas. There is also no statistic of where in the supply chain these failures occur, but it is highly probable that some of these damages occur at the CDC terminal.

Reducing occurrence of damaged goods is something IKEA continually works a lot with. There is extensive projects regarding handling material and protection covers as discussed in chapter *5.3.4 Handling material*. Recently control indicators were introduced which is attached on stone worktops and shows that a package not tipped or rolled over during handling. The problem will therefore not be further investigated in this study.

5.5.3. Missing goods

Missing goods in the supply chain is another delivery failure category. 133 worktops disappeared in FY12, which is about 0.5 percent of all worktop deliveries. Corresponding statistic for sofas is missing. It has emerged, through interviews that goods disappear in the CDC terminal. Due to the lack of statistics, it is not known in which extent this occurs. It is hard to claim that the suppliers are guilty for the missing goods due this low control of when it actually disappears.

It will now be described how the goods are handled inside the CDC terminal and which control that exists to ensure that goods do not disappear. The consignment note handed over by the driver indicates which goods are loaded in the arriving truck. The *Administration* uses this document when manually register incoming goods in the IT-system CNS. When goods are unloaded from the truck, the co-workers in *Goods in* manually control and confirm that the received number of pallets corresponds to the number of pallet in the consignment notes. There is no scanning of the goods to register either arrived or dispatched goods. When dispatching the goods, the *Administration* is manually registering the dispatches in the IT-system CNS, again using the consignment note. The process in the *Administration* therefore depends on that all activities are perfectly performed. If any pallet should be placed at the wrong place in the terminal or in the wrong truck the *Administration* would not notice. The CDC terminal will not notice the error before a hub report that they have one pallet too much or one pallet too little. If the hub reports that goods are missing, the goods can be hard to find.

If missing goods is found at an early stage, it can be redirected and transported to the right destination. If it is not found at an early stage, it is classified as missing goods and new goods have to be ordered from the supplier. In this case, IKEA more than double the cost for these orders. The production-, transportation- and handling cost of the order will be the double and on top on that can the cost of a disappointed customer be added. The cost for handling and transporting the new product is in average 3,000 SEK. The probability of making a customer disappointed is considered as high if goods get lost. IKEA estimates that a disappointed customer cost 15,000 SEK.

5.5.4. Lack of gate area

When the DDC goods need more area inside the terminal, an outbound location for the CCD and DDC goods is changed to an inbound location for the DDC goods. The DDC material flow has during the last seven years had an annual growth of 16 percent counted in number of deliveries. If the DDC material flow will keep growing, problems will occur due to lack of gate areas in the CDC terminal.

The department *Goods out* has a target of always having four to five outbound locations available as buffer for new dispatches. This is required in order to maintain a high efficiency. The amount of received orders is higher at the weekends for the CCD material flow. A few days later this is shown at *Goods out* as an increased amount of volumes that should be handled. During this peaks all outbound locations are often utilized. The warehouse can today be considered as fully utilized regarding inbound and outbound locations. Regarding the variation in the DDC material flow, a small peak can be seen at Wednesdays, but it is considered as relatively stable.

The DDC goods are never stored at the shelves. After the goods are unloaded it is placed at the gate area and the goods are not moved until shortly before departure. This means that the goods in average are stored approximately 48 hours at the gate areas.

5.5.5. Limited way to follow up performance

Key Performance Indicators (KPI's) are something that is used in a large extent to measure the performance of the other processes in the CDC terminal in Torsvik.

Targets are set up for each KPI which are monthly reviewed to see if the target is reached. An example of a KPI is order lines picked per hour.

However, the DDC process lacks KPIs to a great extent. There are currently no KPIs or other performance measurement of the CDC terminal's efficiency in handling of the DDC process. It is therefore not possible to measure how efficient this process is handled. The measurements that exist are delivery precision, delivery failures for worktops and performance regarding the custom declarations. Performance that is measured regarding the customer declarations is how many custom declarations that fail and how much time that is spent on the manual work with custom declarations.

Measurement of the process performance requires available data. Measurement would therefore be facilitated if IT-support for the process existed, from where data could be gathered. Performance measurement is a large area to explore. Due to its scale and complexity, the problem will not be analyzed. However, it will be discussed as future work in chapter 9.1.

5.5.6. Custom related problems

If goods are sold to a country not member of EU, custom declaration must be done. This is the case when IKEA distributes products to Norway. IKEA's CDC terminal in Torsvik acts as an intermediator and never owns the goods transported through the terminal. Therefore, the suppliers are responsible for the custom documents and that custom duty gets paid. If something goes wrong in the handling of the custom documents, custom related problems occur.

The custom documents are created by the suppliers. When a custom document is created for a shipment, it is also registered in an IT-system managed by Custom Service in Norway. The custom documents are sent with the transporter to the CDC terminal. The terminal handles the document and passes them further on to the driver managing the transport between Torsvik and the hubs located in Norway. The driver receives one custom document for each consignment. Several consignments are often loaded at each truck. This leads to that the driver usually will receive many custom documents as there is one custom declaration per consignment. The driver hands over the custom documents to the Custom Service at the Norwegian border. When Custom Service receives the documents they confirm and close the custom declaration of the shipments in their IT-system.

It happens that custom document get lost and is missing when the goods arrive to Norwegian border. This leads to customer declaration failures, which is serious. It can lead to that the supplier is accused for smuggling. In worst case, the supplier may lose their right to export goods to non EU member countries.

6. Analysis

In this chapter it is first analyzed if additional problems could be found in the DDC process. A ranking of all the identified problems is then performed and the chapter ends with analysis of the problems.

6.1. Identification of additional problems

In this chapter two analyses will be performed in order to search for additional problems in the DDC process. A process activity mapping will be performed with the intention to analyze the lead time. Thereafter an analysis of handovers will be performed.

6.1.1. Process activity mapping

The lead time can be seen as fairly long in a competitive market. Considering the lead time of 13 to 29 working days, the supplier stands for 3-12 of these days. This is at most 60 percent of the time. Reducing the supplier’s lead time would be of interest but it is out this study’s scope.

This analysis will focus on the lead time within the CDC terminal, which is 48 hours. This corresponds to between 6.9-15.4 percent of the total lead time for the DDC process. A process activity mapping is performed which is inspired by the time analysis and value analysis described in the theory. The unit of analysis is one full truckload.

Table 11. Process activity mapping of the sub process Consolidate shipment

Activity	Cycle time minimum (minutes)	Cycle time maximum (minutes)	OPERATION	TRANSPORT	ADMINISTRATION
Register arrived truck	5	5			X
Move truck	10	10		X	
Unload truck	15	90		X	
Estimate volume of the goods	5	5			X
Control amount of handling material	5	5			X
Register arrived goods	5	30			X
Coordinate DDC and CCD transport	6	6			X
Book transport from a 3PL company	5	5			X
Move goods to outbound area	50	300		X	
Load goods on truck	15	20		X	
Sum	**121**	**476**	**0**	**4**	**6**
Average lead time	**2880**	**2880**			
Quota (sum of activity's cycle time / lead time)	0,04	0,16			

As seen in Table 11 there are no activities defined as *Operation*. An *operation* is defined as a value adding activity. This means that no of the activities are seen as value adding. The listed activities are defined as non-value adding activities. The remaining time is waiting i.e. waste. As there is not any value adding activities, the non-value adding activities have been used instead. The activities' cycle times have been divided with the total lead time. The resulting quota provides an indication of how much waiting time the sub process includes.

The quota, which is between 0.04 and 0.16, can be considered as low and indicates that there is a lot of waiting time in the sub process. The analysis clearly indicates a big potential for shorten the lead time without any need of improving the cycle times.

Remember that the quota can be larger than 1 if activities is performed in parallel. The *Long lead time* at the CDC terminal is hereby seen as a problem.

The large variation of the cycle times could be seen as a problem but in this stage it is not due to the large amount of waiting time. If the total lead time is lowered, the variation could become a future problem.

6.1.2. Analysis of handovers

As discussed earlier both Smith (2012) and Madison (2012) points out the risk with handovers in the process. Every time the responsibility is handed over to another participant in the process, a risk of error occurs.

The sub process *Consolidate shipment* is analyzed with a full truckload as unit of analysis. The activities in the sub process have been mapped with swimlanes flowcharts. Swimlanes flowcharts provide an overview of the responsible department that's performing the tasks in the sub process and thereby also the amount of handovers. The charts are used as basis for this analysis. The first activity in *Consolidate shipment* is *Receive goods* which is visualized in Figure 52.

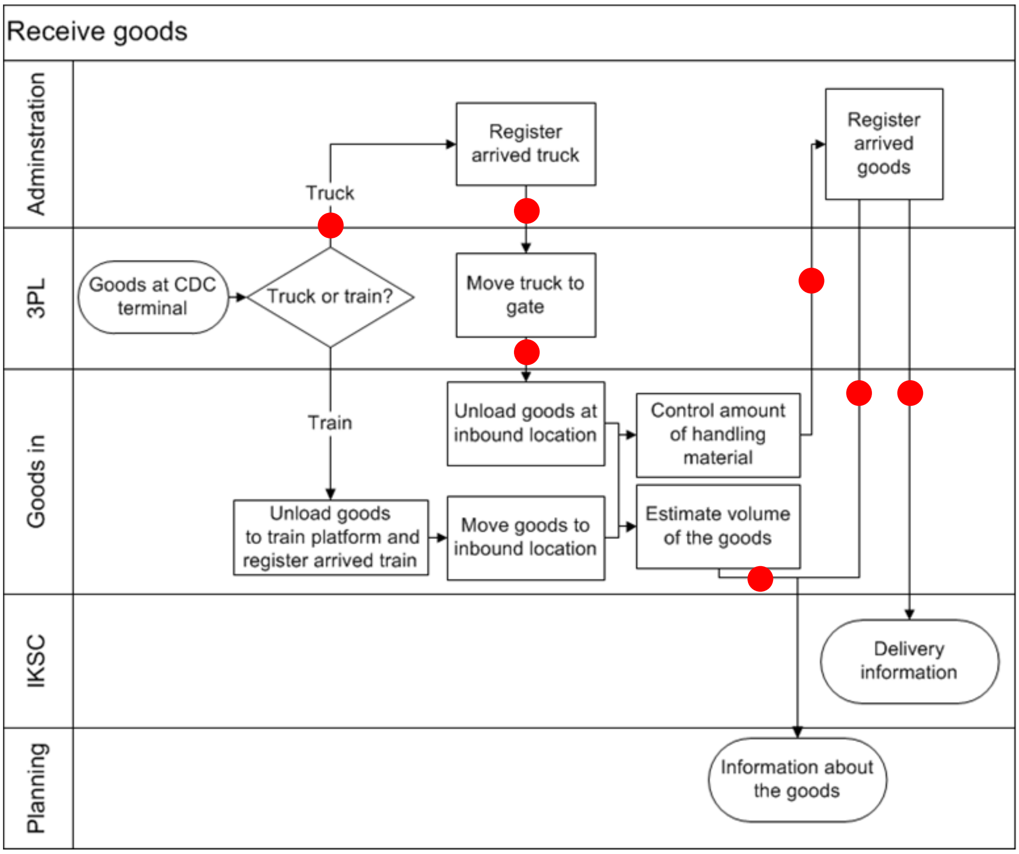


Figure 52. Illustrating the handovers in the activity Receive goods

The red dots in the chart symbolize the handovers. In total there are seven handovers in this activity which is managed by five different actors/departments.

The second activity, *Plan outgoing transport*, is visualized in Figure 53.

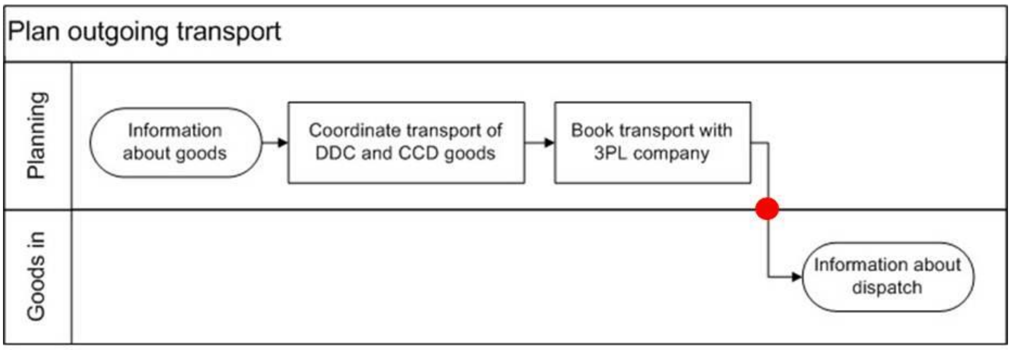


Figure 53. Illustrating the handovers in the activity Plan outgoing transport

In this activity, which includes two departments, only one handover occurs. At this point, six different actors/departments have been involved in the sub process.

Prepare goods for delivery is the last activity which is illustrated in Figure 54.

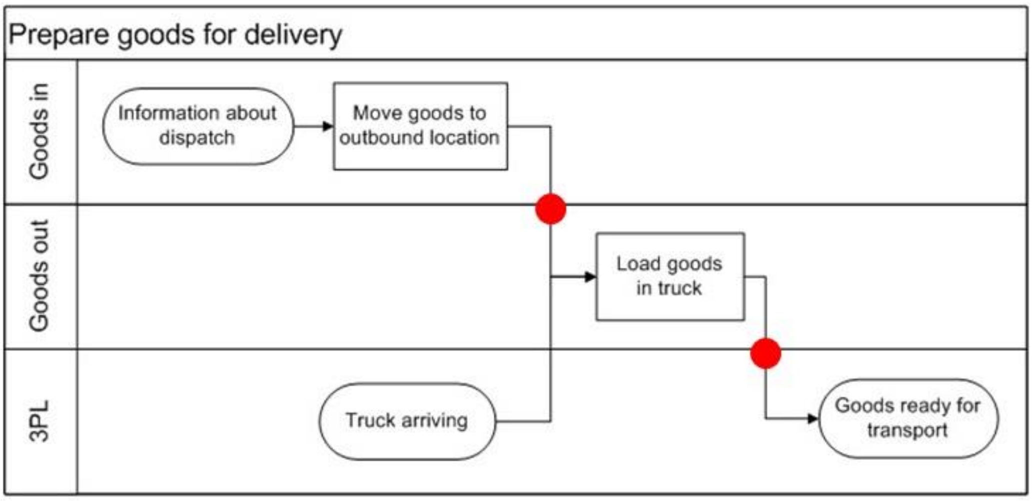


Figure 54. Illustrating the handovers in the activity Prepare goods for delivery

Two handover is identified and the activity is managed by three different actors which all have been involved in the sub process earlier.

The total result for the sub process is 10 handovers. This is considered as a relative large amount in consideration to the 12 tasks carried out. The handovers is therefore seen as a potential problem named *Large amount of handovers,* which will be further analyzed.

During these 10 handovers the responsibility for the process is shared by 6 different departments. Today there is no person/group that is responsible for the entire sub process which is a topic that is discussed in *4.2.3 Process responsibility and roles in a process oriented organization*. There are either none that has the responsibility for the entire DDC process. Instead the responsibility for improving the process is shared between the departments and actors. The problem *No one responsible for the entire process* is thereby identified.

6.2. Ranking of the problems

Nine different problems have in total been identified for the DDC process. All identified problems are summarized in Table 12.

Table 12. List of all problems that has been identified

Problems
Low efficiency in administrative work
Transport damages
Missing goods
Lack of gate areas
Limited way to follow up performance
Custom related problems
Long lead time
Large amount of handovers
No one responsible for the entire process

To be able to understand which of the problems are of most importance for IKEA a ranking of the problem in term of cost and consequence would be suitable. Due to different characters and limited data of the problems are they hard to compare in term of cost or consequence.

The problems have instead during a workshop been ranked by the site manager, associate warehouse manager and operational support manager at the CDC terminal. It was intended that the warehouse manager also would attend this workshop, but stayed out due to illness. The ranking was made by considering which of the problems, existing at the CDC terminal, was of most importance for IKEA. This ranking is listed in Table 13.

Table 13. Ranking of all identified problems.

Ranking	Problems
1	Lack of gate areas
2	Long lead time
3	No one responsible for the entire process
4	Low efficiency in administrative work
5	Transport damages
6	Missing goods
7	Limited way to follow up performance
8	Large amount of handovers
9	Custom related problems

It was decided that the problems *Lack of gate areas* and *Long lead time* should get a larger focus in the analysis due to the high ranking. Two of these nine problems, *Transport damages* and *Limited no way to follow up performance*, will not be analyzed because of different reasons described earlier.

6.3. Analysis of problems

In this chapter further analysis of the problems will be performed. All problems will be considered but the emphasis will be on the problems with highest ranking. The problems are listed in Table 14 and sorted with the problem ranked highest first. The problems will be analyzed in this order.

Table 14. The identified problems in the DDC process that will be analyzed

Problems
Lack of gate areas
Long lead time
No one responsible for the entire process
Low efficiency in administrative work
Missing goods
Large amount of handovers
Customer related problems

6.3.1. Lack of gate areas

Source of problem

The lack of gate areas in the CDC terminal is highly depending on the DDC goods. Three reasons have been identified:

- The DDC material flow grows every year in terms of volume, and requires annually additional gate areas.
- The goods are stored at the inbound and outbound locations during the time in the terminal.
- Long lead times inside the terminal leads to that the goods occupies the space for a long time.

Consequence and customer impact

The warehouse is not sized for a growing DDC material flow. If all outbound locations would be fully utilized, the efficiency at *Goods out* would decrease.

Respondents have pointed out that the risk of mix up pallets increases when a larger amount of DDC goods are handled at the CDC terminal. This contributes to a larger risk of losing goods. Consequences of this are discussed in chapter *6.3.5 Missing goods*.

In worst case the situation can become so serious that there are no more gate areas to unload the goods at, and the terminal cannot manage to receive the amount of goods that is sent to the terminal.

Potential solution

Four different potential solutions have been identified.

- ***Longer working days -*** With longer working days, each outbound location can handle additional amount of dispatches and fewer outbound locations would be needed. Today the CDC terminal receives and dispatch goods between 05.00 and 23.00 o'clock. There is thereby a potential to extend the working days with 6 hours.

  There are though some drawbacks with this solution. The CDC terminal today uses these 6 hours as buffer to be able to handle peaks in the material flow. According to respondents, this buffer is used approximately twice a year during campaigns etc. The buffer would in such case not exist. Also, the running cost of the terminal would increase due to higher salary expenses i.e. it is more expensive to have employees working at night. This is therefore not appropriate as a final solution.

- ***Shorter lead time*** - If the lead time at the terminal could be reduced with one working day. The DDC goods would only need to occupy the gate areas for half of the time. This leads to that the DDC goods only would require half of the gate areas that are occupied today (9 to 12 gate areas). The potential is therefore to free between 4.5 and 6 gate areas. The possibility to reduce the lead time is further analyzed in chapter *6.3.2 Long lead time*.

- ***Direct deliveries*** - A solution could be to deliver the products directly from suppliers to high-volume hubs without consolidation at the CDC terminal. The DDC material flow is growing which will increase the potential in this solution.

  By referring to the test explained in chapter *5.2.2 Why transshipment of DDC products is made at the CDC terminal*, where suppliers delivered directly to the hub, this solution was not recommended. The problem that occurred during this test with having suppliers sending goods to early could be overcome. IKEA has a large impact on its suppliers. By giving a penalty fee to the supplier if goods are delivered to early or to late would probably reduce this problem.

  Removing the CDC terminal in the DDC process would make a less complex supply chain. Fewer actors handling the goods with a lower amount of handovers would contribute to large advantages. To mention examples this would contribute to a reduced risk for custom related problems, reduced transport damages and a lower amount of missing goods.

  There is a potential to shorten the lead time. In Appendix B, the lead times are compared between having a supplier sending goods through the CDC and direct to the hub. It is calculated that the supplier are sending goods 5 days a week when sending goods through the CDC terminal. If the supplier instead sent directly to hubs once a week, the lead time would in average be 0.6 days longer. If the supplier instead sent goods twice a week, the lead time would be 1.3 days shorter.

  One of the largest benefits would be the cost savings potential. Eliminate all costs arising at the CDC terminal would lead to a more cost efficient supply chain.

  A drawback with direct deliveries to high volume hubs would be that two different material flows would be created, i.e. one for high volume hubs and one for low-volume hubs. This may instead add complexity to the process.

Another drawback is the uncertain if the hubs would have the capacity to handle deliveries of these sizes. Today the deliveries are spread out during the whole week. This solution would mean that a supplier would send goods only once a week. The variation of the material flow needed to be handled at the hub would increase a lot.

This solution requires a comprehensive investigation and will be further discussed in chapter 9 *Future work*.

- ***Stabilize variations in the material flow* -** More CCD products are bought during the weekends. The CDC terminal experiences these peaks during Wednesdays and Thursdays and the lack of gate areas increases. The terminal is fully utilized regarding gate areas during these peaks. Stabilizing the variations is therefore seen as a partial solution to the problem. This may be a short-term solution due to its small effect regarding the gate areas but it has in the same time other advantages. It is for instance easier to plan the work with a smother flow which gives possibilities for a higher efficiency.

  The IT-system already has a limit of how many orders that can be placed at each day in the stores. If the limit is reached it is not possible to place more orders at that day i.e. the order will be placed one day later and the customer has to wait one day extra. This limit is used in order to even out the variations in the material flow and make sure that the CDC terminal will manage to dispatch all orders in time. The limit is based on amount of orders, which may not be optimal. It is a large difference when handling an order in the CDC terminal depending on how many order lines the order consist of. An order can include a whole kitchen, which in average contains of 40 order lines, or only e.g. a table containing one order line.

  A potential solution is to base the limit on both amount of orders and order lines. The delimitation of orders would delimit the risk of having a large amount of orders with only one order line, which would contribute to a low throughput. The delimitation of order lines would delimit the risk of having a large amount of orders containing kitchens, which would contribute to a congested terminal.

  Adding a second limitation indicates that the throughput of the material flow in the terminal would be lowered, but this does not need to be the case. The throughput of material flow could perhaps even be increased.

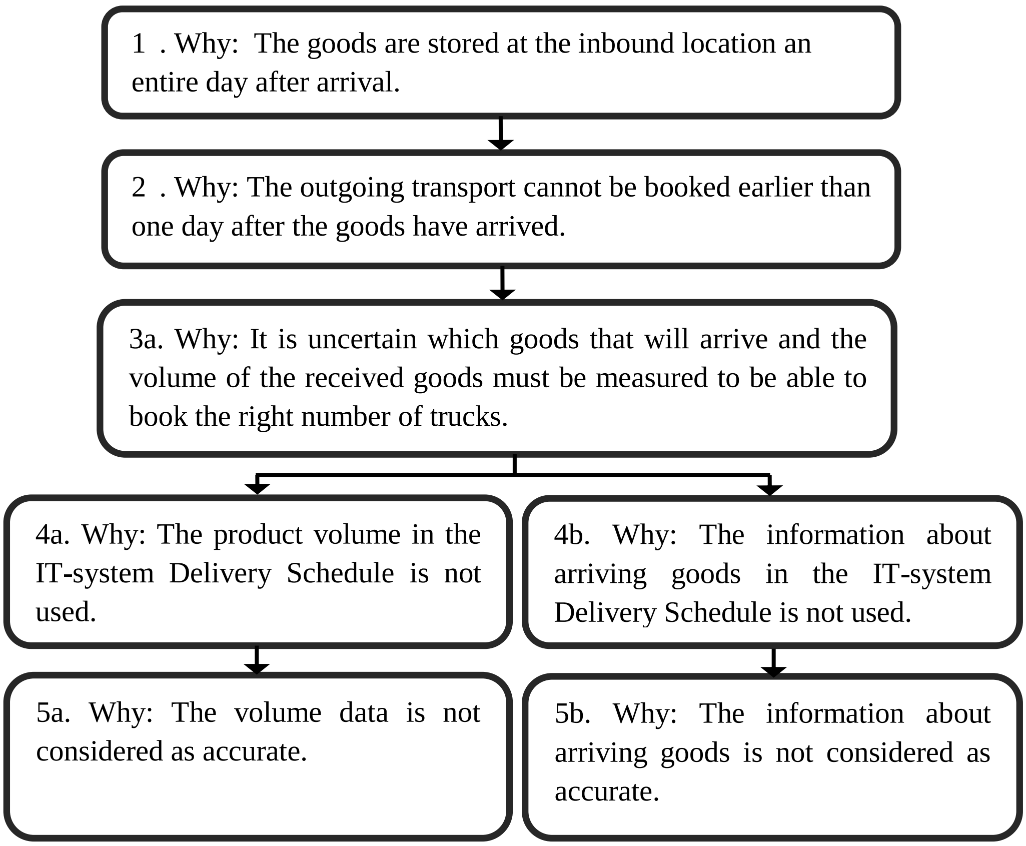
  Today, the limitation of orders has to be set relatively low to ensure that the CDC terminal can handle all orders, even if a large part of the orders consist of many order lines (as kitchen orders). The limitation of amount of orders could be raised if there was another delimitation of total amount of order lines for each day.

It will though not work to only have the limitation of order lines. 40 order lines placed in one order take less time to handle in comparison to 40 order lines which are divided over 20 orders. For instance, if a kitchen should be picked these 40 different articles are stocked in closeness to each other which reduces picking time. To ensure that the CDC terminal's capacity is not exceeded, even if all orders would have one order line, the limitation of the order lines has to be set low enough. Best solution is therefore to have two limitations, both delimiting amount of orders and order lines. If both limitations exist, both could be set higher.

6.3.2. Long lead time

Source of problem

It has been identified that the lead time at the CDC can be considered as long and includes much waiting time. The question arises why there is so much waiting time in the process. A *5 Why analysis* is made:



The main source that contributes to the long lead time is that the volume data and the information about arriving goods in the IT-system Delivery Schedule are not accurate. The planning of outgoing transport can therefore not be done before the goods have arrived. The volume of the goods is measured (estimated) when the goods arrive and the information acts as a trigger for the activity *Plan outgoing transport* as seen in Figure 55.

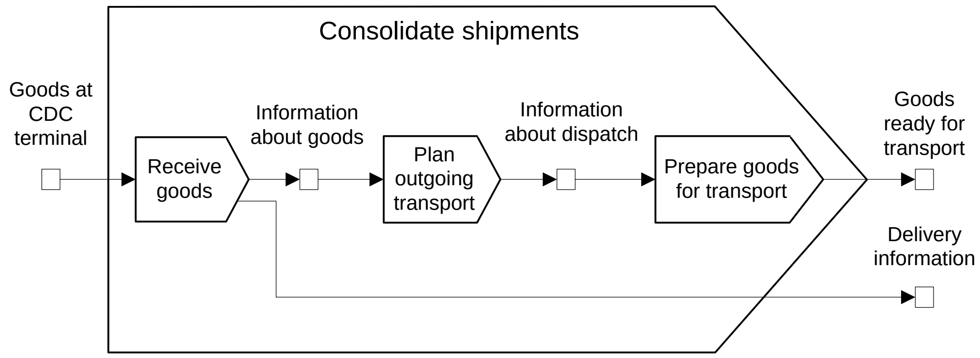


Figure 55. Illustration of how the activity Plan outgoing transport is dependent on the information about the goods

If the activity *Plan outgoing transport* could be performed in parallel with or before the activity *Receive goods* the lead time could be halved. This requires that the information about the goods is available one day before the goods arrive.

Consequence and customer impact

A consequence of the long lead time is less competitiveness at the market and the customer has to wait longer for their products.

Tied up capital could be seen as a consequence. However, due to the fact that the customers are paying the products in advance IKEA do not have any tied up capital in the products.

Potential solution and saving potential

In order to lower the lead time to 24 hours the transport must be booked one day earlier. To enable booking of transport before the goods arrive, two things are required:

1. Knowledge about which goods, or consignments, that will arrive the following day.
2. Knowledge about the volume of the goods that will arrive the following day.

These two things are discussed further under following subchapters.

Information about incoming transports accuracy
Information about the incoming goods exists in an IT-system called Delivery Schedule. Delivery Schedule contains information about which consignments that will arrive the following day. The information that exists in Delivery Schedule comes from the IT-system CNS.

It takes between 0 and 6 days to transport the goods from the different suppliers to the CDC terminal. According to respondents, the transport could sometimes arrive one day in advance or one day too late. As example, if supplier produce faster/slower or if transport takes longer/shorter time than planned. This creates an uncertainty in which goods will arrive the next day.

To be able to check the accuracy of arriving goods both deliveries arriving with truck and train has to be measured. Unfortunately it was not possible to gather data about the truck's delivery accuracy to the CDC terminal. To get an indication of trucks accuracy, were the arrival precision of 50 arriving trucks checked. 1 of 50 trucks had an arrival time deviating from the predetermined. This truck arrived one day before predetermined day. This gives an indication of the trucks arrivals accuracy as fairly good.

Deliveries from the suppliers Com40 and Euroline, located in Poland, are sometimes sent with train transport to the CDC terminal. Unfortunately is there today no accurate data available about the train's arrival accuracy to the CDC terminal. At the moment, there is an ongoing project initiated by Transport management department in Älmhult to improve the measurement of train transports accuracy.

Information about the volume of the goods
The given information about the volume of the goods in the IT-system Delivery schedule differs from the volume estimation performed by *Goods in*. The volume calculation method used today is based on estimations performed by *Goods in* and will further on be named as the current method. The given volume from the IT-system is the net volume, i.e. only the volume of the product. When a product is transported it often requires more space. It is therefore not possible to use the information in the IT-system regarding the volume of the worktops.

One solution is to require the information from the supplier. The supplier would then estimate the volume and send the information before or at the same time as they send the goods. According to respondents there is higher potential to receive this information from the worktop supplier Lechner in comparison to the suppliers of sofas. The reason is that IKEA is a very large and important customer for Lechner. Receiving the volume information from Lechner in advance would be the most suitable solution for the worktops. IKEA is a smaller customer to the sofa suppliers and according to respondents is it highly doubtful if they would gather and send this information.

Regarding the sofas, there is another solution than involving the supplier. It is to use the volume from the IT-system Delivery Schedule anyway, but with modifications. The volume differs less for the sofas in comparison to the worktops. A test was performed comparing the volume specifications from the current method with the volume provided by the IT-system. The test was performed in order to see if the information in the IT-system somehow is useable. 407 consignments were compared. The test included all suppliers providing sofas. The volume given from the current method has been divided with the volume provided by IT-system for every consignment which results in a factor:

$$\frac{Estimation\ of\ volume\ performed\ by\ Goods\ in}{Volume\ from\ IT - system} = Factor$$

This is performed because if the factors are similar for all consignments, a correlation can be found between the volumes. An estimation of the incoming goods can then be made by multiplying the volume given in the IT-system Delivery Schedule with a proper factor. The correlation, in terms of a factor between the volumes, was calculated for all 407 consignments. The frequency of resulting factors is shown in Figure 56.

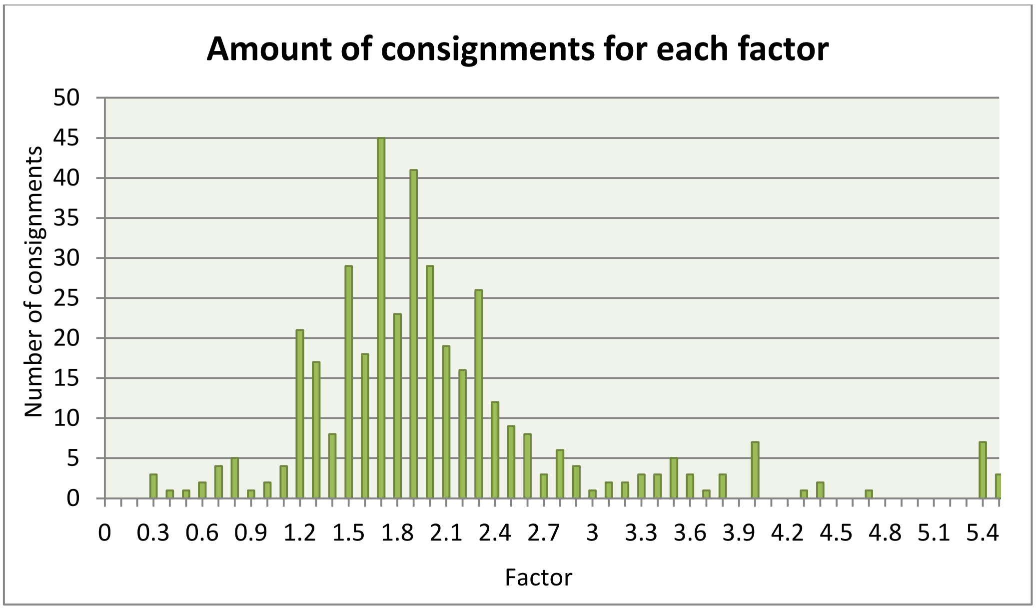


Figure 56. Showing the amount of consignments for each factor. The factor is calculated as the relation between measured volume and volume given from the IT-system.

In Figure 56 the amount of consignments for each factor is shown. At the factor 1.8 a peak could be seen. Each factor between 1.2 and 2.3, with 1.4 as an exception, has more than 15 consignments or more. 292 of 407 consignments have a factor belonging in this range. This is approximately 72 percent of all the consignments.

The same analysis was also performed for each supplier separately. It indicated that factors for the supplier *Euroline* was varying slightly more, otherwise there was no deviation between the suppliers i.e. all diagrams showed similar results as Figure 56.

If a factor would be chosen, more volume than needed would be booked for all consignments with a real factor that is lower than the chosen factor. This will contribute to a lower fill-rate. In opposite, too little volume would be booked for the consignments with real factors that are higher than the chosen factor. This would lead to that goods may not fit into the arriving trucks. These deviations will not even out against each other due to the fact that the consignments will be split up and sent to 37 different hubs.

By summarizing the estimated volumes given by the current method for all 407 consignments and divide it with the sum of all consignments volumes given by the IT-system, an average factor is given. The average factor is 1.84. This means that if a factor of 1.84 is used the same total amount of volume for outgoing transport will be booked as today with the current method. The distribution of the total amount of booked goods between the hubs will though be different in comparison to if transport booking is based on the current method. Calculating the volume of the incoming goods by multiplying the volume given in the IT-system Delivery Schedule with a factor of 1.84 will further on be named as the alternative method.

It is interesting to know if the consignments that have a deviating factor (very high or low) are large or small in terms of volume. For instance, if a consignment has a real factor equal to 4, but transportation volume is booked according to a chosen factor of 2, there will just be half of the needed volume in the truck. If the consignment has a real volume of 1 m^3, a volume of 0.5 m^3 will be missing in the truck. If the consignment on another hand would have a volume of 30 m^3, 15 m^3 would be missing which is a much larger problem. In Figure 57, the aggregated volume for the consignments belong to each factor is shown.

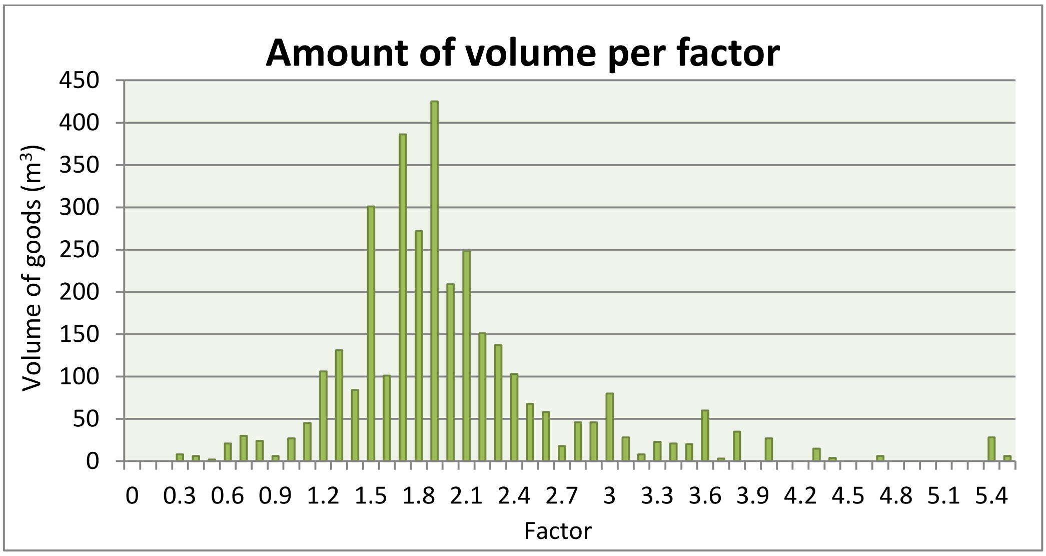


Figure 57. Showing the aggregated volume for the consignments belonging to each factor.

This figure has a similar appearance as Figure 56 above, which indicates that the volumes of the consignments are not significantly different between the different factors. There is low variation of the consignments' volume over the total range.

The volume specifications from the IT-system have so far been compared with the volume estimated by *Goods in*. This estimation is performed differently between the co-workers at *Goods in* and a question mark is raised of how good this estimation corresponds with reality.

A normal pallet requires 0.96 m^2 floor area[8]. The trucks have a height of 2.42 meters. It is calculated that a sofa occupies the full height in the truck. If the sofa do not stick out of a pallet sideways, 2.32 m^3 is required for the pallet in the truck. By following the guidelines the first co-worker used, a pallet like this would be estimated to require 3 m^3, which is 0.68 m^3 too much. The estimation does therefore not always correspond with reality.

The volume of three consignments, all with a high deviation in term of volume (between the current and alternative volume calculation methods) was measured by the authors to check the accuracy of the current method. In order to understand how a co-worker thinks when estimating the volume of the goods, two co-workers from *Goods in* participated. Due to low resources only three consignments were controlled which makes result only useable as an indication. In Table 15, the result is provided.

[8] Wooden EUR-pallet have the dimensions 1200x800x144mm

Table 15. Showing a comparison between volume estimated by Goods in used in current method the and real volume. All volumes provided in the table are measured in cubic meter.

Consign. number	Volume from IT-system multiplied with factor (1.84)	Volume estimated by *Goods in*	Difference in volume (Goods in - IT-system)	Real volume measured by authors	Difference in volume (Real volume - IT-system)
144099	19.5	31	**11.5**	23	**3.5**
144107	7.0	13	**6.0**	9	**2.0**
144285	5.2	10	**4.8**	8	**2.8**

As seen in the table there is a large difference between the volume given from the current method, where *Goods in* estimate the volume, and the real volume measured by the authors. The consignments which in Figure 56 seems to deviate a lot from the average factor, do not deviate that much at all in reality. If this is the case for the other consignments that deviates in Figure 56, the alternative method is much more reliable than the diagram shows. Unfortunately, the result can only be used as an indication. More data must be gathered in order to verify this.

From interviews it is declared that it never happens that the goods do not fit into the trucks. This indicated that the goods volume is estimated with a wide margin with the today current method. Consequently, if the transport booking would book too little volume with the alternative method, is there a high potential that the consignment will fit into the truck anyway. Interviews made are supporting this argument. Through discussion with Associate warehouse manager, consignments which are deviating less than 5 m^3 should be seen as non problematic. According to him should it be possible to fit in up to 5 m^3 extra in the trucks even if the truck is booked as full.

Consignments that would lead to that 5 m^3 or more would be missing in the booked transport with the alternative method are therefore investigated. Of 407 consignments, 12 of them were deviating more than 5 m^3. This corresponds to 3 percent of the consignments. The articles in these consignments were controlled in order to see if a specific product group was frequently appearing. The supplier of the products was also listed for the same reason. These 12 investigated consignments can be seen in Table 16.

Table 16. Showing consignments with a higher deviation than 5 cubic meters which contributes to that too little volume will be booked with the alternative method. All volumes provided in the table are measured in cubic meter.

Consignm. number	**Volume estimated by *Goods in***	**Volume from IT-system multiplied with factor (1.84)**	**Difference in volume**	**Product group**	**Supplier**
ECIS59223	80	48.4	**31.6**	TIDAFORS	Euroline
ECIS56718	50	25.5	**24.5**	TIDAFORS	Euroline
ECIS56632	28	13.4	**14.6**	TIDAFORS	Euroline
144099	31	19.5	**11.5**	ÄLVROS	ITALsofa
ECIS56633	15	6.3	**8.7**	TIDAFORS	Euroline
ECIS57421	21	12.4	**8.6**	TIDAFORS	Euroline
ECIS58926	9	1.6	**7.4**	TIDAFORS	Euroline
ECIS57877	24	17.5	**6.5**	TIDAFORS	Euroline
Com113966	20	13.9	**6.1**	KIVIK	Com40
144107	13	7.0	**6.0**	ÄLVROS	ITALsofa
ECIS57875	13	7.2	**5.8**	TIDAFORS	Euroline
ECIS58928	37	31.3	**5.7**	TIDAFORS	Euroline

As seen in the table, 9 of the 12 consignments came from the supplier *Euroline* and consisted of the sofa model *TIDAFORS*.

The probability of booking too little volume has now been investigated but there is also a probability of booking too many trucks if the alternative method is used. If the real factor of a consignment is lower than the factor used when booking transport, too much volume will be booked. Consignments that would lead to that at least 5 m^3 too much is booked are therefore investigated. 23 of the 407 consignments were deviating with more than 5 m^3. This corresponds to almost 6 percent of the consignments. The result is shown in Table 17.

Table 17. Showing consignments with a higher deviation than 5 cubic meters which contributes to that too much volume will be booked with the alternative method. All volumes provided in the table are measured in cubic meter.

Consignm. number	**Volume estimated by *Goods in***	**Volume from IT-system multiplied with factor (1.84)**	**Difference in volume**	**Product group**	**Supplier**
Com113023	4	9.0	**-5.0**	KIVIK	Com40
ECIS59225	6	11.4	**-5.4**	TIDAFORS	Euroline
ECIS59141	12	18.1	**-6.1**	TIDAFORS	Euroline
ECIS59007	6	12.4	**-6.4**	TIDAFORS	Euroline
ECIS59142	6	12.9	**-6.9**	TIDAFORS	Euroline
ECIS59224	6	12.9	**-6.9**	TIDAFORS	Euroline
Com116581	24	31.2	**-7.2**	KARLFORS / KIVIK	Com40
ECIS58933	6	14.6	**-8.6**	TIDAFORS	Euroline
ECIS56649	2	12.1	**-10.1**	TIDAFORS	Euroline
ECIS58930	33	43.4	**-10.4**	TIDAFORS	Euroline
ECIS57878	22	32.6	**-10.6**	TIDAFORS / KIVIK	Euroline
ECIS59015	3	14.0	**-11.0**	TIDAFORS	Euroline
ECIS57419	27	38.1	**-11.1**	TIDAFORS	Euroline
142891	60	71.2	**-11.2**	ARILD	ITALsofa
ECIS59008	3	14.5	**-11.5**	TIDAFORS	Euroline
ECIS59219	9	22.4	**-13.4**	TIDAFORS	Euroline
ECIS58924	21	37.0	**-16.0**	TIDAFORS	Euroline
ECIS59011	30	46.8	**-16.8**	TIDAFORS	Euroline
ECIS56720	9	27.0	**-18.0**	TIDAFORS	Euroline
ECIS59016	6	24.3	**-18.3**	TIDAFORS / KIVIK	Euroline
ECIS59324	12	30.4	**-18.4**	TIDAFORS	Euroline
ECIS59140	12	32.5	**-20.5**	TIDAFORS	Euroline
ECIS56634	56	79.0	**-23.0**	TIDAFORS / KIVIK	Euroline

This result is similar to the result in Table 16. 20 of these 23 consignments are delivered from *Euroline*. Also here, all 20 consignments consist of articles in the sofa model series *TIDAFORS*. It is highly recommended to investigate the possibility of changing the volume specifications in the IT-system Delivery Schedule regarding this product group. It is also recommended to investigate how the volumes of the *TIDAFORS* sofas are estimated in the current method. The complex structure of

IKEA's IT-systems is set as delimitation for this study and this will therefore not be further analyzed.

Booking transport using the alternative method (using volume from the IT-system multiplied with a correlation factor) could lead to that too little or too much volume is booked. This could lead to that too few or too many trucks are booked, but it is not certain. For example, let say that the sum of the volume of all CCD and DDC goods are 120 m^3. Then two trucks, which have the capacity of 80 m^3 each, have to be booked. The first will be fully loaded and the second will be half loaded i.e. there are 40 m^3 left in the second truck. If this is the case, it does not matter if the DDC goods in reality require 20 m^3 more or less than what was booked; the same amount of trucks would have been booked anyway.

A simulation was done to investigate if the amount of booked trucks would differ if the alternative method was used instead of the current. It was conducted as follows: the alternative method was used in order to gather the volume for every consignment that arrived during an entire day. To clarify; a factor of 1.84 was used. The consignments were sorted by destination, i.e. hubs. The amount of volume that would be booked for each hub, if the booking was based on the alternative method, was now given. This data was then compared with the volume that was booked with the current method. An analysis was made, investigating if the amount of trucks booked to each hub would be changed if the booking instead was based on alternative method.

This simulation was performed over a period of three days. During these days, 193 trucks were in total dispatched from the CDC terminal. In Table 18 is the result shown. This low amount of data makes that the result only can be seen as an indication.

Table 18. Showing occasions when the amount of booked trucks would differ between using the alternative method and the current method.

Hub	Dispatch date	Remaining volume in trucks (based on estimation by goods in)	Remaining volume in trucks (if volume from IT-system is used[9])	Difference in number of trucks
658	16-jan	0	-13.08044	**+ 1**
933	16-jan	6	-5.6708	**+ 1**
654	14-jan	1	-1.272	**0**
655	16-jan	19	-0.36348	**0**
5	16-jan	0	-0.0576	**0**

As seen in the table, two additional trucks had been booked if the alternative method had been used instead of the current method. When booking according to the current

[9] multiplied with factor 1.84

method, all goods fit into the trucks. Therefore would the two extra booked trucks not be needed i.e. they had been leaving the CDC terminal empty. There are additional three trucks that according to the alternative method would be overloaded. Due to the low amount of volume that is missing it had been assumed that the goods would fit anyway and no extra trucks had been ordered. So, in total, 195 trucks had been ordered instead of 193 if the alternative method had been used. It should also be noted that during these three days, using the alternative method would never lead to booking fewer trucks compared to if the current method had been used. This means that all consignments had fit into the trucks and no customer impact had arisen. An investigation was performed exploring why the volume differed that much regarding the two consignments that lead to additional booking of trucks. It turn out that these consignments also consisted of sofas from the product group *TIDAFORS*.

To summarize the trustworthiness of the alternative method; there were 35 of the total 407 consignments that deviated more than 5 m^3. This comparison has been made against the current method i.e. the volume estimation performed by *Goods in.* The procedure of performing the estimation was investigated and a question mark is raised about the accuracy of this estimation. An investigation indicates that the diagrams visualizing the accuracy of the alternative method shows a higher deviation than it should. The current method of estimating the goods volume differs from the real volume of the goods. A simulation over three days where the booking had been based on the alternative method was made. This resulted in that all consignments would fit into the trucks if the transport booking was based on the alternative method. However, two additional trucks would be booked in comparison to if the current method of booking transport would be used. The additional trucks would not be needed. It was declared that the product group *TIDAFORS* from Euroline is contributing to the most of the deviations. 29 of the 35 consignments that were deviating with more than 5 m^3 included *TIDAFORS* sofas.

Risks with this solution

The risk with the alternative method is to book too many or too few trucks. If too many trucks are booked, the consequence will be that IKEA has to pay for an extra shipment. This extra cost could be reduced if an agreement is done with the 3PL about paying a lower cost if a booked truck is not used.

If too few trucks are booked the consequences are worse. This could have an impact on the customer. If the consignment does not fit into the truck it has to be sent with the next truck. If more than one truck is booked to the same hub the consignment may fit in the next truck. If this is done, it has to be reported to the department *Administration* because otherwise will the consignment notes and custom documents, if there are any, be sent with the wrong truck. The risk to fail with sending the consignment notes and custom documents with the right truck increases.

If the consignment does not fit into any truck dispatching to the specific hub at the same day, two options exist. An express truck could be booked which will deliver the goods in the right time to the hub. This will lead to additional cost but no customer impact would occur. The other option is to store the goods at the terminal and send it with the next day's shipment. This could affect the customer in form of a late delivery.

To-Be map

To illustrate the potential solution analyzed above a To-Be map is made of the sub process *Consolidate shipment,* which is shown in Figure 58.

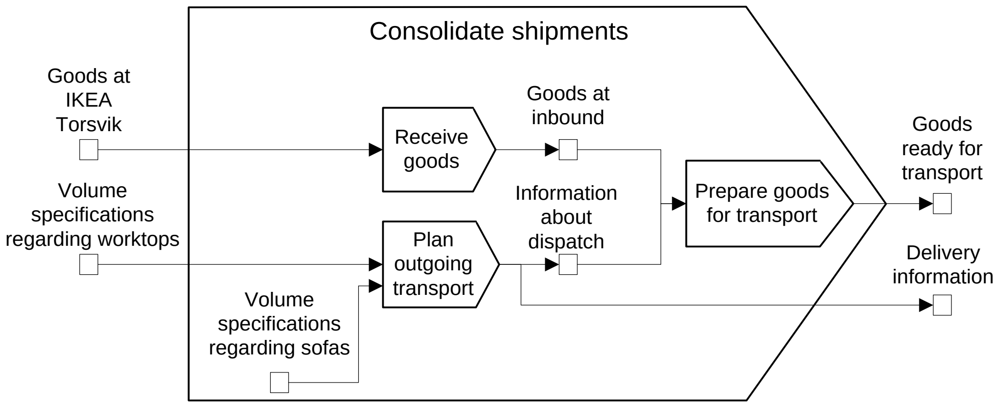


Figure 58. Future state for the sub process Consolidate shipment.

Regarding the worktops the information about the goods volume would be received from the supplier. The supplier would estimate the volume and send this information to the CDC terminal the day before arrival. The volume for the sofas would be calculated based on the alternative method, i.e. volume gathered from the IT-system which is multiplied with a factor equal to 1.84. Those changes enable that the activities *Receive goods* and *Plan outgoing transport* can be performed in parallel. The *Delivery information* would trigger the sub process *Communicate information. The Delivery information* would be sent from *Planning* instead of *Administration*. This recommendation is considered to be short-term on a tactical level.

6.3.3. No one responsible for the entire process

Source of problem

As identified in *6.1.2 Analysis of handovers,* several departments at IKEA are involved in the DDC process. The responsibility of the sub process *Consolidate shipments* and the DDC process in its entirely is divided between the departments and actors. There is no overall responsibility assigned for the entire process that extends over the functions and units within the supply chain.

Consequence and customer impact

There is no one responsible for improving the process in its entirety. It was revealed in interviews that this leads to disagreement of who should take care of problems that arise in the process. Should the department that experiences the problem take care of it? Some argues so, other argues that “We experience the problem, but it is caused somewhere else in the process, so they should take care of it”. This uncertainty can lead to that problems stay unsolved.

Another consequence may be the risk of sub optimizing the process. An improvement in one part of the process could lead to that it works worse in another part of the process. It is therefore important that someone have a holistic understanding of the entire process and understands how to improve the whole process in its entirety.

Another potential consequence is the risk of performing double handling and unnecessary work. This can be an effect of not having anyone with the comprehensive view of the process. By having departments performing work that is not needed or having different departments performing the same activities causes low efficiency.

The lack of a holistic view of the process and a responsible process owner risk to lead to that the process is performed without considering the customer. It is important that the process is performed to create highest possible value for the customer.

Potential solution

Processes can be improved by centralizing process responsibility (Mansar and Reijers 2007), since this could lead to integration of the process and potentially minimizes parties involved. As discussed in the literature review, one way to assign central process responsibility is to introduce a process owner. Introducing a process owner requires a re-organization and is therefore seen as long-term solution at strategic level.

If central responsibility existed, the DDC process could be controlled and managed differently and lot of mistakes and errors could be possible to avoid. A process owner could enable that the process is comprehensively improved to avoid sub optimizing. Problems could easier be handled because disagreement regarding whose fault it is and who should be responsible to deal with the problem should not exist.

A holistic view of the process and a responsible process owner can ensure that customer not gets forgotten in the process and so that the customers can be served in best possible way.

6.3.4. Low efficiency in administrative work

Source of problem

The low efficiency in administrative work is associated with a lot of manual performed work that is time consuming. The reasons that so much work is done manually has two explanations. The most significant is the low support from IT-systems. With low IT-support is there no other way than to manually handle the information flow in paper form, which is very time consuming and leads to low efficiency.

The other explanation may be undeveloped processes in need of streamlining. If double handling and unnecessary work occur, also seen as waste, it causes time consuming work.

Consequence and customer impact

The time consuming work leads to a lot of labor hours which is associated with cost. A low price is of interest for the customer, which is only possible if the processes are conducted with as low cost as possible. Low efficiency also leads to slow processes and the customer has to wait for the products. However, these aspects are seen as negligible from a customer impact perspective due to the low impact.

Potential solution and saving potential

If the DDC process was supported by an IT-system and managed comparable as ordinary CCD process is managed, less labor hours would be needed. Estimation, based on interview with operational support manager and team leader of *Administration*, is that in total one co-worker less would be needed. Co-workers work 37.5 hours/week which is 1,950 hours/year. Calculated on an hourly rate of 230[10] SEK/hour, cost saving would be 448,500 SEK annually[11]. Implementing IT-support for the DDC process is seen as a long-term solution at strategic level.

Another partial solution that appears possible is to improve the activities handling of the information flow in the process. During the mapping, potential double work and unnecessary work were exposed. Also an uncertainty exists if all information is needed that today is gathered and handled. By conducting a workshop with people from each involved department, it could be declared which information that is of importance and which is not. The process maps are recommended to be used as a basis for the workshop. Hopefully, the workshop can lead to agreement of where unnecessary steps and double handling occurs so it will be possible to improve the process. The expected result is higher efficiency in terms of less manual work. Conducting a workshop is seen as a short-term solution which can be done at an operational level.

[10] 230 SEK/hour is used for co-workers employed in the department *Administration*
[11] Calculation: 1,950 hours/year * 230 SEK/ hour = 448,500 SEK/year

6.3.5. Missing goods

Source of problem

The registration of incoming and outgoing goods is performed manually and not dependent of the activities inside the terminal. If an activity in the terminal is performed incorrectly problems arise. For instance if a pallet would be loaded on the wrong truck no one would notice.

Due to low support from an IT-system, no scanning of the goods, no statistic or history data exists. If the goods would be scanned, registration of received and dispatched goods would be done automatically. This registration would also be dependent of the activities in the terminal. If goods are lost it could easily be checked if it been loaded on wrong truck or if the goods still are inside the terminal. Lack of an IT-system with a scanning function so the goods could be traced and tracked is therefore seen as the main source to the problem.

Another source of the problem is the low level of control. A manual control of every shipment could ensure that the pallets have been loaded in the right truck. By referring to value analysis in literature review, inspection and control is though seen as waste.

Consequence and customer impact

If the goods are classified as missing, a new order to the supplier has to be made. This creates cost for handling a new order, transport and producing the new product. This type of order will have about two weeks shorter lead time but still, the customer has to wait a long time for the delivery. If the product later is found, it can in best case be sold in “bargain corner” (in Swedish: fyndhörnan) in a store, for a fraction of the real value.

It is assumed that the customer will be disappointed if the delivery fails in this way. IKEA estimates that a disappointed customer cost 15,000 SEK. Considering the worktops, 133 deliveries failed due to that the goods was lost in the supply chain during FY12. This creates 133 disappointed customers which in turn can be calculated as a cost of 1,995,000 SEK[12]. The cost for handling and transporting the new orders corresponds to a cost of 399,000 SEK[13]. In addition to this, there is a cost for the new products. If the products are found, but too late, they can be sold only for a small fraction of the real value.

No information exists of how many of these failures were caused by the CDC terminal. If data existed, the analysis tool *quality filter mapping* could be used in order to identify which part of the supply chain causing these delivery failures. Then

[12] Calculation: 15,000 SEK/disappointed customer * 133 failed deliveries = 1,995,000 SEK
[13] Calculation: 3,000 SEK * 133 new orders = 399,000 SEK

it could be identified how large the problem really is at the CDC terminal. Unfortunately, this data does not exist.

Potential solution

Adding an inspection of all loaded DDC goods would be a solution for the missing goods at the CDC terminal. This could be done by control every pallet to ensure that it is loaded in correct truck.This control will not require much additional work. Each pallet is labelled with the hub number. The co-worker that loads the goods into the truck would check the label including the hub number of each pallet to ensure it that the pallet is loaded on the right truck.

In year 2012 were 37,617 pallets with DDC goods shipped from the CDC terminal. Estimated that the additional control would take 15 seconds to perform per pallet, and calculated on an hourly rate of 277[14] SEK/hour, this control would theoretical cost about 43,000 SEK annually. The cost of introducing a control would correspond to the cost of losing about two worktops a year. According to interview with team leader, the control would in practice not drive any extra cost since the co-workers will be able perform the control in the same time range as today. It is doubtful that is actually would require extra time since it would mostly be possible for the forklift driver to control the pallet's label during the movement of the pallet.

It is recommended to keep statistics of when a pallet stands at the wrong gate area. After 6 month period is it recommended to evaluate the number of times a pallet was reported at wrong place and decide if the control should be kept or not. If there are such occasions, it is confirmed that the terminal contributed to the goods that gets missing in the supply chain.

Another solution is to implement an IT-system with scanning function so the goods can be trace and tracked. Each loaded pallet could be scanned. The IT-system could then notify the co-worker if the pallet is placed in the wrong truck. With track and trace possibilities, the risk of losing track of goods would be lowered and in the same time would statistics and history be gathered. The history of received and dispatched goods could be used as evidence when claiming the supplier or the 3PL company for losing the goods.

6.3.6. Large amount of handovers

Source of problem

A large number of handovers exists. The process is managed with low support from IT-systems. This creates manual work which in turn creates additional handovers. Low support from IT-system is therefore seen as the source of this problem.

[14] 277 SEK/hour is used for co-workers employed in the department *Goods in* and *Goods out.*

Consequence and customer impact

A large number of handovers increases the risk of error. When responsibility is transferred from one department/actor to another misunderstanding can arise. This consequence is for instance shown in the problem *Custom related problems*.

Potential solution

Support from an IT-system would be a potential solution. Two handovers can be eliminated in the activity *Receive goods*, which would reduce the total number of handovers in the CDC terminal from 10 to 8. An improvement would also be that information would be handed over through an IT-system instead of through papers. A To-Be map is created for the activity *Receive goods* in order to visualize which handovers that could be eliminated. The maps are shown in Figure 59. The To-Be map is designed under the assumption that the process is supported by an IT-system that keeps the information available for all departments.

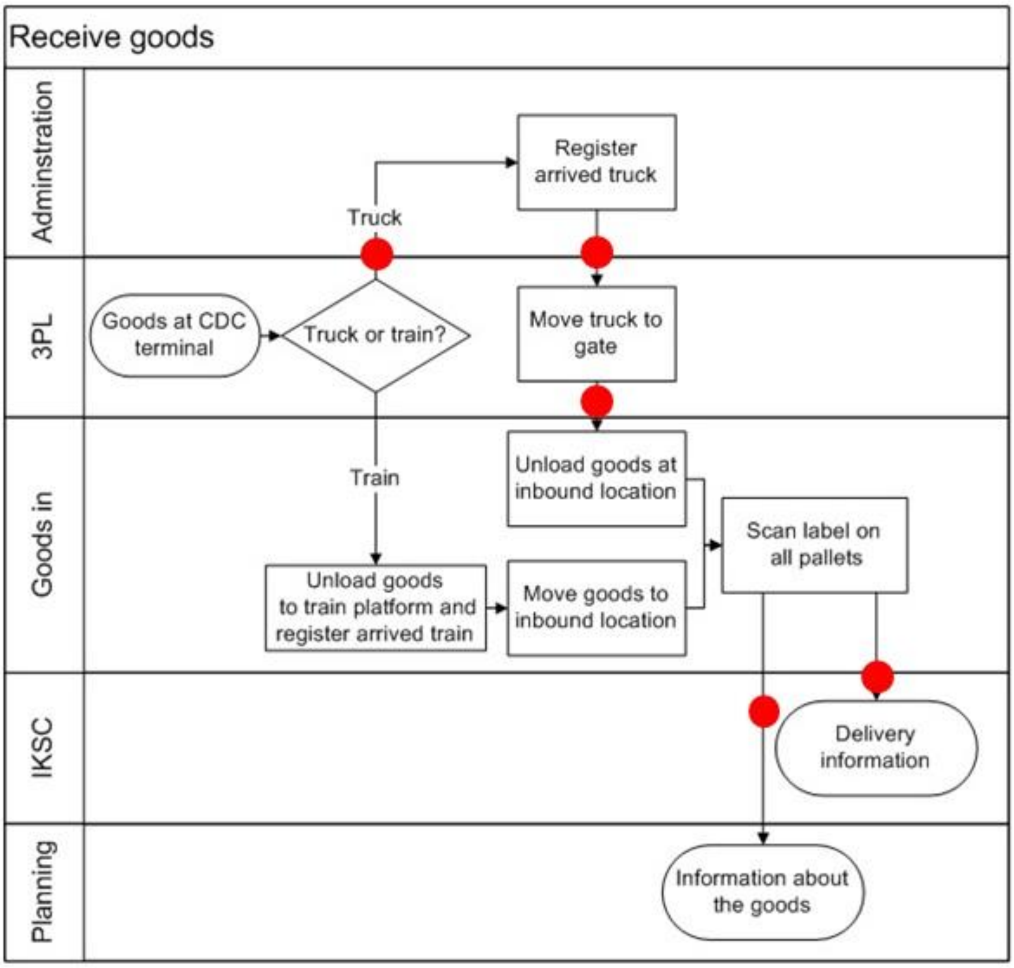


Figure 59. A To-Be map over the activity Receive goods where the red dots illustrating a handover.

Manual registration of goods in the *Administration* will not be needed. Scanning the labels on the goods leads to that the goods will be registered arrived automatically. Five handovers instead of 7 is needed in this activity if the sub process is supported by an IT-system with a scanning function. The *delivery information* and the *information about the goods* that earlier was sent via excel documents that was compiled by the *Administration* will now be sent directly through the IT-system instead.

6.3.7. Custom related problems

Source of problem

Troubles occur when custom documents are not handed over to the Custom Service at the Norwegian border. If all processes are performed right, correct custom documents would be handed over every time. Human errors, occurring through manual work and many handovers increases the risk of losing documents. This could be avoided if support existed from an IT-system. The source of this problem is therefore seen as lack of IT-support.

Consequence and customer impact

If any document would be lost or missing, the customer declaration would not be finalized in the IT-system at Custom Service in Norway. This can lead to that the supplier is accused for smuggling. In worst case the supplier may lose their right to export goods to non EU member countries. As long as this do not happened the customer is not impacted.

Potential solution and saving potential

Short-term partial solution is to increase the follow-up of that the customer declarations are completed and gets approved. In October FY13, the CDC terminal changed their work routines regarding how to handle customer declarations with the attempt to reduce human errors and increase the control. The first indication of the new work routines is that occurrence of human errors and lost custom documents are reduced. However, this is not a complete solution.

A long-term solution is to have an IT-system that can handle the DDC process the same way CCD process is handled regarding custom information. The CCD process that is supported from an IT-system does not have this problem. In difference to the DDC goods, do IKEA own the CCD goods at the CDC terminal and thereby act as the sender. The amount of manual work is less because they do not need to receive, handle and submit the custom documents from the supplier. They are instead creating new custom documents that are submitted with the driver of the truck to the Norwegian boarder. Fewer handovers reduce the risk of human error. These benefits will the DDC flow not gain due to that IKEA still would not own the DDC goods. But, if Custom Service is missing a document, IKEA can prove which goods that have been sent in which shipment by refereeing to IKEA’s own IT-system. This is enough evidence for the Custom Service in Norway that then confirms and closes the declaration for shipment in their IT-system.

7. Result and recommendations

This chapter begins with a summary of the analyzed problems. Thereafter short- and long-term recommendations are given.

7.1. Summary of analyzed problems

The problems have been analyzed in form of source and consequence. A short summary of the result can be seen in Table 19.

Table 19. Summarizing of the problems their sources and consequences.

Problems	Source	Consequence
Lack of gate area	Long lead time in terminal, unstable material flow	Full warehouse leads to lower efficiency, risk of failure increases
Long lead time	Low support from IT-system, undeveloped processes	Lack of gate area, less competitive
No one responsible for the entire process	Lack of process responsibility	Problems remains unsolved, risk of sub optimization
Low efficiency in administrative work	Low support from IT-system, undeveloped processes	High administrative cost
Missing goods	Low support from IT-system	Delivery failures
Large amount of handovers	Low support from IT-system	Increased risk of errors
Custom related problems	Low support from IT-system	Customer declaration fails which is seen as smuggling

Five of these seven problems depend upon low IT-support, one way or another. This confirms the original hypothesis that a lot of the problems depend on missing IT-support for the DDC process. In this case study it became clear that a growing material flow creates a more complex information flow. This information flow often requires to be managed with IT-support, which was missing in this case.

During the analysis potential solutions have been analyzed. From this analysis short- and long-term recommendations have been formed which are specified in the following chapter.

7.2. Short-term recommendations

7.2.1. Reduce lead time

The benefits of reducing the lead time from 48 to 24 hours are large. Regarding the worktops it is recommended that IKEA should require information from the supplier about which consignments they are sending and about the volume of the pallets. This will enable to reduce the lead time for the worktops because outgoing transport planning can be done before the goods arrive to the CDC terminal.

The authors find a potential in using the alternative method to gather the volume of the sofa goods, i.e. the volume information provided by the IT-system Delivery Schedule. The volume from the IT-system need to be multiplied with a chosen factor to get the volumes that needs to be booked. If the same amount of volume should be booked as with the current volume calculation method, a factor of 1.84 should be used. Before recommending this alternative method of calculating the sofa volume, the arrival precision of the trains must be controlled. There are today no data considered as accurate of the trains' arrival precision. The ongoing project initiated by Transport management department in Älmhult, may lead to progress so accurate data can be gathered. Meanwhile it is recommended to investigate if the transport provider can provide useable data. If the accuracy of the trains' arrival precision could be considered as good, it is recommended to perform a real test over a week where the lead time is reduced to 24 hours also regarding the sofas.

Due to the uncertainty in the data's trustworthiness it is recommended, during the test, to book extra trucks if there is a risk of not fit all consignments into the trucks. During the test, it is recommended to order an extra truck for shipments including sofas if there is less free space than 10 m^3 in the truck. This may add extra cost but it will eliminate the risk of customer impact.

It is also recommended to investigate the volume specifications for the product group *TIDAFORS* in the IT-systems. If the volume specifications can be changed it is recommended to do so for this product group in order to match reality better. This will increase the accuracy for the alternative method.

7.2.2. Share process maps

A recommendation is to hang a picture at the wall of the created process map at the CDC terminal in Torsvik and at CDOS office in Helsingborg. An available process map would increase the understanding of the process for the performers in the DDC process. By referring to the interviews, the respondents were asked how valuable process map would be for them and the answer was 8.5 in a scale from 1 to 10, where 10 are most valuable. A map describing the entire DDC process will be provided by the authors.

7.2.3. Workshop with intention to increase efficiency in administrative work

The low efficiency in administrative work depends upon that the work is performed manual in a large scale. After mapping the process, an uncertainty exists if all information is needed that today is gathered and handled. It appears possible to improve the process by improve the handling of the information flow.

By conducting a workshop with people from each involved department, it could be declared which information that is of importance and which is not. The process maps are recommended to be used as a basis for the workshop.

At the mapping some issues were exposed that is recommended to be discussed:

- Explore the need of copy consignment notes and archive them, this may be an unnecessary action.
- Explore the need of sending documents to the hubs, and which information that is necessary.

Then, it is recommended to discuss the process by looking at the process map and follow it step by step. Questions recommended to be discussed for each task is:

- Which information is gathered?
- Which information is sent, and to whom?
- Which information is received, and from whom?
- Which information is required to perform the task?
- Which information is missing?

Employees from following departments are suggested to be represented in the workshop:

- Administration
- Planning
- Goods in
- Hub representatives from both low- and high-volume hub
- IKSC

Hopefully, the workshop can lead to agreement of where unnecessary steps and double handling occurs so it will be possible to improve the process. The expected result is higher efficiency in terms of less manual work.

7.2.4. Inspection of loaded goods

It is recommended to add an inspection of all loaded DDC goods. This is a solution for the problem with missing goods at the CDC terminal. Every pallet should be controlled to ensure that the pallet is loaded in correct truck. Even if this is an action that adds waste to the process will it ensure that goods do not get lost and explore if the problem with lost goods has a source at the CDC terminal.

This control would cost about 43,000 SEK annually. Exclusive the cost of the products, the cost of losing 2 worktops almost correspond to the cost of having a control.

It is recommended to keep statistics of when a pallet stands at the wrong gate area. After 6 month period is it recommended to evaluate the number of times a pallet was reported at wrong place and decide if the control should be kept or not. If the process would get support from an IT-system including a scanning function, this inspection should be removed.

7.2.5. Modify the limit of orders in the IT-system

A limit exists in the IT-system regarding the number of CCD and DDC orders that can be delivered each day. Modifying this limit of orders could lead to a small improvement regarding the problem with lack of gate areas. A suggestion is to modify this limit to both delimit the number of order lines and orders. This would create a more stable and predictable material flow in the CDC terminal.

7.3. Long-term recommendations

7.3.1. Investigate possibility to implement IT-support

It is recommended to investigate the possibility of having an IT-system that supports the DDC process. Implementing IT-support is seen as a long-term solution on strategic level both due to the long time aspect, over 1 year, and the size of the investment.

IT-support can be created in two ways; either by designing and implementing a new system or modify existing IT-systems to support the DDC process. However, the new IT solution needs to exchange information and communicate with other IT-systems that today are used in the terminal.

When the optimal solution for creating an IT-support is found, the cost of developing and implementing this solution has to be investigated. It is also recommended to investigate other CDC terminal's IT landscape to see if the system can be implemented in those terminals as well. If so, the development cost could be shared.

As discussed in the analysis for respective identified problem, IT-support for the DDC process is seen as a solution for many of these problems. Desired features from an IT-system are a scanning function, so it is possible to trace and track the goods. It would solve the problem with missing goods. It should be possible to integrate with other IT-systems used by IKEA, so all information can travel digital and without need of manual handling papers. Less need of manual handling would in turn, increase the efficiency in administrative work. When information exist and travels via an IT-system instead of via paper document, is less handovers required which is a large source for errors. The problems that exist with custom when exporting to Norway would also be eliminated, though it would be possible to handle custom declaration in same way as the CCD process working today. IT-support for the DDC would also enable storage of data. Historical data would permit introduction of KPI and performance measurement.

7.3.2. Centralize process responsibility

By centralizing process responsibility, process improvement would be facilitated. No doubt would occur of whose responsibility it is to improve the process and take care of arisen problems. It would ensure that someone keeps track of the entire process performance and tries to minimize occurrence of sub optimizing and double handling.

Introducing central responsibility can be done by appointing a process owner. This is an action that requires re-organization of the organization and is therefore seen as a long-term solution at strategic level.

8. Conclusions

In this chapter is it confirmed that all objective has been answered by giving a short explanations for each objective. An evaluation is also made of the used research procedure.

8.1. Meeting the objectives

1. Explain why a product is classified as DDC and why transshipment is made at the CDC terminal in Torsvik

Several reasons exist to why a product is classified as DDC. The most obvious reason is if the product is unique and produced after customer's requirements, as worktops. Another reason is that it is cheaper to manage a low-flow product with large volume, as a sofa. The product would take a large portion of space in the DC, CDC and stores and are therefore better to treat as a DDC product. This is further explained in chapter *5.1.3 Why is a product classified as a DDC product?*

The DDC goods are transshipped through the CDC terminal in order to consolidate shipments with the aim of lower the transportation cost and higher the fill-rate. The volumes sent from the suppliers to each hub are seen as too low for direct deliveries. IKEA also sees the benefit of getting larger control of the flow. This is further explained in the chapters *5.2.2 Why transshipment of DDC products is made at the CDC terminal* and *9.2 Direct deliveries.*

2. Create understanding of the DDC process by mapping from customer order to the point when the products are delivered at customer's home.

The DDC process been mapped from the point when a customer places an order to the point when the order is delivered at customer's home. The DDC process has been divided into seven sub processes.

The sub process *Consolidate shipment*, which is managed by the CDC terminal, has been mapped in more detail in comparison to the others. These maps were used as basis for the analysis. All maps can be found in chapter *5.4 As-Is process map*

3. Identify and describe problems that occur in the part of the DDC process managed by the CDC terminal in Torsvik

Nine different problems (seen in Table 20) were identified through interviews, observations and analysis.

Table 20. Identified problems in the DDC process.

Problems
Low efficiency in administrative work
Transport damages
Missing goods
Lack of gate areas
Limited way to follow up performance
Custom related problems
Long lead time
Large amount of handovers
No one responsible for the entire process

The identified problems are described in the chapters *5.5 Problem identification* and *6.1 Identification of additional problems.* Seven of these problems were further analyzed in chapter *6.3 Analysis of problems.*

4. ***Suggest short-term and long-term improvements in the DDC process for the CDC terminal in Torsvik.***

5 short-term and 2 long-term recommendations were made to IKEA. They are summarized in Table 21 and further explained in chapter 7 *Result and recommendations,*

Table 21. Listing both short- and long-term recommendations

Time aspect	Recommendation
Short-term	Reduce lead time
	Share process maps
	Workshop with intention to increase efficiency in administrative work
	Inspection of loaded goods
	Modify the limit of orders in the IT-system
Long-term	Investigate possibility to implement IT-support
	Centralize process responsibility

8.2. Evaluation of research procedure

In this section the study will be discussed from an academic perspective including a discussion of the used research procedure.

The main part of the study is about mapping. The described mapping tools were categorized into three categories; strategic, tactical and operational. The categorization was useful when choosing mapping tool. It would be interesting to further develop this categorization which is discussed in chapter 9 *Future work*.

Regarding the analysis tools the categorization was not that useful. It may depend on that the mapping was conducted on a tactical/operational level their most of the analysis tools was considered as usable. However, many of the tools were not applicable to the operations of this study's. Some tools are created in order to be used in manufacturing companies and not at a transit terminal without inventory. A share of the analysis tools was intended for analyzing inventory, and was therefore not applicable to this study.

In the research procedure it was stated that the mapping should start with an interview with the site manager, which would follow Jacka and Keller's (2002) mapping approach. This was not possible in the reality and the site manager was instead interviewed later during the mapping. It is easier to understand and map details after a wide perspective is gained. The author therefore recommends other researchers to interview the management first.

The literature review discussed the limited availability of data as a difficulty in mapping (Hines *et al.* 1997). This was a problem in this case study. One reason is that there is no process owner. The participants in the process were interviewed in order to gather data about the process. In some cases, only one person had knowledge of a specific part of the process, which made it difficult to verify this information. The risk of basing the mapping of subjective information increases if only one person is interviewed.

Referring to the research procedure it was chosen to use process mapping and swimlane flowcharts as mapping tools. Benefits were seen with using different tools at different levels because the tools have different strengths. The predicted benefits were confirmed in reality while performing the mapping. Swimlane flowchart was a good tool at the lowest level since it clearly shows who is performing the task. Unfortunately, drawbacks were identified with using more than one mapping tool. When compiling all maps of the sub process into one process map problems arise, due to the difficulty in connecting maps which has been mapped with different tools. Another drawback is that if the maps should be used as education material both mapping tools have to be explained.

A problem was encountered regarding how specific the names of the processes should be. A person that holds knowledge in process thinking and how the business is working would understand a general name. Ljungberg and Larsson (2012) prefer general names as "Consolidating goods". This is good when you want to check if the processes are designed in correct ways. But on another hand, using general process names can lead to that the process maps may not be usable and understood by the many people. General names therefore may not be good when the process map is used as an educating tool to create understanding of the process. If the purpose with the maps both is to create understanding and to be used as a basis for process improvement, the choice of process names can be a challenge.

This study provides a case study which uses existing mapping tools and analysis tools. This will in, a perspective of academic research, contribute by reflecting the suitability and applicability of these tools.

9. Future work

This chapter discusses topics that the authors recommend to be further investigated in the future.

9.1. Performance measurement

It is suggested for IKEA to investigate the area of performance measurement regarding the DDC process. Today, there is no measurement of how efficient the CDC terminal handles the DDC process. In turn, knowledge is missing of how well the work is performed and it is hard to address improvements. Investigating performance measurement may be a suitable project to be performed as a student master thesis.

9.2. Direct deliveries

As discussed in the analysis there is a potential to have direct deliveries to high-volume hubs. It is suggested to investigate this further. A deeper analysis is needed to fully understand the scale of the advantages. Solutions must be developed for potential problems, as the lack of control and suppliers' misbehavior. Investigating the potential of direct deliveries may be a suitable project to perform with this report as basis.

It is also suggested that this investigation includes the possibility of direct deliveries with one shipment to several nearby located hubs. By aggregating the goods sent to several nearby located hubs in one shipment, appropriate fill-rates could be reached.

9.3. Categorizing mapping tools

This study aimed as methodology to investigate mapping tools and categorize them as strategic, tactical and operational tools. It would be interesting, as future academic work, to explore additional mapping tools and divide them into the categories and through case studies explore if it is a reasonable categorization. A comprehensive categorization of existing mapping tools would facilitate the choice of tool for all mapping practitioners.

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Appendix A - Interview guide

Introduction

The authors presented themselves, the project and purpose of the interview.

Personal background

What is your name?

What is your position and role?

What are the main task and activities of your role?

How many years have you worked at IKEA? How many years have you worked at current position?

DDC

How do you come in contact with the DDC process in your work?

What tasks and activities in the DDC process do you perform?

> How is this done?
>
> How much time does it take to perform the activities?
>
> What information do you need in order to perform the activity? (Object in?)
>
> What information do you send after performing activity, and to whom? (Object out?)

How does your work task differ when you work with the DDC process compared with CCD process?

> Which extra activities are needed when managing the DDC process?
>
> How much of your time is spent on the DDC process?

What other persons and departments do you interact with while managing the DDC process?

Requires handling of DDC process extra features, knowledge or skills?

Problems in DDC process

What problems do you experience personally in the DDC process?

What problems do you see in the DDC process in total?

Do the problems become worse when the material flow grows?

What problems do you consider as most serious and need to be prioritized first?

Do you have any suggestions of improvement regarding the DDC process?

Value of a process map

Do you think you have enough information about the DDC process?

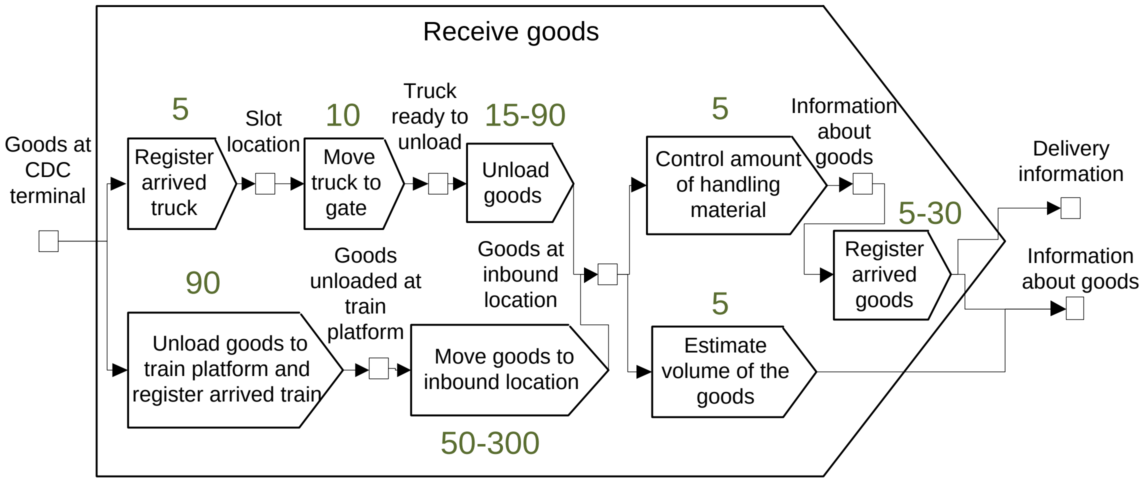
How much would you value a DDC process map, at a scale from 1 to 10?

Appendix B - Lead times comparison between direct deliveries from supplier to hub and sending the goods through the CDC terminal

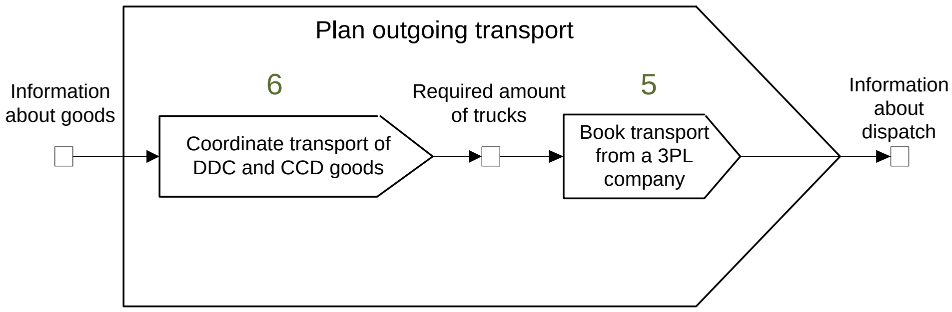
Scenario	MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH	FR	SA	SU
Direct hub	O	P	P	P	P	P	P	P	P	P	P	P					LS	UL H	AC		
Deliver once a week		O	P	P	P	P	P	P	P	P	P	P	P				LS	UL H	AC		
Wednesday			O	P	P	P	P	P	P	P	P	P	P	P			LS	UL H	AC		
				O	P	P	P	P	P	P	P	P	P	P	P		LS	UL H	AC		
					O	P	P	P	P	P	P	P	P	P	P	P	LS	UL H	AC		
						O	P	P	P	P	P	P	P	P	P	P	P				
							O	P	P	P	P	P	P	P	P	P	P	P			
Direct hub	O	P	P	P	P	P	P	P	P	P	P	P			LS	UL H	AC	D			
Deliver twice a week		O	P	P	P	P	P	P	P	P	P	P	P		LS	UL H	AC	D			
Monday &			O	P	P	P	P	P	P	P	P	P	P	P				LS	UL H		
Thursday				O	P	P	P	P	P	P	P	P	P	P	P			LS	UL H		
					O	P	P	P	P	P	P	P	P	P	P	P		LS	UL H		
						O	P	P	P	P	P	P	P	P	P	P	P				
							O	P	P	P	P	P	P	P	P	P	P	P			
Via CDC	O	P	P	P	P	P	P	P	P	P	P	P			LS	UL CDC	PL CDC & AC	L CDC & AC	UL H		
Deliver 5 times a week		O	P	P	P	P	P	P	P	P	P	P	P		LS	UL CDC	PL CDC & AC	L CDC & AC	UL H		
Monday - Friday			O	P	P	P	P	P	P	P	P	P	P	P	LS	UL CDC	PL CDC & AC	L CDC & AC	UL H		
				O	P	P	P	P	P	P	P	P	P	P	P	LS	UL CDC	PL CDC & AC	L CDC & AC		
					O	P	P	P	P	P	P	P	P	P	P	P	LS	UL CDC	PL CDC & AC		
Denotation:						O	P	P	P	P	P	P	P	P	P	P	P	LS	UL CDC		
P =	Production						O	P	P	P	P	P	P	P	P	P	P	P	LS		
O =	Order creation																				
LS =	Load at Supplier																				
UL CDC =	Unload CDC																				
PL CDC & AC =	Plan load CDC and advise customer																**Assumtions:**				
L CDC & AC =	Load CDC and continue advise customer																Delivery date at POS				
UL H =	Unload hub																Leadtime supplier 11 weekdays				
AC =	Advise customer																Total leadtime in weekdays				
D =	Deliver to customer																Order creation date is not a leadtime date				

MO	TU	WE	TH	FR	SA	SU	MO	Leadtime	
D								21	
D								20	
D								19	
D								18	
D								17	
		LS	UL H	AC			D	23	
		LS	UL H	AC			D	22	
								20	**Average**
								17	
								16	
AC	D							20	
AC	D							19	
AC	D							18	
LS	UL H	AC	D					19	
LS	UL H	AC	D					18	
								18.14285714	**Average**
D								21	
D								20	
D								19	
UL H	D							19	
L CDC & AC	UL H	D						19	
PL CDC & AC	L CDC & AC	UL H	D					19	
UL CDC	PL CDC & AC	L CDC & AC	UL H	D				19	
								19.4	**Average**

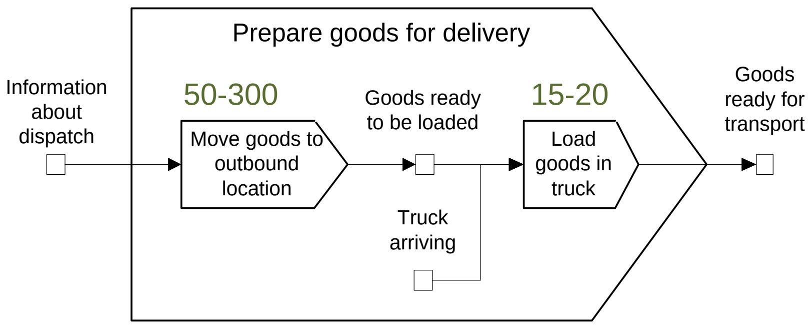
Appendix C – Time spent on tasks in sub process Consolidate shipment



Sum of tasks: 185-535 min



Sum of tasks: 11 min



Sum of tasks: 65-320 min