TAMPEREEN AMMATTIKORKEAKOULU

IMPROVING DELIVERY QUALITY IN SUPPLY CHAIN

A Case Study

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Bachelor's Thesis
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ABSTRACT

Tampereen ammattikorkeakoulu
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Improving Delivery Quality in Supply Chain
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This thesis was carried out as a case study for a company in the technology industry with the purpose of evaluating the logistics service level and quality of the delivery process in a supply chain, following the DMAIC-process of Six Sigma. The main objective was to detect the most relevant root causes for defectives and to provide improvement solutions for supply chain processes - packaging and material handling as the main focus.

By applying methodology from literature references and meetings with the case company, this thesis examined the essential tools and techniques required to measure service levels and to substantially improve process quality. The relevant theoretical concepts were explained, including supply chain management, logistics and supply chain customer service, total quality management and the concepts of quality, and finally, the method of Six Sigma.

Primary data were collected in mostly quantitative form, from four delivering countries during a four-month period. The results were analyzed using the quality control tools such as the checksheet, run charts, Pareto charts, and cause-and-effect diagrams. Qualitative data was used to support the analysis in form of pictures and phone calls.

The key findings suggest that only a few root causes lead to most of the defects in the supply chain. These root causes were most commonly related to process - in terms of material handling. Improvements were planned and piloted for both processes and packaging functions and a control plan was created to follow up on the implementation of these improvements. Further research could be expanded to a wider area scope to investigate area-specific logistic problems.

Key words: supply chain, process, service level, quality, six sigma

CONTENTS

ABBREVIATIONS AND TERMS

3PL	Third Party Logistics
CTC	Critical to Cost
CTD	Critical to Delivery
CTS	Critical to Satisfaction
CTQ	Critical to Quality
DC	Distribution Center
FL	Front Line
DMAIC	Define, Measure, Analyze, Improve, Control
DPMO	Defects per Million Opportunities
KPI	Key Process Input
KPO	Key Process Output
QC	Quality Control
QMS	Quality Management System
RLP	Reloading Point
SCM	Supply Chain Management
SIPOC	Supplier, Inputs, Processes, Outputs and Customer
SQM	Supplier Quality Management
TQM	Total Quality Management
VOC	Voice of Customer

1 INTRODUCTION

In today's economy, it is now supply chain versus supply chain instead of the old business versus business model. Quality and customer service have become more and more important as means of competition. In order to maintain position in the market, organizations need to develop their strategies based on the commitment and awareness of the management towards continuous quality improvements. To be able to achieve the best quality and a supply chain superior to the competition, organizations need to learn to integrate, grow and develop functions inside their whole supply chain. (Bergman & Klefsjö 1994, 15; Fish 2011, 25.)

The theoretical framework walks the reader through the basics of supply chain management and the concepts of logistics customer service and quality, all the way to quality management principles. The case company's selected quality management system, Six Sigma, will be described in greater detail. An introduction of the case company and its main supply chain functions will follow, moving on to the definition and implementation of the initial Six Sigma project.

This thesis was conducted as a case study of a Six Sigma quality improvement project for a company in the technology industry. The whole flow of materials in the supply chain is examined, from the material suppliers all the way to their arrival to the installation site. The Six Sigma quality project puts under control logistic functions and aspects such as quality of package materials and designs, material handling and transportation.

1.1 Research background

The case company delivers approximately 2 million component packages yearly to installation sites through their Distribution Centers. From these deliveries, logistics quality feedback is collected, which is used to detect quality issues and improvement opportunities. Based on the feedback received, whether it concerns material or process defectives - changes and repairing actions need to be done.

The need for a Six Sigma quality improvement project was first seen when going through customer and logistics feedback data from the previous year, 2014. It was noticed that concerning amounts of claims of damaged materials had begun to arise, causing increases in costs, decreases in logistics service level, and therefore also, customer satisfaction. The material damages were occurring somewhere in the supply chain but the exact root cause and place was unknown. The Case Company also suspected that all of the defects might not be reported - unless there were actual significant material damages.

In this thesis, all deliveries of component packages, as delivery units, going through the supply chain from suppliers all the way to the final installation sites were analyzed. The research took into consideration the quality of deliveries and material handling as well as the quality of packages.

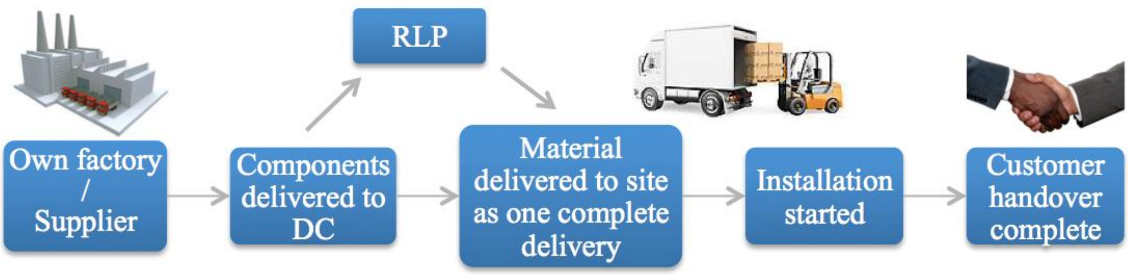


FIGURE 1. Case company’s investigated supply chain process model

1.2 Research objective

The purpose of this thesis is to explain the importance of logistics customer service and to gain understanding of effective quality management in supply chain management - using the case company as an example. The goal is to determine the current level of quality of the case company’s supply chain by analyzing component deliveries, utilizing the tools and methodology of quality management and Six Sigma. When all the needed information has been gathered, corrective actions are to be planned to avoid and eliminate the factors that cause damages.

The main objective of this thesis is to detect the most relevant root causes for defectives and to provide improvement solutions for the supply chain processes - packaging and material handling as the main focus. Possible recommendations and further investigation needs are presented to the case company.

This thesis investigates the following research questions:

- In what stages in the supply chain do the damages appear?
- What is the root cause for the damages?
- How to avoid the damages in the future?
- What could be done to improve the quality throughout the supply chain?

1.3 Research design

The research method chosen for this thesis was primarily in the form of quantitative research. It is typical for quantitative research to have a larger sample of data, and therefore, it is easier to have results that represent the average opinion, attitude or experience of the population in the investigated matter. (Vilkka, 2007, 17.)

To avoid an unnecessary large amount of data, a judgement based sample, or a purposeful sample, was used in narrowing down the scope of the research. This sample is based on a researcher choosing the scope according to own judgement that is seen to fit best in relation to the initial research questions. It is seen to applicable when the research does not aim in generalizing results into a larger population. (Vilkka, 2007, 58.) The monitoring countries chosen for the scope were United Kingdom, Italy, France and Germany. This decision was done based on delivery volumes.

Primary data was gathered in the form of reports, including possible problem descriptions done by Logistics Partners and Front Lines. A feedback template was filled out when detecting a near-miss situation with need for improvement, or when actual defects were identified. The reports were then forwarded by e-mail to the assigned contact person in the Case Company.

Secondary data was collected in a more a qualitative way. Pictures, e-mails and phone calls supported the feedback reports. The project team also made visits to all three Distribution Centers in Europe, seven Reloading Points and installation sites in Germany, Finland, France, Italy and UK. Both primary and secondary data were collected into one Excel follow-up file, which was created specifically for the project. To support the analysis, Click View was used for getting internal data.

2 THEORETICAL FRAMEWORK

This part of the thesis explains relevant concepts that help to understand and clarify how the logistics service level and the quality of a supply chain can be improved. The chapters are divided into four parts: logistics and supply chain management in general, logistics customer service, total quality management and quality concepts, and finally Six Sigma.

2.1 Logistics and Supply chain management

Supply chain, as a concept, is generally described as the flow of information, materials and money from the initial supplier all the way to the end customer. As it is stated by Donald Waters (2007, 38): *The simplest view of a supply chain has a product moving through a series of organizations, each of which add value to the product*.

The term ‘logistics’ is often confused with supply chain management, but more precisely, logistics refers to a function inside a single organization, managing all movements of materials. Further, the concept of logistics contains all functions that are not related to the physical manufacturing and selling of products. (Hokkanen, Karhunen & Luukkainen 2011, 57.) SCM, on the other hand, takes a broader view of the movements as it manages the flows between and among all related organizations that form the entire supply chain. (Waters 2007, 37-38.)

The supply chain consists of suppliers, the focal organization and customers, as seen in figure 1. The movement of materials from suppliers to the organization is called inbound logistics and the movement out of the organization to the customer refers to outbound logistics. The movement of materials inside the focal organization is referred to as internal logistics or more generally, material management. (Waters 2007, 36.)

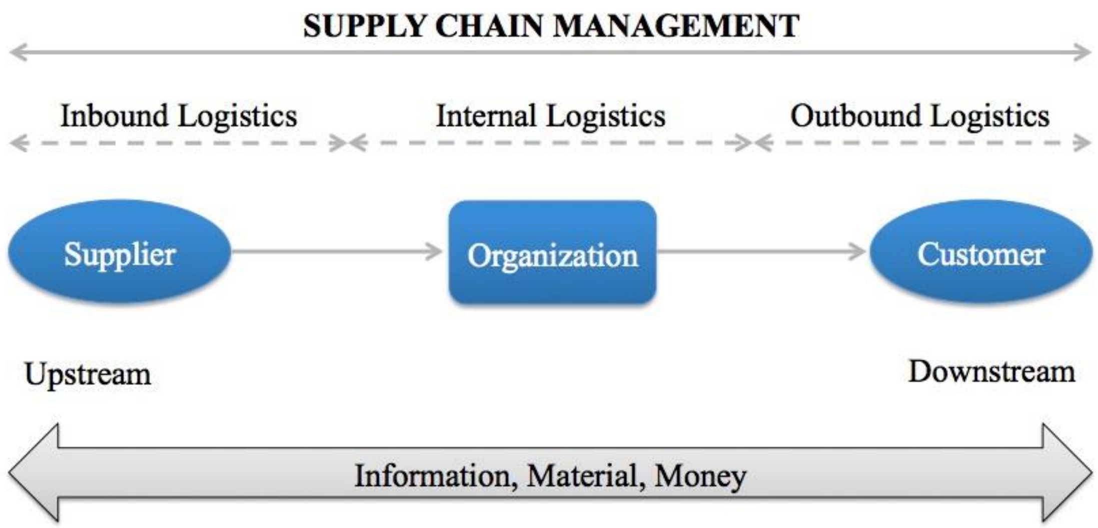


FIGURE 2. Logistics and material movement (Waters 2007, 36, modified)

The materials in inbound are flowing upstream and on contrary, materials moving outbound are flowing downstream. The upstream activities can be divided into tiers of suppliers. A first- tier supplier refers to a supplier that sends materials directly to the focal organization; a second-tier supplier is a supplier that sends materials to a first-tier supplier, and so on. Downstream activities are also divided into tiers of customers. A first-tier customer is one that receives products directly from the focal organization; a second-tier customer is one that receives products from the first-tier customer, and so on. (Waters 2007, 39.) As a matter of fact, all organizations act as a customer as well as a supplier in the supply chain; first, while purchasing from own suppliers and then, when delivering to own customers. This gives insight on how complex a supply chain can often be and how it can spread widely around the globe. (Waters 2007, 36.)

The supply chain consists of three main flows: information, material and money. The flow of information consists mostly of purchase and customer orders but is also very much needed in forecasting and planning. Unlike information, material flow is physical, which means that material has to be grabbed on to and moved from one place to another. It can involve many stages of handling and transportation, which means that personnel and equipment are needed. Further, the flow of cash in the supply chain is very much dependent on both information and material flow. When information flows smoothly, deliveries speed up and stocks reduce, which means that also the circulation of money speeds up. (Sakki 2009, 22-23.)

The design process is critical for the survival of the company and its supply chain. The decisions made in process design are divided into design for logistics and design for supply chain. Designing logistics focuses on the processes used in moving products through the supply chain. The design of logistics takes into consideration the quality of packaging, transportation and material handling, among others. On contrary, the design for supply chain addresses the simultaneous design for materials across the different supply chain levels. (Fish 2011, 28.)

When determining a supply chain, two types of decisions need to be made: strategy and execution. The first is deciding the best structure and the second is finding the most efficient ways to move materials through the chain. In order to have a well-functioning and efficient supply chain, logistics has to bring together different functions and parties responsible for various aspects regarding the flow of materials.

The core activities of SCM include procurement, warehousing, stock control, material handling and transportation. In addition, SCM can include several other logistic activities, and them working together is key in achieving the most efficient flow of materials. (Waters 2007, 43-44.) With the help of logistics, companies aim to create as much value as possible to their customers. Management, handling and transportation of materials need to have positive productivity in order to benefit the business. (Hokkanen et al. 2011, 57.)

2.1.1 Packaging

Packaging is an essential part of a product. It is an important aspect in marketing and logistic activities but mostly it is used for protecting materials. Packages protect against mechanical wear and tear, contamination, leaking and pilferage, among others. It also makes the handling of materials much easier and reduces distribution costs.
(Hokkanen et al. 2011, 151; Pakkausmateriaalit, 2015.)

The packing of materials takes place generally at the facilities of suppliers. The materials used in packaging vary depending on the materials inside and their intended use. Most common materials found in packaging types are wood as well as fibre-based materials such as paper, cardboard and carton.

Smaller share of the packages include metal-based materials such as aluminum and aluminum foil, tinplate and steel. Also glass and plastic are used. The share of metal-based packaging materials is constantly increasing due to its recyclability. Wooden packages are also often recyclable, but however, fibre-based packages are usually disposable. (Hokkanen et al. 2011, 151.) A product needs to fill its package completely without excess space and all packages need to include handling markings with points of fixing and lifting. The proper packing materials and design need to be in place to ensure the proper durability of the package. (Pakkausmateriaalit, 2015.)

PICTURE 1. Most common wood-based packing materials (Case company's internal material)

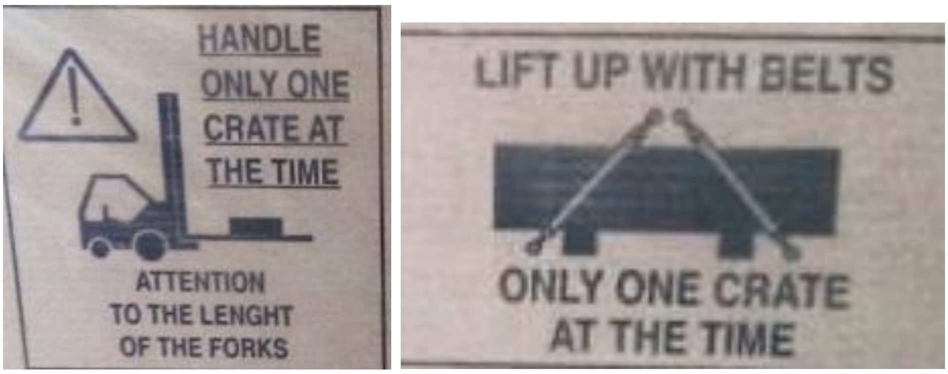
Especially in long supply chains, packages face multiple handling, warehousing and transportations. These expose packages to hits, moisture, dust and deterioration. Further, if they are not fixed properly during transportation, vibration and movement caused by especially road transport can also damage packages and even the materials inside. To improve the stacking ability and handling abilities, packages are often stacked on top of pallets (Bowersox, Closs & Cooper 2007, 240; Pakkausmateriaalit, 2015).

2.1.2 Material handling

Material handling includes all activities that influence the physical state of the material. This involves the modification and movement of materials and packages. Even though the material is also moving during transportation, it remains untouched, only the location changes. Internal movement inside factories, warehouses and distribution centers, among others, is categorized as material handling. Also loading and unloading of materials to and from transportation vehicles is categorized as such. (Hokkanen et al. 2011, 139.)

Material handling is classified as mechanized, semi automated and automated. Mechanized handling refers to traditional manual handling with the help of machinery, but is not in any way automated. Semi automated and automated, on contrary, refers to information technology based machines working to move materials with no help from manpower. They are most commonly used when the sizes of packages are constant and volumes quite big, as for example material components in factory inventories. When the form and size of packages vary, it is often much cheaper and easier to use manpower and mechanized handling instead of automated machines. (Hokkanen et al. 140-142.)

Tools and equipment used in material handling vary depending on the package handling markings, weight and size of the package as well as the environment where the package needs to be moved. Also a contributing factor is whether the material is moved horizontally or vertically. Most commonly used equipment in mechanized handling is lift trucks, rider trucks, towlines, tractor-trailers, conveyers and carousels. When handling heavier loads, the most common handling equipment from these is the forklift. (Bowersox et al. 2007, 243; Hokkanen et al. 2011, 140-144.)



PICTURE 2. Material handling markings (Case company's internal material)

2.1.3 Transportation

Transportation refers to moving materials between two points. There are five main modes of transportation for moving materials: road, railway, water, air and pipeline. Trucks and trailers attached to them are most often used in Road transportation in the technology industry. As the names state, transportation by railway is simultaneously done via trains, airfreight by airplanes and water transportation by ships.

Pipelines, which refer to transportation inside a tube or wire, is a more rare transportation method and is used for moving fluids, electricity and gas. (Hokkanen et al. 2011, 82-85.)

Today, most companies want to focus on their core competences, which rarely include transportation. This is why companies often utilize 3rd Party Logistics in their supply chain. 3PLs are external partners specializing in forwarding and used by companies to take care of warehousing and transportation activities. (Hokkanen et al. 2011, 83.)

2.2 Logistics and supply chain customer service

Customer service is defined as a fulfillment process of providing the customer the required service from the initial order all the way to the after sales service. This process of filling a customer order includes the receiving and handling the order, picking and packing the product, shipping and delivering the package, and handling the possible return of the product. (Ballou, 2004, 92.)

From the perspective of logistics, customer service is the output from all supply chain processes or logistic activities combined. As the design of the logistics processes is critical for the survival of the company and its supply chain, it therefore also sets the required level of service offered to the customer. Determining and measuring the level of logistics customer service is key in achieving the profit objectives of a company as well as maintaining and achieving customer loyalty. (Ballou 2004, 91.) The provided logistics customer service has substantial effect on customer patronage. Also, it affects sales, but the effect is quite difficult to determine (Ballou 2004, 102).

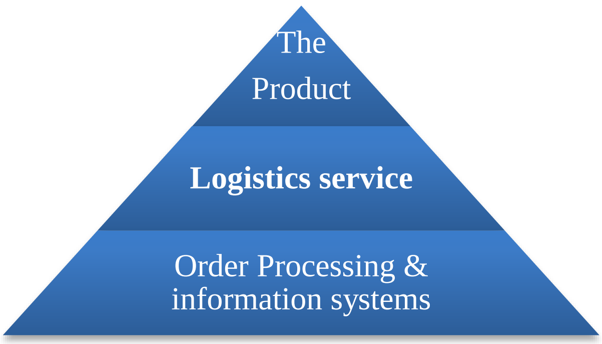


FIGURE 3. Customer service goals (Ballou 2004, 91, modified)

2.2.1 Service elements

The elements of logistics customer service were studied by the National Council of Physical Distribution Management and grouped into three categories: pre-transaction, transaction, and post-transaction (figure 4). Organizational customer service is a combination of all these elements.

The pre-transaction elements establish the climate for good customer service. This includes providing the customer a written statement of a service policy to let the customer know what to expect from handling and delivering orders. To contribute to a good buyer-supplier relationship aspects such as providing technical training and manuals to customers, as well as implementing and creating customer service policies within organizational structures, need to be considered.

The transaction elements are those that directly have an affect to the delivery of the product to the customer in terms of order fulfillment, delivery time and the condition of the delivered goods.

Lastly, the elements of post-transaction include the services taking place after the sale of the product. They need to be planned in the previous stages to effectively support the product in the field in terms of prevention of defective products, handling claims and returns. (Ballou 2004, 93-94.)

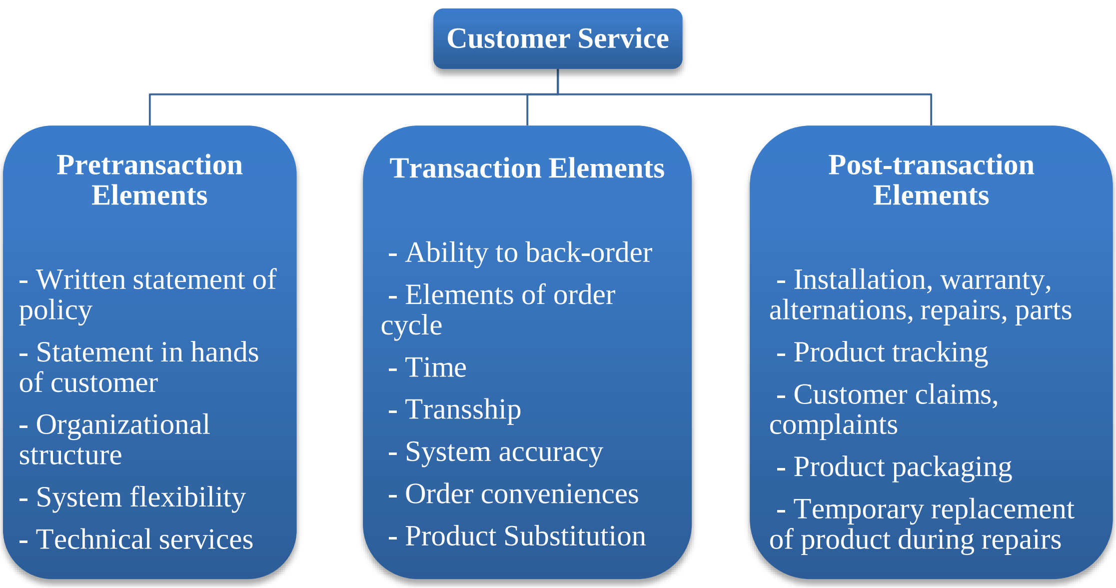


FIGURE 4. Elements of Customer Service (Ballou 2004, 94, modified)

2.2.2 Measuring service levels

It is rather difficult to measure the performance of logistics customer service due to the various dimensions of services. Customer service can however be measured in terms of individual logistics activities. Organizations need to find the correct measures according to the design of their own logistic systems and supply chain model. (Ballou 2004, 118.) Some common measures of performance for organizations are illustrated in figure 5.

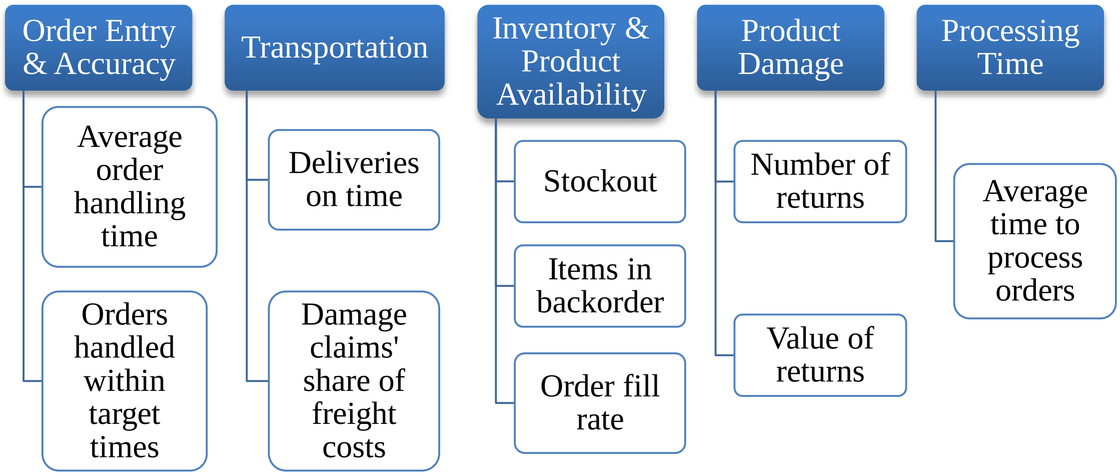


FIGURE 5. Measures of performance (Ballou 2004, 118, modified)

These service performance measures have two potential shortcomings. Firstly, the measures can be internally oriented, which means that data can possibly be more accessible and controllable than measures that are externally oriented. So far, well-developed external service measures do not exist. Secondly, the measures might not have customer requirements as the main focus. Organizations that only measure customer service elements directly under their control often have belief that the level of performance is good, even though customers find it lacking factors critical to them. This may lead the organization to have a vulnerable position against competitors that measure the service level from the customers' point of view. (Ballou 2004, 119.)

Variability in logistics customer service is seen as more important than the average overall performance. While customers are able to count on customer service performance, variability in the service levels lead to uncertainty and high costs for the customer and the company. (Ballou 2004, 114.)

The concept of customer service is quite similar with the quality concept. Just like product supply chain processes that fulfill service variables are able to measure the level of customer service in logistics, quality can be measured by its correspondence to specifications. (Ballou 2004, 114.)

2.3 TQM

Quality Management is generally defined as maintaining and managing the quality of products and services to reach a required standard (Logistiikan Maailma). Total Quality Management takes a more comprehensive view into quality management. The method has spread worldwide as a quality standard through ISO 9000. TQM is a philosophy that strives towards excellence in all functions inside an organization and comprehensive change in the organization’s culture. The main objectives of TQM are continuous improvement and overall customer satisfaction. (Laatuakatemia; Laadunhallinta, laatujohtaminen ja –järjestelmät 2015.) According to Dr. Joseph M. Juran, Quality Management is about achieving world-class quality. This can be achieved when the need for improvement is identified and the most appropriate projects are chosen and correctly analyzed. (Summers 2005, 27.)

FIGURE 6. Total Quality Management (Lecklin 2006, 19, modified)

Table 1 illustrates the critical methods and factors required in implementing successful TQM. The figure links together critical factors of TQM, methods, techniques and tools, forming a network. (Laadunhallinta, laatujohtaminen ja –järjestelmät 2015.)

CRITICAL FACTORS	METHODS
Customer focus	Handling of customer complaints, identification of customer needs, customer satisfaction surveys, after-sales operations
Management commitment and leadership	Commitment of top management, supporting improvement actions
Quality planning	Definition of mission and vision, quality policy and objectives, business plan, communication strategies, control and improvement plans
Factual management	Quality audits, evaluation of performance and satisfaction of employees, business analysis, quality costs, the use of indicators
Continuous improvement	A method of self-assessments (ISO 9000, EFQM), seven quality control tools, other tools and techniques
HUMAN RESOURCE MANAGEMENT	
Participation of all members of the company	The flow of information and communication, work teams, initiative activity, recognition and reward systems
Training	Individual training plans, job orientation, a general training program
Working teams	Multi-functional teams, quality circles
Communication systems	Top-down and bottom-up hierarchical communication, work-related knowledge, posters, slogans
Process management	Quality Manual and procedural instructions, work instructions, the ISO 9000 certificate
Supplier collaboration	Supplier audits, evaluation and training, agreed quality
Organizational awareness of social and environmental issues	Environmental Handbook and Code of Conduct, ISO 14000 certification

TABLE 1. Critical factors and methods of TQM (Laadunhallinta, laatujohtaminen ja –järjestelmät 2015, modified)

The objective in implementing TQM is to ensure the high and consistent quality for company's products, services and processes, and therefore also customer satisfaction. Quality management is used to support employees in training and supervision, and also to create a common practice. By managing quality, new and innovative solutions and methods are systematically developed and the ones that are approved, also documented. The goals and criteria of quality depend on the current situation inside the organization but initially need to be realistic and easily measured. Also, the quality of measurement tools is far more important than the amount of tools used. (Laatu yrityksissä 2015; Lecklin 2006, 29-30.)

Quality Management Systems are used to support the actions of quality management. The most commonly known QMS worldwide is ISO 9000. The standard of ISO 9000 includes the criteria and vocabulary, while ISO 9001 sets demands for quality that needs to be filled. ISO 9004 gives guidance for organizations towards continuous success. (Lecklin 2006, 31.)

According to Juran, to achieve the right quality, the three managerial processes inside Quality Management should be considered: Quality Planning, Quality Control and Quality Improvement. Quality Planning advises organizations to develop their strategies in line with the needs and expectations of customers. This includes activities of planning and preparing actions in order to achieve the quality goals. Quality Control, on the other hand, focuses on comparison between products being produced and the initial goals and specifications. It is a process of operating activities that aim in achieving the quality targets. Lastly, Quality Improvement involves the ongoing improvement activities to ensure continuously better quality. (Sandholm 2002, 59; Summers 2005, 27-29.)

When implementing the methods and tools of TQM, it needs to be acknowledged that no matter how comprehensive the quality programs might be it still may take several years before all operations inside a process are improved. (Harry & Schroeder 2000, 11.) The implementation requires commitment from both top management level as well as the rest of the personnel. Strategic hold and resources are supporting functions, but nevertheless, equally required. (Laatuakatemia; Laadunhallinta, laatujohtaminen ja –järjestelmät 2015.)

Organizations investing in TQM have been proven to significantly improve the quality of their products and services as well as the overall productivity, efficiency and level of customer service inside the organization, while increasing their market share. Other benefits from successful TQM include reduces in defects and stocks, employee and customer satisfaction and increases in flexibility. (Laadunhallinta, laatujohtaminen ja –järjestelmät 2015.)

2.3.1 Quality Control tools

In the continuous strive for better quality; simple statistical methods for QC (Quality Control) to control processes and solve problems have been developed. As a foundation for improvement actions, data is required and this data needs to be analyzed. There are many quality tools but the most commonly known are the seven QC-tools: checksheet, Run chart, Pareto chart, histogram, cause-and-effect diagram, scatter diagram and stratification. (Bergman & Klefsjö 1994, 188.) Checksheet, run chart, Pareto chart as well as cause-and-effect diagram will be introduced in greater detail due to their relevance in the implementation of this thesis.

Checksheet

In data collection, it is essential that the data is collected in a simple and easy to use from. A checksheet is a worksheet used to collect qualitative data of process outputs. Its purpose is to make data collection as easy as possible and to organize the data into a form that is easy to use. (Kume 1998, 14.)

The checksheet includes selected output variables and additional columns for dates, times and shifts. Also, possible columns used to indicate categories for non-compliance or adherence is often included. The form of the checksheet is standardized in order to be able to transform the data for quantitative data analysis. (Internal company Six Sigma training material 2015.)

Output Metric:	Handwashing				
Date / Time	Unit	Room #	Followed handwashing protocol	Reason for Non-compliance	Comment
5/18/2007	5E	124	Yes		
5/18/2007	5E	126	No	Non-cleanser in dispenser	
5/18/2007	5S	148	No	Nurse carrying items; no place to put down	

FIGURE 7. A checksheet example (Case company's internal material)

Run chart

A run chart is a simple graph that illustrates the data in the form of values in a time sequence. It used to investigate trends or shifts from data over a specific period of time. The purpose of a run chart is to record the performance of a process and oversee all changes, trends and cycles in terms of time. This enables the comparison of data before and after the corrective actions and improvements have been made. Therefore, run charts measure the effect of implemented solutions towards the process under improvement. By utilizing the run chart, quality improvement projects can draw attention to the actual improvements achieved. (Karjalainen & Karjalainen 2002, 156.)

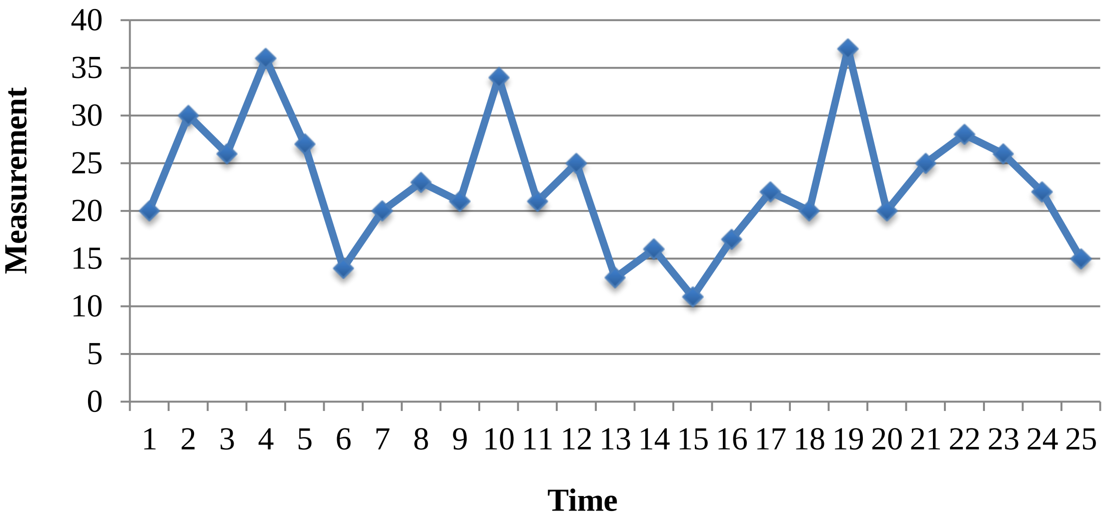


FIGURE 8. A Run Chart

Pareto chart

The Pareto Principle, named by a quality management pioneer Dr. Joseph M. Juran after the Italian economist Vilfredo Pareto, is based on the 80-20 rule, which states that only 20 percent of the problems are responsible for 80 percent of defects and non-quality costs. (Bergman & Klefsjö 1994, 194-196.)

The Pareto principle is described visually through a Pareto chart. There are two types of approaches when creating Pareto charts. A cause-related chart focuses on processes and is used in finding a cause to a significant problem. Effect-related Pareto charts, on the other hand, focus on undesirable results and are used to find significant problems such as defective products, deficits and delivery delays. (Kume 1998, 25.)

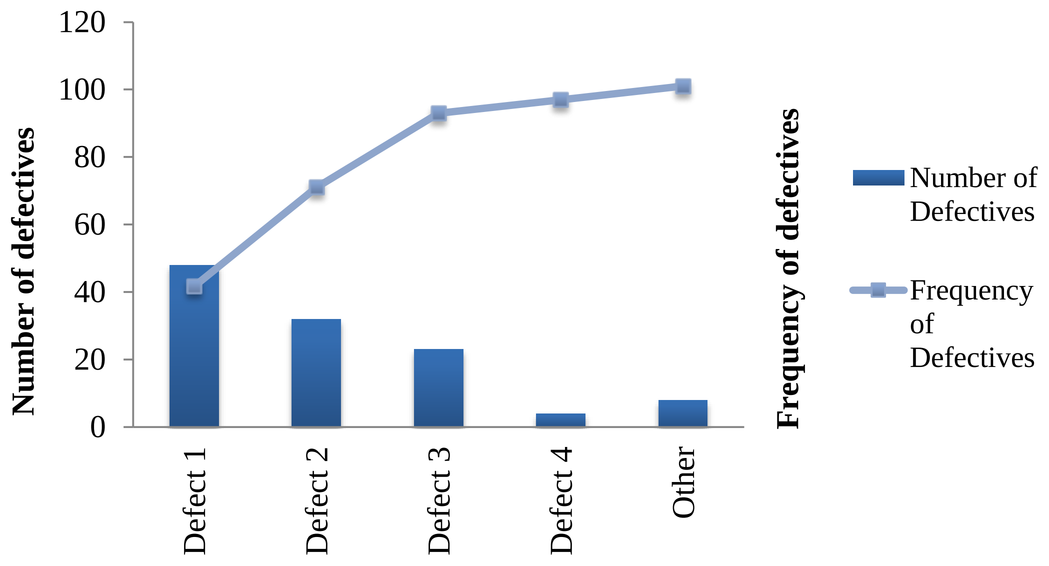


FIGURE 9. A Pareto chart (Bergman & Klefsjö 1994, 196, modified)

In a Pareto chart, the types of defects are presented in the form of bar graphs. The defects are arranged in declining order according to the total number of defectives. The smallest bars can be combined into one group and named "others" if each defect contributes only a little. In some charts, a line representing the fraction of defectives is also drawn. By organizing the data correctly, the most significant problem is made very clearly visible and when it is solved, the next problem can be focused on. This ensures that each problem is solved one at a time. (Bergman & Klefsjö 1994, 195-196.)

In quality improvement programs, where there are known to be several different cause or problems present, the Pareto principle is often implemented (Bergman & Klefsjö 1994, 196). The Pareto chart is of great help when estimating the level of errors and planning actions in eliminating those errors (Six Sigma Pareto Chart 2012).

Cause-and-effect diagram

The Cause-and-effect diagram is a graphic tool developed by a Japanese organizational theorist Kaoru Ishikawa. The diagram can be referred to by several different names: Fishbone diagram, Root Cause Analysis, Cause-and –effect diagram, or Ishikawa diagram. The diagram is used to organize and identify all possible causes that might affect the outputs of a process. The Cause-and-effect diagram enables the identification, investigation and graphic illustration of possible causes. (Karjalainen & Karjalainen 2002, 130-131.)

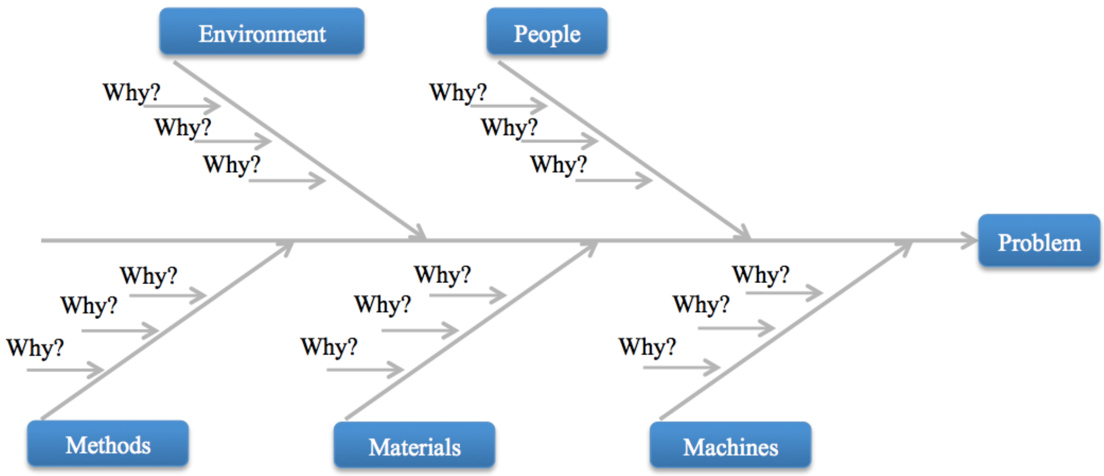


FIGURE 10. Ishikawa diagram (Karjalainen & Karjalainen 2002, 130, modified)

In a Cause-and effect diagram, the core problem is placed at the end of the fishbone, on the right side of the diagram. The branches of the bones are categorized by the root causes of the problem. These causes are often named according to the category of four M's: Materials, Machines, Methods and Manpower. Some diagrams might also include Environment and Measurements. The variables from the process, relating to each of the root causes, are placed on the branches of the bone. (Karjalainen & Karjalainen 2002, 131; Lecklin 2006, 183.)

The Cause-and-effect analysis suited for teamwork, where brainstorming is utilized. The complete fishbone gives a clear, illustrated idea of all causes relating to the defined problem. It opens up the problem, and often helps to find those causes that are not easily detectable. (Lecklin 2006, 183.)

2.4 Defining the quality concept

The concept of quality has many different interpretations. Bergman and Klefsjö (1994, 16) define the quality of a product to be the ability to satisfy the needs and expectations of customers. According to Dr. Joseph M. Juran, quality is “fitness for use”. In general, quality is fulfilling customer needs in a way that is as efficient and cost-effective as possible to the company. (Lecklin 2006, 18-19.)

Quality has several features and dimensions, which do not exclude but complete one another. Durability, feasibility, performance and safety are examples of quality features of a product. A product is also often tied together with a service. The quality features of a service hold delivery times, service levels and reliability among others. It is often more difficult to maintain service quality than product quality. (Lecklin 2006, 20.)

2.4.1 Quality in supply chain

The operations inside a supply chain, between the initial supplier and the customer can be rather complex. There can be a separate supply chain from the initial supplier through the end-user, and at each stage within the supply chain; the receiving party has to be satisfied. The requirement of having provided a quality product or service is that all parties in the supply chain are satisfied. Even if it is not possible for a company to control a product once it leaves the premises, the inherent characteristics are still the company’s responsibility. Quality in a supply chain is measured by delivery times; accuracy and reliability, inventory rotation, claims, reverse logistics, process efficiencies. (Hoyle 2007, 7.)

The integration of supply chain management and quality is very important when implementing different business processes. Design, production, delivery and support processes affect customer satisfaction and therefore also the quality of the supply chain. The production process's responsibility is to manufacture a quality product, while the delivery process guarantees the delivery to the customer without defects. Supporting processes do not directly add value to the product but provide a basis for the core processes. (Fish 2011, 28.)

It is important not to only observe the quality of own organization but also the quality of suppliers. Hard work in a company's logistics processes requires hard work with the suppliers as well. (Bergman & Klefsjö, 1994, 44.) Integrating suppliers and customers in the design process of the supply chain can help in reducing costs as well as improving quality, material management and therefore the competitiveness of the whole supply chain. (Fish 2011, 29.)

Quality advantage is one of the supporting advantages in a supply chain. The aim is to have the product reach the customer with the proper quality, which means that the product has been flawlessly manufactured and has not been damaged during transportation and handling. If the product has been damaged, the repair or replacement of the product causes expenses in the form of passing time. Interruptions in the delivery create delays in the commissioning of products for the end user causing additional costs. (Hokkanen et al. 2011, 18.)

2.4.2 Quality in organizations

High quality is a strategic competitive factor for most organizations. Satisfied customers are the basis of a profitable business and therefore the products and services provided by companies need to fulfill their expectations. A company's operations reach high quality if the customer is satisfied with the products or services provided. Quality is also about the need for continuous improvement in performance. (Laatu yrityksissä 2015; Lecklin 2006, 18.)

In a company, the quality of products as well as the quality of the whole operating processes is focused on. The concept of quality also involves the company's stakeholders such as suppliers, customers, owners and investors. By linking these stakeholders into the same process chain, processes can be understood better as a whole and therefore attention is paid to the right aspects. (Lecklin 2006, 17-21.)

CTS (Critical to Satisfaction) include features leading to customer satisfaction. The customer defines its satisfaction in three substantial ways:

1. CTQ (Critical to Quality) – features of a product or a service that affect the quality of a process with substantial importance to the customer

2. CTD (Critical to Delivery) – features of a product or a service that affect the quality of a process with substantial influence on CTS in terms of delivery

3. CTC (Critical to Cost) – features of a product or a service that affect the quality of a process with substantial influence on CTS in terms of costs (Karjalainen & Karjalainen 2002, 117.)

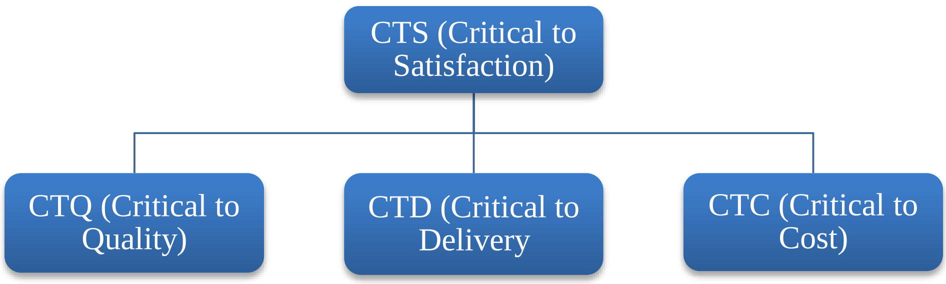


FIGURE 11. Customer requirements

As repairing damages is more costly, providing products and services right the first time around is important in order to lower quality-related costs. Non-quality costs in the company's awareness account for around 6% of the company's turnover. However, because there is a relatively large amount of non-quality costs and not all of them are acknowledged, the real costs can total up to 20 to 25 percent.

Costs due to returns, claims and deficits are easily detectable but for example post-deliveries and unnecessary stocks can be left unnoticed. Quality-related costs can never be avoided completely but with the correct actions, their amount and structure can be influenced. (Laatu yrityksissä 2015.)

In today’s business environment, more and more attention is paid on continuous improvement and development of quality. Moreover, aspects used to progress quality are quality tools, technology, co-operation between different stakeholders as well as the know-how of employees’. On contrary, poor organization of work, problems with suppliers, rush as well as the incompetence and negative attitudes of employees complicate the development of quality. (Laatu 2015.)

2.5 Six Sigma

Six Sigma is a forward-thinking management and quality method that is designed to essentially change the way companies do business. It allows companies to improve the capability of their business with customer satisfaction as the main focus. While quality control programs focus on detecting and correcting defects that occur in everyday business activities, Six Sigma takes a broader look. It ensures that performance problems and defects never arise in the first place by utilizing specific methods that help re-creating key processes. (Harry & Schroeder 2000, vii-2.)

2.5.1 History

The method of Six Sigma originated from Motorola Corporation in 1984. It was Bill Smith, a reliability engineer for Motorola, who firstly introduced the quality program as a counter method for the overriding Japanese quality systems. According to Smith’s studies, the growing complexity of processes created high failure rates in performance. He created a strategy that seeks to reduce these failure rates to a zero-approaching level by improving reliability and quality of processes. (Karjalainen & Karjalainen 2002, 9-10; Summers 2005, 44.)

Smith, who created the foundation for Six Sigma, worked together Dr. Mikel J. Harry and Richard Schroder to develop the Six Sigma Breakthrough Strategy. In 1988, the strategy came into the knowledge of the public, when Motorola won USA's first Malcom Baldrige quality award. This led to other companies implementing and developing the strategy. (Karjalainen & Karjalainen 2002, 10.) The methodology of Six Sigma became even more known in 1995, after Jack Welch from General Electric made it a part of his business strategy (El-Haik &Yang 2003, 21).

Today, Six Sigma is the fastest growing quality management system in the industry and it is the first quality improvement method with proven influence on the profits and therefore also the quality of companies'. (El-Haik &Yang 2003, 21; Karjalainen & Karjalainen 2002, 10.)

2.5.2 What is Six Sigma

Sigma **(σ)** is a Greek letter, used in statistics as the definition of standard deviation, which refers to a measure of how far the result is from average. Sigma states the variation among the results. In terms of Six Sigma, it is a vision and strategy of how to reach 0-level of defects. (Karjalainen & Karjalainen 2002, 17-18.)

A process is the basic unit for improvement in Six Sigma, whether it is internal or provided to outside customers. The improvement of a process aims in decreasing variation and increasing performance, leading to the reduction of defects. These improvements have an effect on employee morale and the quality of a product, and ultimately to business excellence. (El-Haik &Yang 2003, 21.) Factors influencing Six Sigma of are reduced lead times, decreased defects, improved customer satisfaction. Improvements in these areas often lead to dramatic cost savings and therefore generate immediate improvements to profit margins. (Karjalainen & Karjalainen 2002, 17.)

Six Sigma is a quality goal, a philosophy and a new way to measure the capabilities of businesses. Six Sigma is very close to the 0-level of defects, which means 3,4 DPMO (Defects per Million Opportunities). In Finland, the typical sigma level is 2-3 sigmas, as the worldwide level is already between 3 and 4 sigmas. (Karjalainen & Karjalainen 2002, 18-21.)

SIGMA LEVEL (σ)	DEFECTS PER MILLION OPPORTUNITIES (DPMO)	COST OF QUALITY
2	308,537 (Noncompetitive companies)	Not applicable
3	66,807	25-40% of sales
4	6,210 (Industry average)	15-25% of sales
5	233	5-15% of sales
6	3.4 (World class)	‹1% of sales

TABLE 2. Benefits of reaching higher sigma levels (Harry & Schroeder 2000, 17, modified)

2.5.3 Six Sigma in logistics

Even though Six Sigma was firstly intended as help for companies in the manufacturing sector, it can also easily be applied to logistics due to the customer-based focus. Companies implementing Six Sigma to their logistics processes have been reported to have substantial improvements in reliability and cuts in supply chain costs. (Applying Six Sigma to Logistics.)

Introducing the methodology of Six Sigma begins with selecting a project. The voice of the customer (VOC), which reflects to the needs of the customers and their observations on products and services, is often one of the biggest influences for logistics processes. Therefore, a good place to begin is to review logs of customer reports and claims. A common problem in logistics is related to shipment errors. (Applying Six Sigma to Logistics; Karjalainen & Karjalainen 2002, 112.)

In terms projects related to logistics, Six Sigma offers three different approaches. It can either improve processes, redesign those that are no longer up to date or help managing current ones. Companies implementing Six Sigma projects in their logistics need to monitor the improvements and follow up periodically to ensure the solutions from these projects continue to work. (Applying Six Sigma to Logistics.)

2.5.4 Six Sigma projects

When there is a need to start a Six Sigma project, it usually means that a process is not performing in a satisfactory level and has need for improvement. (El-Haik &Yang 2003, 42.) Compared to other quality development projects, Six Sigma projects are often more extensive and challenging and are targeted towards processes with potential for substantial financial benefits and increases in customer satisfaction. (Lecklin 2006, 205-206.)

A Six Sigma organization is a combination of the executive board and employees that receive specific Six Sigma training. The executive board consists of project Champions, and their task is launching Six Sigma projects and to define requirements and set goals, schedules and resources.
After assigning the project to the company's Six Sigma team, the Champions move on to guiding and supporting the team to achieve the goals of the project. (Karjalainen & Karjalainen 2002, 12.)

The Six Sigma team consists of team members called Green Belts and is lead by the Black Belt. The Black belt is trained and mentored by the Master Black Belt, which is responsible for leading the whole organization into a required level of Six Sigma knowhow. All members of the team are expected to use the methodology and tools of Six Sigma. (Karjalainen & Karjalainen 2002, 12, 68, 76; Lecklin 2006, 205.)

The Six Sigma project progresses according to the continuous improvement model, where theory, hypothesis, idea and assumption alternate with data and fact. The model of continuous improvement in Six Sigma consists of the five-stage process of DMAIC. (Karjalainen & Karjalainen 2002, 15–16.)

2.6 DMAIC

Applying the method of Six Sigma is all about focusing on the whole system and finding factors inside the system that improve the performance of a process (Karjalainen & Karjalainen 2002, 43.). The strategy involves finding solutions to eliminate root causes that cause performance problems and variation to performance in a process, while leaving the fundamental structure of the process intact (El-Haik &Yang 2003, 41).

In order to improve performance, a common cause has to be found. The five-stage DMAIC-process was created to find this cause. The definition comes from the words define, measure, analyze, improve and control. (Karjalainen & Karjalainen 2002, 43.)

The DMAIC-process progresses systematically towards solving the problem, moving from induction-deduction reasoning towards the root causes of the problem. The process begins with a characterization stage, which focuses on the description of the problem and the search for potential causes. The optimization stage follows, which focuses on optimizing and improving the process or product by modifying the causes. The method is based on data and structured statistical problem solving. Different statistical tools are used as a support. (Karjalainen & Karjalainen 2002, 43.)

There are a few differences and benefits in the DMAIC-model compared to regular problem solving tactics. Firstly, it is not only assumed that a problem is understood in a DMAIC-model, but it also has to be validated with facts. Secondly, giving up old ways in solving the process is an asset in DMAIC-projects as it creates new and creative solutions. Re-proving the root causes with data, focusing on the customer, testing and developing solutions and measuring the results are also included in the benefits. Lastly, the maintenance of improvements is key in this model. (Karjalainen & Karjalainen 2002, 43-44.)

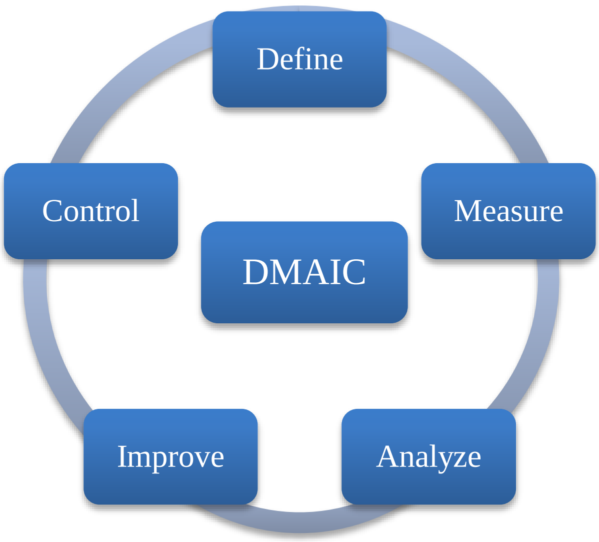


FIGURE 12. DMAIC-process

2.6.1 Define

The first stage of the DMAIC-process is defining the problem and customer requirements, which help in determining the purpose and extent of the improvement project. Background information of customers and the process is gathered, and by doing so, the problem is formulated into a clear form by the executive team together with the project team. Their job is also to estimate the profitability as well as to resource and schedule the project. (Karjalainen & Karjalainen 2002, 46.)

The first step in defining the project is drafting a project charter. It is used to set direction to the project as well as to create an understanding of the goals and project plan. The purpose of a project charter is to clarify what is expected of the project; keep the team goal-oriented and the goals of the project in line with the company strategies. (Karjalainen & Karjalainen 2002, 92.) In general, the project charter includes the following elements: the business case, goals and objectives, milestones and schedule, the scope, constraints and assumptions, team members; their roles and responsibilities as well as the preliminary project plan. (El-Haik &Yang 2003, 42.)

The second step in the define stage is to identify the process. The process model is determined and the process description is documented and analyzed in a top-level basis. A process model used in the analysis may be i.e. a P-diagram or a SIPOC model. When identifying the process, whether it is core or supporting, it is important that one process is worked on at a time. (El-Haik &Yang 2003, 42-44.)

Identifying customer requirements, the analysis and prioritization of these requirements is the last step in the define stage. (El-Haik &Yang 2003, 44.) Factors critical for customer satisfaction, such as CTD, CTQ and CTC need to be taken into consideration. (Karjalainen & Karjalainen 2002, 46.)

SIPOC

The SIPOC-model is a top-level based process map and means supplier, inputs, process, outputs and customer. It is used as a documentation method to simplify a process and is also an efficient tool that ensures seeing the business from a process point of view.

SIPOC helps to identify the data collection points in Six Sigma projects, in order to achieve the wanted results. (Karjalainen & Karjalainen 2002, 100.)

Suppliers provide inputs, which are factors that the process needs to function. The following process includes 4-7 process steps and is a description of what produces the outputs that fulfill the needs of the customers. These customers can be either external or internal but are those, who are at the receiving end of the process and set the demands for outputs. Quality of the process is determined by the KPOs (Key Process Outputs) and is improved by analyzing the KPIs (Key Process Inputs). (Karjalainen &Karjalainen 2002, 100.)

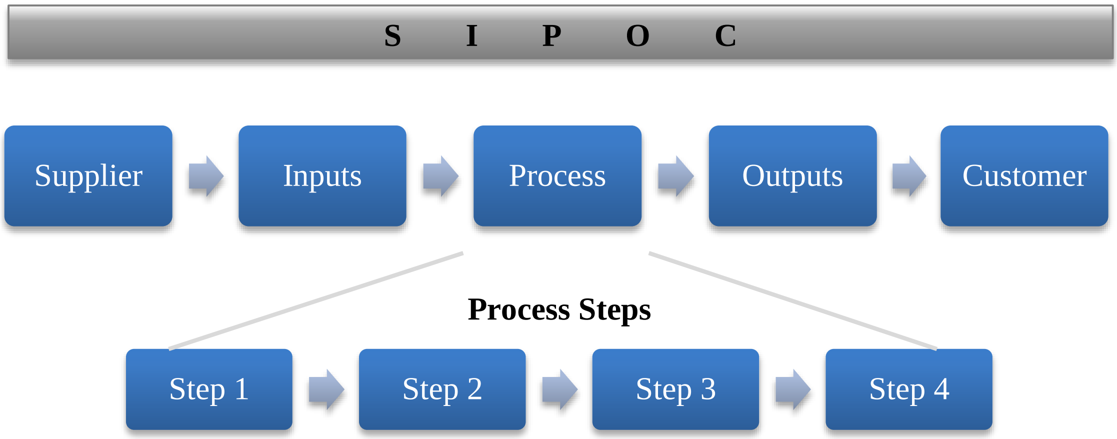


FIGURE 13. SIPOC-process (Karjalainen & Karjalainen 2002, 102, modified)

2.6.2 Measure

Measuring the performance of the process is an important stage in Six Sigma projects. (El-Haik &Yang 2003, 44.) The goal of the measure stage is to validate the existence of the problem in the form of data collection as well as to verify the reliability of the measurement. The focus is eventually being able to calculate the sigma level of the process and detect six sigma. This begins the search for the root causes to the problem. (Karjalainen & Karjalainen 2002, 47.)

The first step is selecting what needs to be measured. The most commonly measured are: input, process, and output (CTQ and defects), as well as data stratification. (El-Haik &Yang 2003, 44.) Next, the team has to form a data collection plan. This includes determining the sampling frequency, the format of the data collection form, measurement tools, as well as the person in charge of performing the measurement. Also, the type of data and the sampling method needs to be paid attention to. (El-Haik &Yang 2003, 45.)

Tools that support the measurement stage along with the data collection plan are check sheets and Pareto charts, among others. The method of Six Sigma is based mostly on quantitative data collection. (Lecklin 2006, 206.) The measured results provide information and form a base for the following stages of the DMAIC model. Next, the data and process are analyzed. (Karjalainen & Karjalainen 2002, 48.)

2.6.3 Analyze

After collecting the data, it needs to be analyzed together with the process in order to find ways of improvement. At this stage, the collected data can suggest, support or dismiss the hypothesis made about problem. (Karjalainen & Karjalainen 2002, 49.) The goal is to find the root causes for defects and problems, as well as the effects of those causes. As a foundation for the future improvement actions, the analysis stage should reveal all critical success factors regarding the process. (Lecklin 2006, 206.) There are two different approaches to the analysis: the process analysis and the data analysis.

In data analysis, the data is used to find patterns, trends or other differences by taking a look at process values and statistical hypothesis testing. Based on data analysis, the structure of a process chain is viewed and improvements to the process made based on this. (Karjalainen & Karjalainen 2002, 49-50.) The methods used to analyze data include root cause analysis, cause-and-effect diagram, histograms and Pareto charts among others (Karjalainen &Karjalainen 2002, 126.)

Process analysis, on the other hand, provides a detailed look into the existing key processes that supply the requirements of customers. The goal is to identify steps that do not add value to the customer such as cycle and down times as well as rework. (El-Haik & Yang 2003, 46.)

2.6.4 Improve

After the analysis of the collected data, the root causes for the problem in the process should have been identified. Therefore, corrective and improving actions can be initiated. These actions include the development of different solutions and in order to find the most applicable one, the expenses, risks, results and vulnerability to errors need to be assessed. Easy solutions are hardly sufficient in Six Sigma projects and often brand new and innovative ideas and methods are developed. (Lecklin 2006, 206-207.)

The new and most applicable solutions should be tested and planned in a quantitative way before implementation (Lecklin 2006, 207). The essence of the Six Sigma method is how the quality level of Six Sigma is achieved. In other words, how the improvement and optimization is carried out. (Karjalainen & Karjalainen 2002, 51.)

When the tested results reach acceptable level, the repair and introduction plan is drawn and implemented. The improved or repaired process then needs to be documented carefully. (Lecklin 2006, 206-207.)

2.6.5 Control

The last stage of the DMAIC improvement process is the control stage. After the improvement of the process, its performance should be monitored (Lecklin 2006, 207). The goal of this stage is to hold on to the solutions made at the improve stage (El-Haik & Yang 2003, 46).
If the improvement is made through the elimination of the root causes of performance problems, the future performance after the improvement needs to be kept track of. Also the critical variables related to the performance need to be controlled by i.e. control charts and a control plan. On the other hand, if the improvement is made by process management methods, new standards need to be established for the process. (El-Haik & Yang 2003, 46.)

Every completed Six Sigma project should have a control plan. It is used to combine CTS together with the functional details of processes and to document all controlling actions and methods from the project.

If a Six Sigma project lacks a control plan, it means that one of the essential elements of the project is missing. The control plan ensures that the process does not drift into its old state. (Karjalainen & Karjalainen 2002, 176.)

As a result of the control stage, it should be clear what has been achieved and what is the effect of the process towards the business revenue. (Karjalainen & Karjalainen 2002, 53.)

3 THE CASE COMPANY

Founded in 1910, the case company is operating in the field of technology industry as a leading manufacturer of elevators, escalators, and automatic doors. The company operates in approximately 50 different countries all over the world, in over 1 000 working stations. The service portfolio includes providing versatile solutions for the maintenance and modernization of the company's products. In 2014, the total turnover equaled to 7,3 billion euros and the amount of staff to 47 000 employees.

The key clientele extends to building contractors, owners of buildings, property management companies as well as operators focused on property development. In addition to these, architects, authorities and consultants are important influencers in the purchasing processes.

The different functions of the business are directed by standards of Quality Management ISO 9001:2008, Environmental Management ISO 14001, Energy Management ISO 50001, and Occupational Health and Safety Management OHSAS 18001. In addition to these standards, also the method of 5S (sort, stabilize, shine, standardize and sustain) is implemented in all offices, construction sites and DCs.

3.1 Supply chain

The supply chain consists of all processes and functions required for components reaching the installation site and ends at the point where the components are installed into one complete product and then handed over to the final customer. The main purpose of the case company's logistic operations is to ensure that all materials are delivered on time, cost efficiently and in high quality, as required by the installation schedule.

The delivery process consist of demand and supply planning as well as effective management of relationships between procurement and suppliers, production, delivery of components to installation sites, as well as ensuring the high quality of installations. As a support for the delivery process, a company's own standard is used, which provides the basis for scheduling and management of orders and distribution of information.

The main modes of transport used in the case company's supply chain include road freight inside Europe, as well as ocean and airfreight to overseas destinations. Road freight can be divided into two different processes; direct deliveries to site and deliveries through Distribution Centers. Materials from DCs are sent to Front Lines either as direct site deliveries or through reloading points. Components from factories and suppliers are consolidated in DCs, which are operated by external service providers. Components are then collected together in DCs according to the purchase order and delivered as a complete delivery to the installation site.

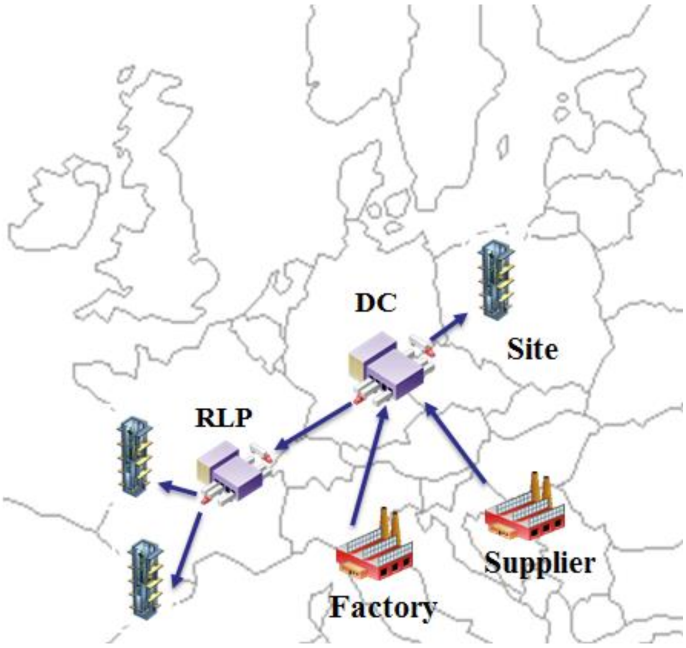


FIGURE 14. The case company's supply chain

3.2 Packaging

Different package types and sizes are used to pack materials, depending on the content. As the materials are only assembled together into a final product at the construction site, all materials and components are packed into their own package. Cardboard, plywood and wood boxes, as well as pallets, crates and bundles are approved package types in the Case Company. All packages should include handling markings, which provide information about the size, weight, center of gravity, as well as stacking limits. Because of a high variety of different materials and package types, handling methods and needs vary depending on the type and content of the package.

3.3 Material handling

During all handling of packages, the weight and center of gravity, labels and stacking instructions, as well as the handling side of the package need to be considered. All packages must be handled with suitable equipment to prevent damages. Most commonly preferred equipment used in loading and unloading include forklifts, cranes and belts. The warehouse operator should always check that truck drivers have all necessary equipment for loading and unloading.

Loading principles ensure secure loading, fixing and unloading of all packages. Once packages are loaded and properly stacked and placed in trailers, they need to be tied with fixing belts to ensure that packages do not move during transportation. To prevent damages caused by fixing belts, corner protectors are used for especially carton boxes. Trucks are not allowed to leave the warehouse unless materials are properly secured and covered for transportation. All packages should be handled and loaded in such way that damages during transportation are avoided.

PICTURE 3. Example of properly fixed load

3.4 Quality programs and systems

The strategy for quality in the case company is to offer first class customer experience by involving people and continually improving the quality of solutions and processes. The goal is to increase customer satisfaction, decrease defectives in all processes, as well as to develop a strong quality business culture.

The case company strives to continually improve the productivity and quality of the all business functions by exploiting different QM methods and tools. By implementing the QMS of Six Sigma, the company strives to reduce waste and process variation throughout their supply chain.

The tools of Six Sigma are used to analyze systematically collected customer feedback before moving on to implementing corrective actions. Over 250 employees have participated in Six Sigma training and in 2014; nearly 150 Six Sigma projects were successfully implemented.

The case company strives to continually improve the quality of all functions with the initial objective of having a superior supply chain in the industry. To achieve this goal, Supplier Quality Management program has been implemented as a part of Quality Management to support processes. To guarantee dependable quality, the company aims in sustaining long lasting relationships with their suppliers. The case company focuses on continuous improvement of supply chain quality, efficiency and productivity, as well as increasing customer value.

4 IMPROVING THE PROCESS

The implementation of the project followed the five-stage DMAIC process. Specific Six Sigma quality tools were chosen to support the data collection and analysis to make sure that the essential results were received in terms of root causes for defects and factors QTC. During the improvement process, the performance of transaction elements of customer service was investigated.

4.1 Define

The project began with defining the problems in the supply chain processes and what their effects were to customers and the case company. The first step in defining the project was to assign team members. The team included a project sponsor, a project champion, two project managers and an internal reference group from the company. Also key external partners and vendors were assigned for support.

4.1.1 Project charter

As an important step in the Define-stage, a project charter was created (APPENDIX 1.). It included a detailed description of the business case along with the goals and objectives. Also the scope of the project was determined and the milestones for the progression of the project were set (figure 15). It was decided that the project would last no longer than six months, three of which would be collecting the data. Finally, a preliminary project plan was made.

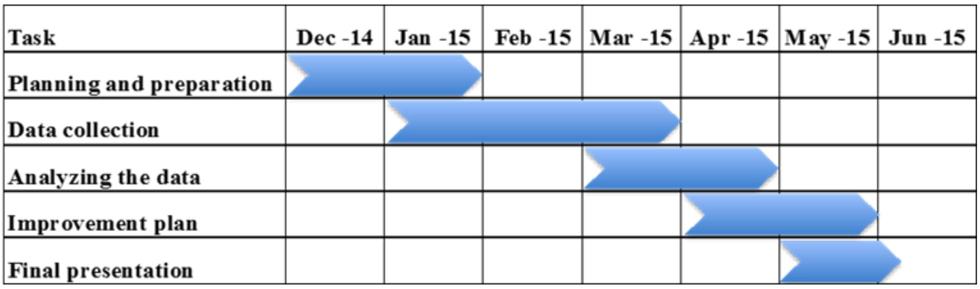


FIGURE 15. Project Schedule

4.1.2 Project scope

Due to large delivery volumes, it was impossible for the project scope to include all delivery countries. The project team narrowed the monitored scope of the project down to four of the biggest countries in terms of delivery volumes. These countries were Germany, France, United Kingdom and Italy. The scope of deliveries to the chosen countries was further narrowed down to whole elevators parts and repair components, managed by the European Logistics Unit. Spare parts were left out of the scope.

4.1.3 Project plan

As a preliminary project plan, it was decided that the whole flow of materials needed to be examined, from goods arriving to the distribution center all the way to the arrival in the installation site. Also, the quality of package designs and materials needed to be investigated in order to understand if the quality was fitting into the Case Company's standards. By having realistic insight on these aspects, corrective actions could be defined and set in motion.

4.1.4 Identifying the process

The Case Company's supply chain process map was put in the form of a SIPOC model, in order to clearly state the investigated process. Major elements regarding the project scope were defined on a top-level basis and only one process was being focused on, to avoid confusion.

The SIPOC began with external suppliers and the Case Company's own factory packing and dispatching the materials. The KPIs inside the project scope included packaging design, material handling and transportation. Further, the actual measured process consisted of packages from suppliers arriving in and shipping out of DCs, arriving in and leaving Reloading Points and finally reaching construction sites. KPOs measured from were the overall delivery quality, customer satisfaction and the amount of defects of the provided packages and products.

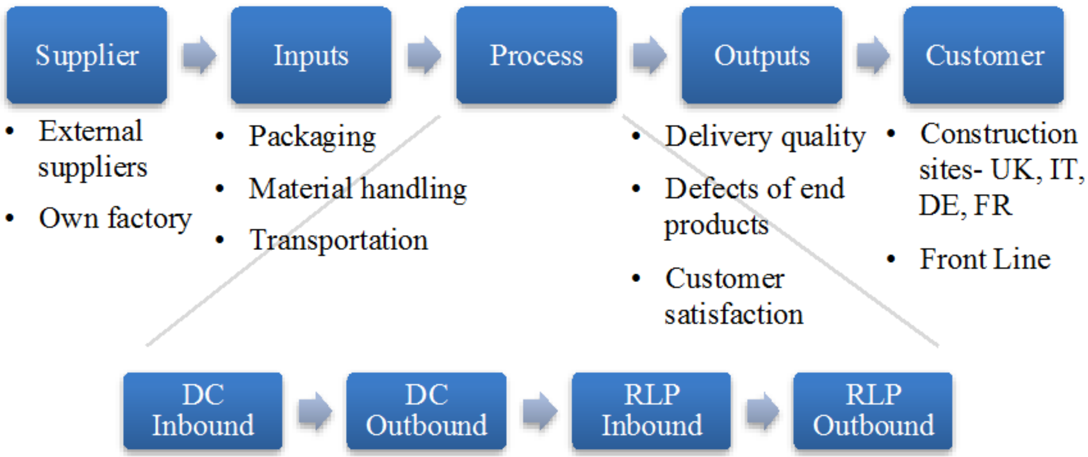


FIGURE 16. Top-Level SIPOC-model for the Case Company

4.1.5 Identifying customer requirements

When defining the Six Sigma project, it was very important to review, why the project was initially started. As mentioned earlier, VOC as well as logistics customer service is one of the biggest influences is logistics. Therefore, factors for overall customer satisfaction such as CTC and CTQ needed to be measured. Indicators for CTCs, in this case, were factors such as defects of end products, delivery accuracy, satisfaction and total costs. On the other hand, CTQ were packaging quality, material handling and transportation quality.

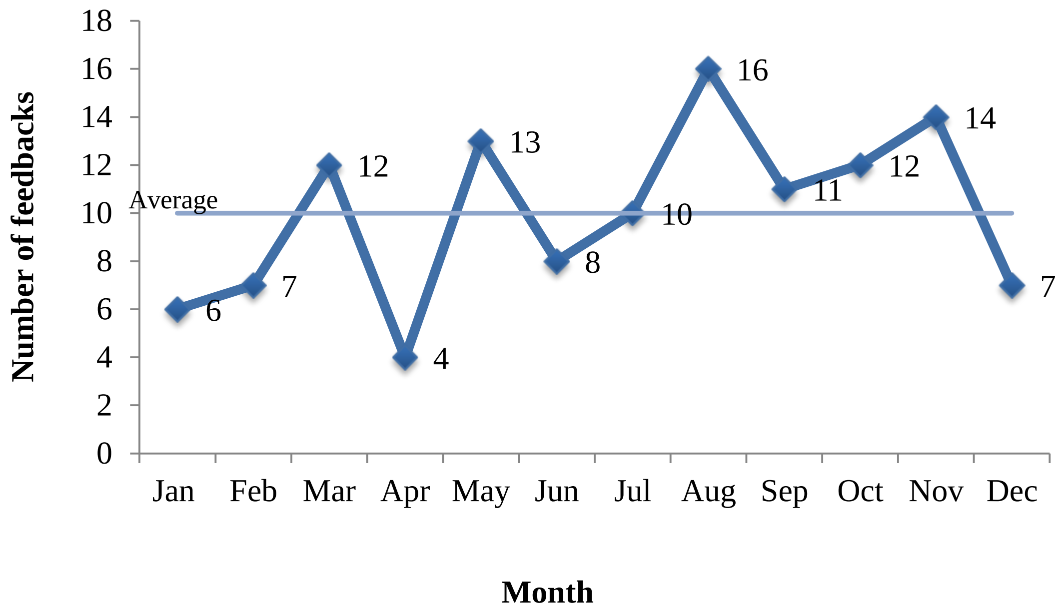
4.2 Measure

Referring to the initial business case, it was clear that causes related to CTQ and defects of end products inside the supply chain process would be measured. KPOs based on the created SIPOC were measured by taking into consideration the defined KPIs. Reports with pictures were collected from all steps of the case company's supply chain process according to the SIPOC model.

4.2.1 Cost analysis before improvement

Before beginning the data collection and its analysis, a run chart (graph 1) was created to understand the number of claims and costs before the improvement of KPIs and processes. The run chart was used to illustrate the average and trends in post-transaction elements of customer service in terms of monthly amounts of logistics feedbacks in 2014. As seen from the figure, the variation of total feedbacks between months was quite significant. The monthly average was 10 logistics feedbacks.

The cost of quality and the overall service level of logistics was measured by calculating the total sum of material costs used for these logistics feedbacks. The sum of these material costs was rounded up to 115 900 euros for the year 2014. However, the total cost of quality for these feedbacks was known to be significantly higher. This was because the costs for reverse logistics, handling fees, and transportation among other costs was not included in this calculation.



GRAPH 1. Logistics feedbacks in 2014

4.2.2 Data collection

As a form of data collection, an Excel-based check sheet for reporting (appendix 2.) was created. Front Line staff and key external partners assigned by the case company were given clear instructions for filling out a reporting template. The reports were sent together with supporting photographs via e-mail to the project manager, who gathered all the data into the follow-up check sheet.

The data were gathered into the check sheet in mostly a quantitative way but also qualitative in the form of phone calls and pictures. The check sheet also included a field for open comments for the project members to write their own observations for each report.

4.3 Analyze

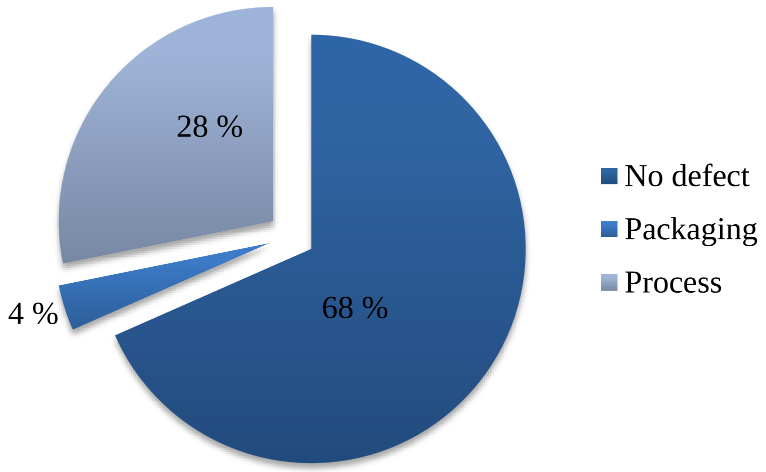
After completing the data collection phase, the reports were analyzed by going through the check sheet - deliveries and their pictures one by one, recording observations. Between January and April, the data collection period, there were 4133 actual deliveries in total inside the project scope countries. The amount of received data was 987 reports from all stages of the supply chain. These reports included multiple pictures and both defectives and good quality of delivery were reported.

4.3.1 Deviations

Deviations in the data were defined as two separate categories - process and packaging. Process referred to all defects involving transportation, loading and unloading, as well as material handling, among others. On contrary, packaging referred to all defects relating to the physical package, such as material, design and feasibility.

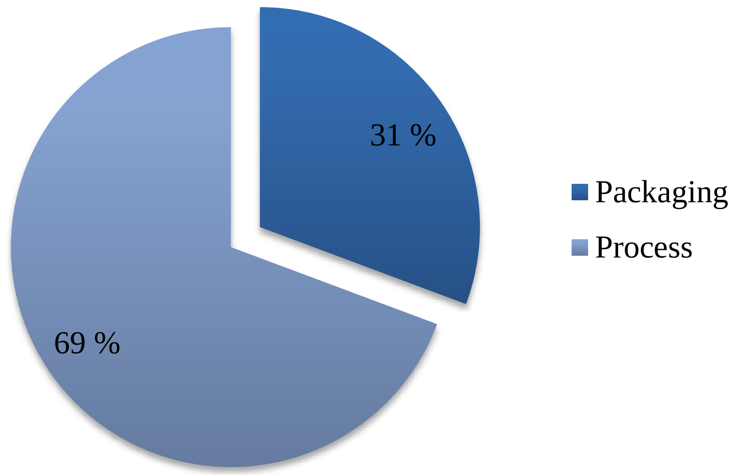
In total, from all 987 reports, 273 of cases had some remarks of deviations related to process. Remarks of deviations related to packaging remained quite low with the total amount of 39 reports. 675 reports were of good quality performance and had no deviations.

Even though not all of these remarks of defectives lead to actual defects, they were recorded to support the analysis and to help investigate patterns for possible risks of defects inside the supply chain.



GRAPH 2. Share between all remarks of deviations

Out of the received 987 reports, 101 cases were reported to having actual package or material damage. Out of these defects, 70 cases were related to process and 31 relating to packaging. Only 16 cases lead to actual reported material damage.



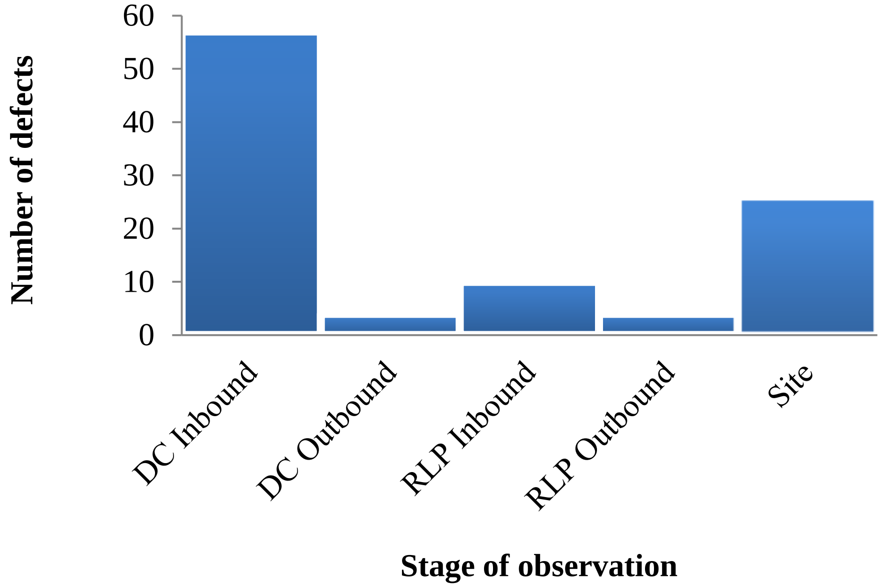
GRAPH 3. Share between actual defects

4.3.2 Moment of observation

In order to properly understand the patterns for defects and to be able to target the future correcting actions accurately, it was very important to determine the stage of the logistics process where damages were occurring. When the stages for specific cases of occurring damages were clear, it was easy to also determine who was responsible first hand for the damage.

A graph was created to illustrate the division of occurring defects between different stages of the supply chain (graph 4). From the graph, it could clearly be seen that the highest frequency of defects occurred already at the earliest stage of the supply chain. According to the data, materials coming from the case company's own factory and external suppliers already arrived damaged in DCs. In fact, from all 57 reports received from DC Inbound, every single package had been damaged.

Along with DC Inbound, a noteworthy amount of defects were also reported from construction sites. Out of the total amount of 86 site reports received, 64 % contained remarks of process deviation or actual package and material damage. 30% of reports from sites contained package damage and of which 31% lead to actual material defect.

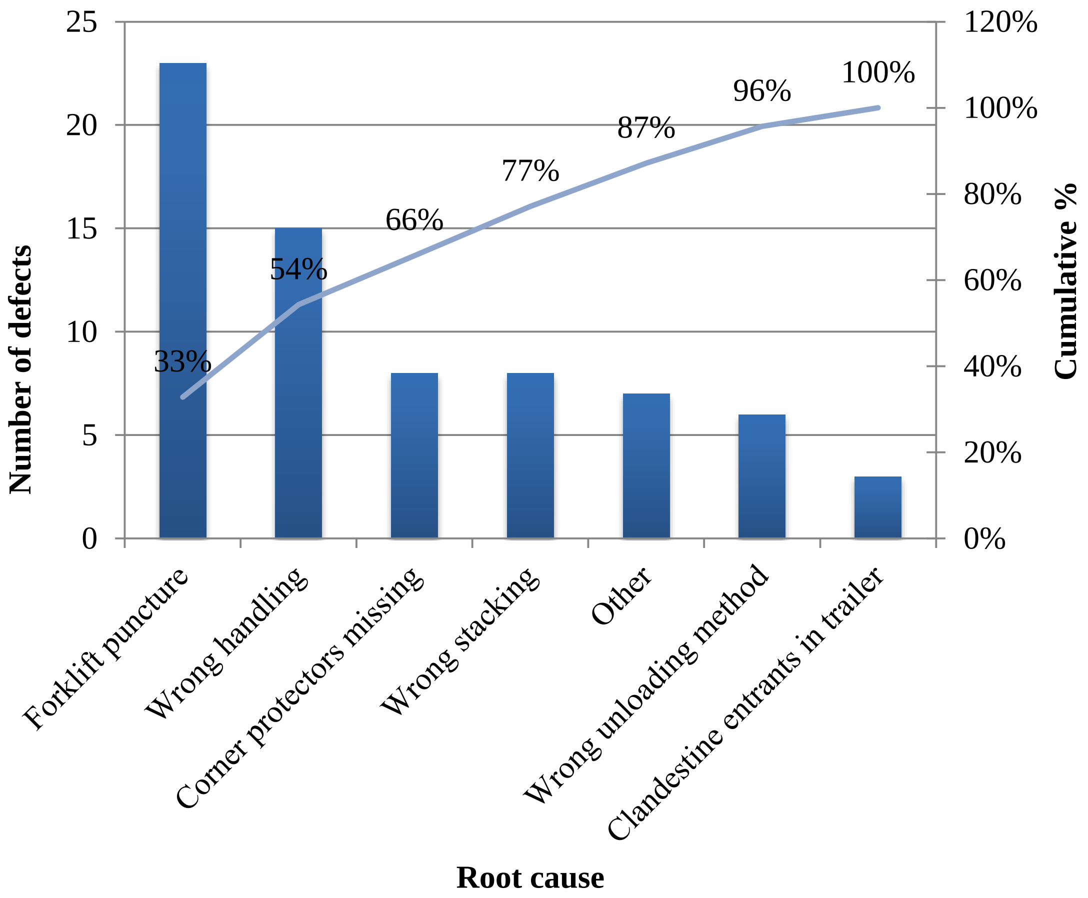


GRAPH 4. Defects between stages in the supply chain

4.3.3 Root causes for process defects

As most of the deviations found from the data were related to process, the root causes for these needed to be investigated further. According to Pareto principle, only a few causes can lead to most of the defects. Therefore, a Pareto chart was used as a tool for the analysis and search for the main root causes.

The Pareto chart (graph 5) shows that there were four relevant root causes under the cumulative 80%: forklift puncture, wrong handling, corner protectors missing and wrong stacking. Random root causes were combined into one group “others” because these defects contributed only a little and had no actual relevance. Wrong unloading method was causing a few defects, but was not however investigated further as an individual root cause. An interesting, and non-expected cause was also clandestine entrants been in trailers. This problem was also left out of the analysis due to the fact that it was not a defective in the case company’s processes - rather a society issue.



GRAPH 5. Pareto chart of root causes for defects related to process

Out of the 70 reported cases of process defects, one of the most common root causes were forklift punctures in packages (picture 4). These punctures are caused when forklift trucks are used carelessly, causing the force of the forklift to pierce packages. Most these reported cases were from DC Inbound stage, and therefore, it could be easily deduced that the root of the problem was most probably coming from the material handling of suppliers.

PICTURE 4. Forklift puncture

Wrong handling of materials also turned up to be one of the most contributing root causes. This included careless handling, loading and handling with the wrong equipment and otherwise inadequate compliance with the case company’s instructions. Picture 5 illustrates an example of such. These reports also came mostly from DC Inbound but also from sites.

PICTURE 5. Wrong handling – package collapsed from truck due to lack of compliance with instructions

Corner protectors missing from under the fixing belts were a re-occurring remark of defectives in the data and also often lead to actual package damage. Neglecting the use of corner protectors can often cause packages to collapse because fixing belts need to be adjusted tight enough for the load to remain in place during transportation (picture 6). This root cause was reported equally from all stages of the supply chain.

PICTURE 6. Corner protectors missing – package collapsed under fixing belt

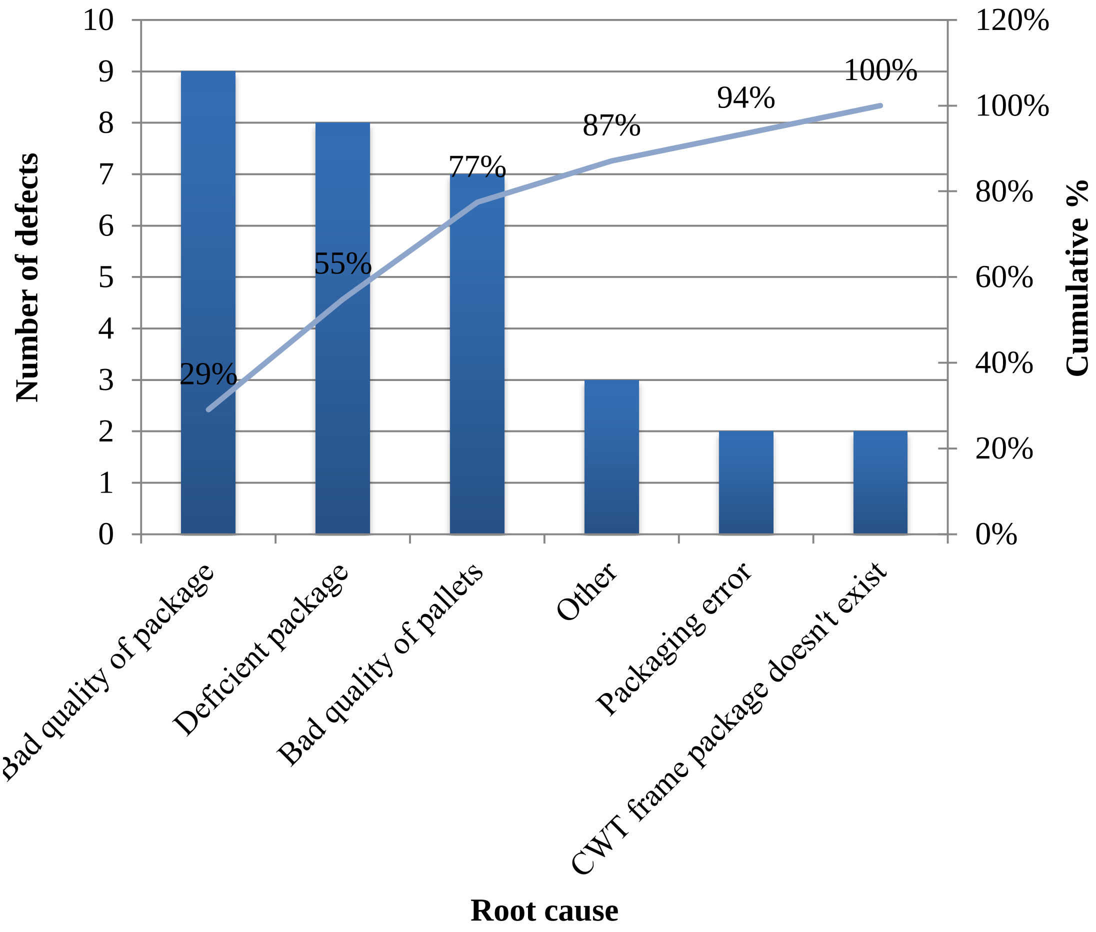
The fourth root cause contributing relevantly to most defects was wrong stacking. This meant that the instructions on packages about stacking regarding weight, size and gravity points were neglected, causing defects for packages. Very often cardboard boxes were stacked under wooden pallets and materials that did not allow stacking on top were left under other packages. Most of these reports came from sites, which meant that stacking instructions were not respected during loading in DCs and RLPs.

PICTURE 7. Wrong stacking – top wooden package stacked on top of cardboard, causing the pallet to pierce cardboard

All process deviations were investigated along with cases leading to actual defects. Most of the defectives were related to flaws in material handling and in the practices of suppliers, Logistic Partners and their subcontractors. Root causes were carefully analyzed and the planning of corrective actions was started.

4.3.4 Root causes for packaging defects

A cause-related Pareto chart was also created for analyzing root causes for defects related to packaging (graph 6). The scope in the analysis included the 31 defects out of the total amount of 101. Like the Pareto chart for process defects, also the chart for packaging defects revealed only a few root causes leading to most of the defects. Three of the root causes were below cumulative 80%. Also in this case, the “other” category included causes that contributed only a small amount.



GRAPH 6. Pareto chart of root causes for defects related to packaging

The root cause contributing the most for packaging defects was the bad quality of packages. Bad quality means that the package material is not at an acceptable level and might lead to damage materials inside the package. The reports for bad quality were received from all stages in the supply chain but since the supplier is responsible first hand for the packaging, this was taken into consideration.

PICTURE 8. Bad quality of package – mold and humidity on plywood box

A very relevant root cause for defects related to packaging was the deficiency of packages. Deficiency in this case meant that the material or design of the package was not suitable for the materials inside. This often caused the packages to collapse when stacking and unloading. Also, in some cases, materials were damaged inside the package because the frame was not efficient enough to protect the materials inside. Deficiencies in packages were material and supplier specific.

PICTURE 9. Deficient packages – package was not resistant enough for diagonal pressure

Bad quality of pallets also appeared in quite many cases. This root cause was reported mostly from DC Inbound but was not dependent on a particular one supplier. Bad quality of pallets makes it more difficult to move packages around and might lead to the package to tilt or the nails from pallet legs to damage other packages.

PICTURE 10. Bad quality of pallets

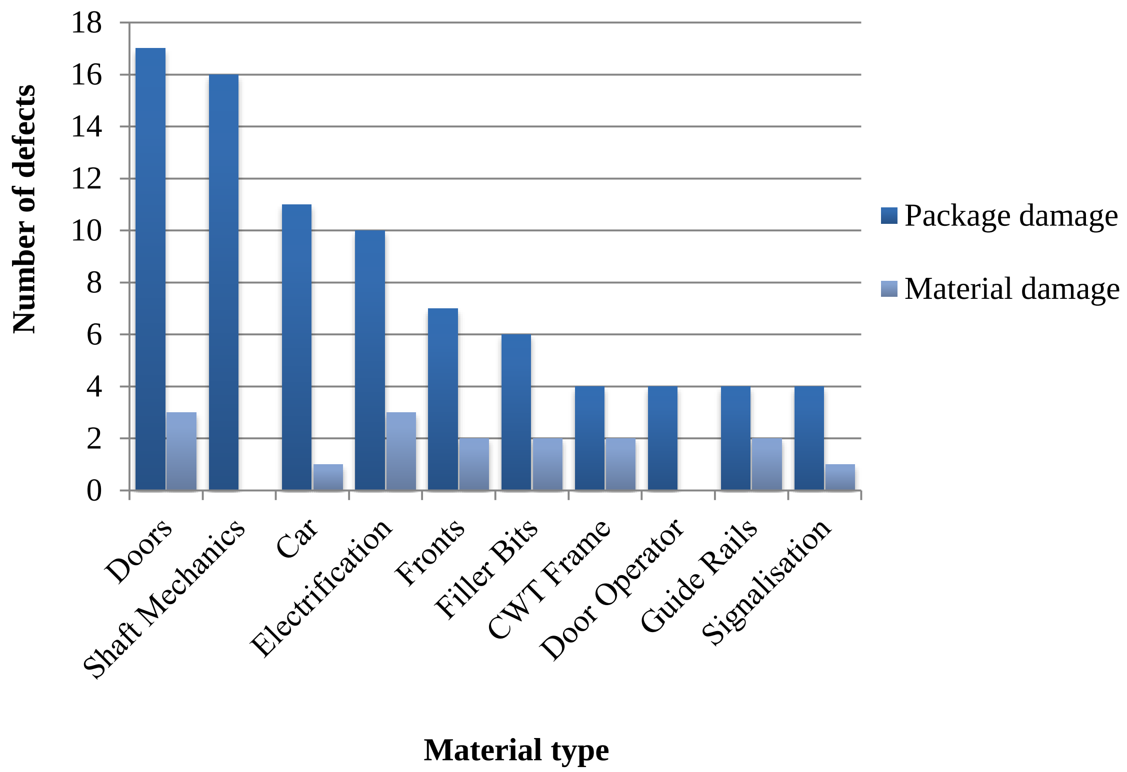
Because the data was analyzed simultaneously as it was received, corrective actions could already be planned. Acute corrections for package design as well as unloading methods were piloted in the middle of the ongoing project to avoid further defectives. Deficient package design was one root cause that needed to be corrected immediately.

When the root causes for both process and packaging defectives were analyzed individually, they were also analyzed by suppliers and material types. Individual cause-related Pareto charts were created for the most contributing suppliers, with the most defectives. This was done to be able to measure the individual performance of suppliers; an important part of the case company's already implemented SQM. This part of the analysis is left out of this thesis due to the discreet data.

4.3.5 Defects by material type

The defects according to different material types were also included in the analysis stage. A descending graph was created to visualize the most common materials having either package of actual material defects. This was done in order to understand the problems at a material specific level.

Material types having the most defects are illustrated in graph 7. Materials without actual patterns for defects were left out of the graph. Therefore, only the essential data was focused on.



GRAPH 7. Defects by material types

The results of the material type analysis were used later on as supporting data for improving packaging solutions. These solutions are further introduced in the improve-stage of the DMAIC process.

4.3.6 Cause and effect analysis

To investigate the root causes on a deeper level, the Cause-and-effect diagram (figure 17) was used in support. The root causes to package and material defects were rather simple at the first glance. However, when putting together the diagram hidden causes began to arise. This analysis was used as support in the improvement stage.

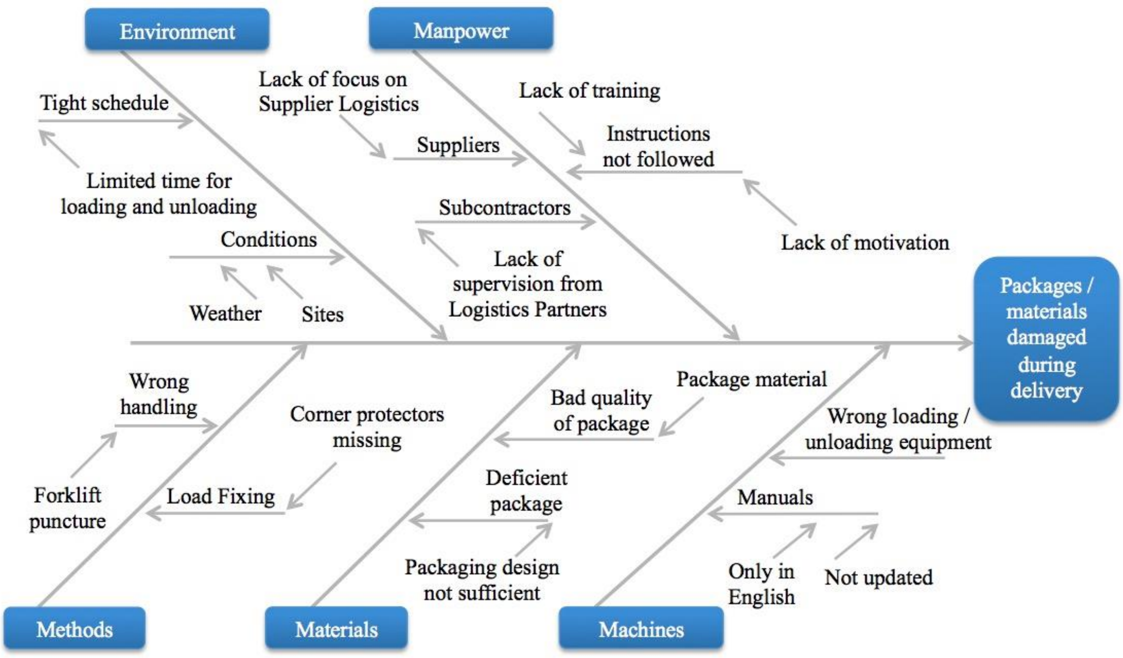


FIGURE 17. Cause-and-effect diagram

4.3.7 Calculating the Sigma level

In a Six Sigma project, the Sigma-level states the capacity of a process. Therefore, it was interesting to find out the quality of the processes and the supply chain as they currently were. DPMO was calculated according to the following formula (Karjalainen & Karjalainen 2002, 111):

$$DPMO = \frac{defects}{total\ opportunities}\ x\ 100\%$$

The total opportunities in this case were the 4133 deliveries inside the project scope within the four-month period. Out of these 4133 opportunities, 101 were defects. The DPMO were calculated as follows:

$$DPMO = \frac{101}{4\ 133}\ x\ 1\ 000\ 000 \approx 24\ 437$$

The DPMO was converted to a sigma level using a converter table, seen in appendix 3. The yield totalled to 97.56% and the process sigma was 3.47.

4.4 Improve

After collecting and analyzing the data, improvements on both processes and packaging were planned. The project team listed the proposals for corrective actions by arranging follow-up meetings. In these meetings, the results of the analysis were reviewed and brainstorming was used to come up with new improvement ideas. Specific action plans were created for loading and package development.

Based on the results received from the analysis, prompt actions were required in several areas of the supply chain. As mentioned, the implementations of some of the improvements were already planned as quick wins during the analysis stage. These quick wins were based on their rapid and easy implementation and were seen to have immediate benefits on the quality of logistics and related processes. The improvements were made based on the analysis of reports and pictures received, as well as the observations made from the visits to DCs, RLPs, and sites.

The Feedback Team reports all received logistics feedbacks. They are responsible for ordering replacing materials in cases of damage and they also keep track of the processing times and material costs. Since the processing time of one logistic feedback might be over two months to process (see appendix 4), all improvement ideas were very crucial and welcome.

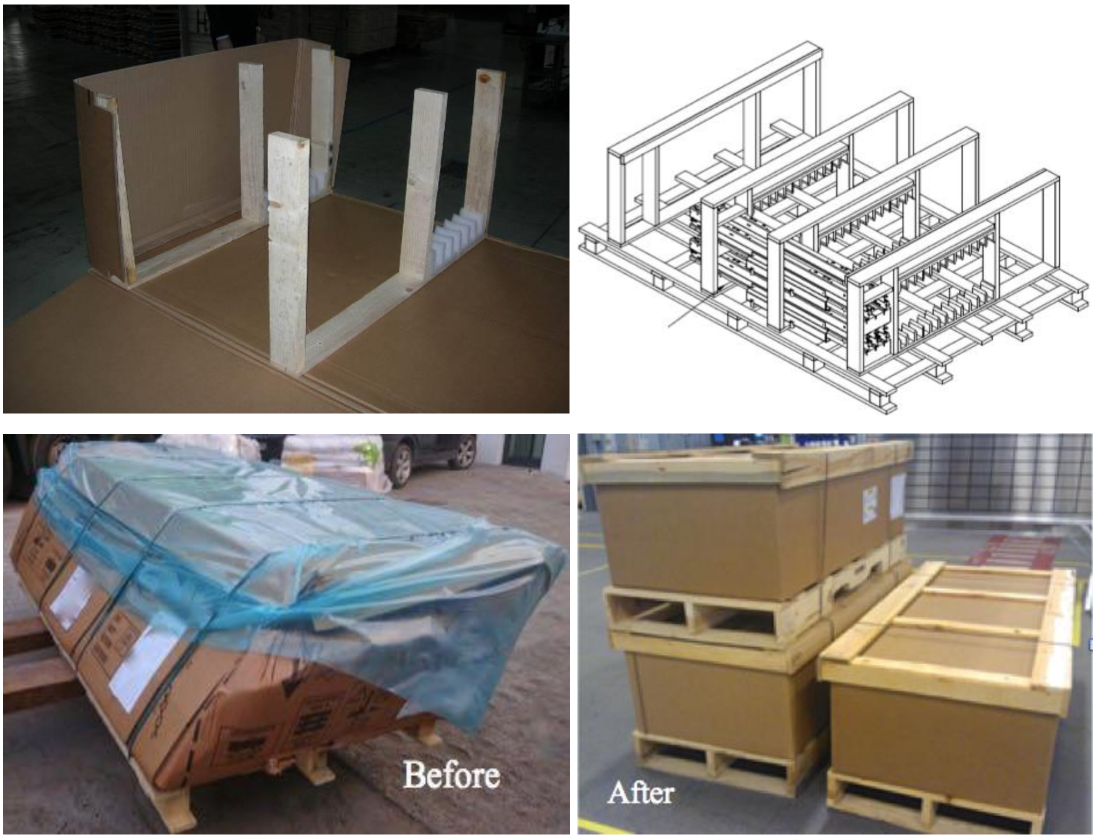
4.4.1 Packaging solutions

With the help of the case company's own Packing Solution Team, small supporting changes to the designs of packages were piloted for introducing process efficiencies. As mentioned in the analysis section, the root causes and number of defects was also analyzed according to material types. One of the most common causes was a deficient package.

One of the material types with a deficient package was shaft mechanics. The improvement was made by re-designing a more rigid carton type to stand under the pressure of fixing belts (picture 11). Also, the package size and shape needed to be changed to better fit the materials inside the package.

PICTURE 11. Shaft mechanics package improvement pilot

Door and car packages were also seen to be deficient, often leading to actual material defects. The package was re-designed and supportive materials were added inside to increase the package rigidity. Supportive materials were also added outside the package to improve stacking capabilities and to help with load fixing.



PICTURE 12. Door package re-design

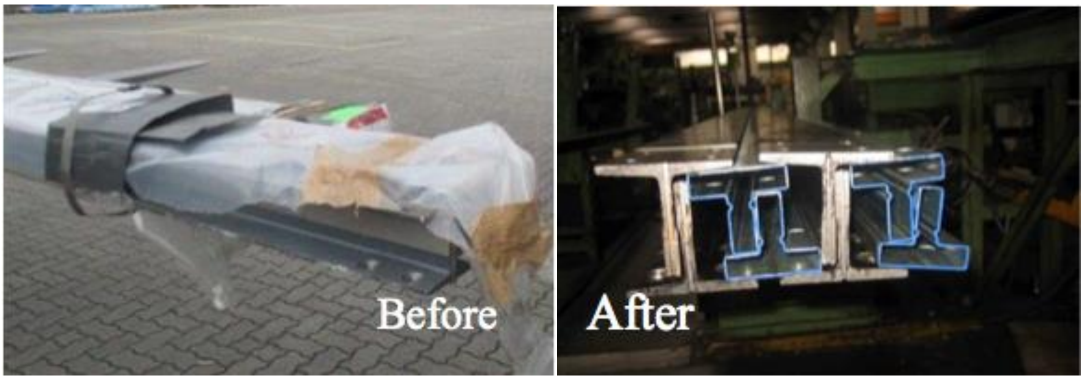
Front packages were renewed similarly with supportive materials added to the outside to allow stacking and better structure against physical stress. Fronts package was improved by adding supportive wooden planks in pallet footing.

PICTURE 13. Fronts package

Filler bit pallets were often facing humidity and damages due to the lack of protection and bad quality of the package. The package was improved by covering the materials with plastic foil. Also, package handling instruction stickers were added, which were missing before because there was nothing to stick them to. This improvement did not create any additional costs.

PICTURE 14. Filler bit packaging improvement

Renewal package pilots for guide rails were designed to cover the material in a better way and to make the bundle thicker with polystyrene in between. Before, there was only plastic foil to cover the materials, which made it easier for the materials to be damaged and the stacking capability quite difficult (picture 15).



PICTURE 15. Guide rail package improvement pilot

Along with individual improvements on packaging solutions for specific material types, general improvements were also made. Many packages had wrong lifting instructions and therefore, the markings were renewed. One improvement for this was adding marking of center of gravity into handling units, where center of it is not centrally located.

The costs for improvement are still being evaluated from the improved pilot packages, and therefore, no information on total costs material costs for old package versus new package are available. Also, the discussion about the scenario of reduces in the cost of bad quality after improvements is still ongoing and will therefore be left out of this thesis.

4.4.2 Material handling

A substantial issue with process defectives was that the case company's existing logistics guidelines and standards were not properly followed and were being neglected - even though an instructions manual did exist. As a quick win, the case company's logistics manual for loading and unloading instructions was updated, and to ensure a proper distribution, it was shared with all Logistics Partners. The manual was to be handed to every warehouse operator, truck driver and forklift driver.

As most subcontractors of the company's Logistic Partners did not understand English, Logistic Partners were required to release their own end-user manual, which was translated to local languages to improve the communication between all parties.

Another requirement for Logistic Partners was to provide training on best practises for their subcontractors based on the manual. This was done to guarantee that all parties involved in logistic processes understood the guidelines given and would put them into practice. In addition to the manual, visual instructions were also placed in loading areas of DCs.

4.4.3 Supplier Quality Management

When analyzing the data based on reports coming from DC Inbound, it could be deduced that most of the materials had already been damaged when first arriving to DC from material suppliers. Before this quality project, the case company only audited closely DCs and warehousing functions operated by their Logistics Partners. However, after the analysis of the root causes, it was deduced that Material Supplier Logistics was in need of improvement. In order to improve SQM, the role needed to be defined more accurately and operations required further focus. Closer cooperation between SQM and packaging development was also required. 10 times better Supplier Quality Program for Logistics Suppliers was used to support the project improvements.

4.4.4 Long-term improvements

In order to improve the logistic processes in a way that the actions have long-term impact, the Operative Logistics, Packing Solution Team and SQM must establish a common development forum. To continue these long-term improvements, the case company's logistics would need a dedicated process and packaging quality person to conduct and lead further delivery quality projects, which need to be expanded to other areas to understand area-specific requirements and issues in KPIs.

Regarding packaging solutions, more customer-focused packaging designs need to be implemented. This requires the continuous cooperation between Packing Solution Team and installation functions, when releasing new products or packages.

4.5 Control

Repairing actions were planned in the improvement stage and they were piloted. In the control stage, the aim was to ensure that the methods would be implemented permanently. A control plan was made to ensure that the Six Sigma project was concluded properly and ready to come to its end.

The implementation of the new instruction manual was set as the first operation for the control plan. To guarantee that subcontractors were following the new instructions manual, Logistics Partners were required to arrange subcontractor meetings as a control method. In these meetings, the instructions manual would be explained and gone over to guarantee the punctual implementation of these instructions. The frequency of the meetings would be whenever there would be an update in the manual or when seen accurate. The participation would be obligatory for all subcontractors.

To ensure that the methods for loading and unloading were implemented according to the case company's standards, DC audits were planned to focus on the transportation side. Before, the audits only focused on warehousing activities. Audits would be expanded to all RLPs as well.

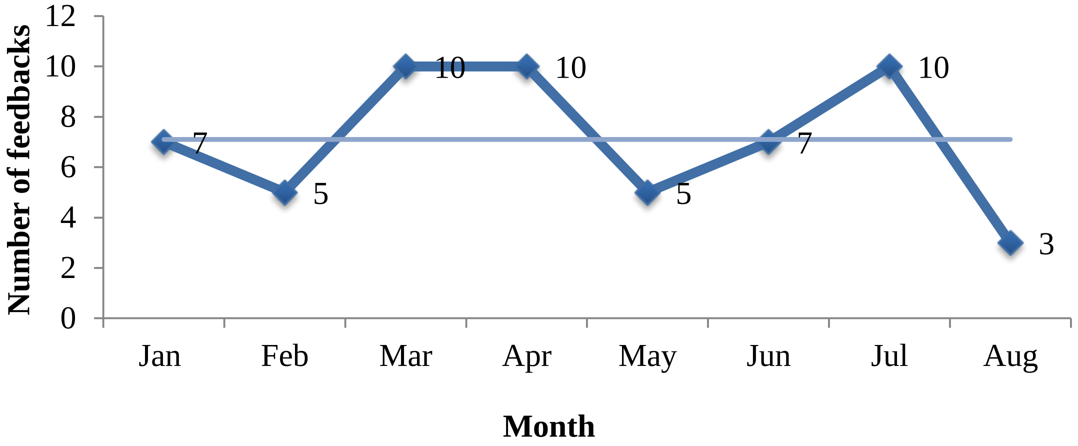
Another crucial aspect that needed to be controlled was SQM. Audits for Material Supplier Logistics were planned as control methods – starting from one of the case company's most substantial supplier. Furthermore, Logistics Suppliers were required to apply auditing practicalities also for their RLPs and own subcontractors. The frequency for these audits would be determined depending on the perceived need arising after the first audits.

On contrary to the control of processes, the quick wins made for package improvements would require follow-up as well. The control methods of packaging solutions would require close cooperation with installation functions to ensure that the all package designs would serve their purpose in the best way possible. As a reaction plan in case of a defective package design or material, the Packing Solution Team would need to start the planning and design of a better functioning solution.

4.6 After improvement

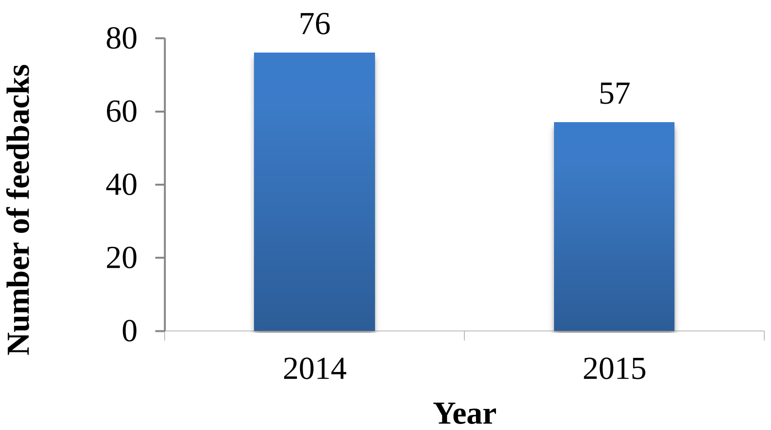
As the critical variables related to the performance of processes need to be controlled, a run chart of logistics feedbacks in 2015 was created at the end of the project (graph 8). The run chart was used to compare data between 2015 and 2014, whether there had been any influence of the project towards the amount of logistics feedbacks. The amounts of feedbacks give an idea of current process KPOs in terms of CTQ and CTC.

The monthly average of feedbacks in 2015 totalled to 7,1. When comparing this to the average amount of 10 feedbacks per month in 2014, the difference was -2,9 feedbacks per month.



GRAPH 8. Logistics feedbacks in 2015

A comparison table of the amounts of logistics feedbacks in January to August for 2014 and 2015 shows that the amount of feedbacks was reduced from 76 to 56, which indicates a reduce of 19 feedbacks. This can be concluded as a step into the right direction in improving the delivery quality.



GRAPH 9. Comparative table of logistics feedbacks Jan-May 2014 and 2015

As a final controlling action, a new cost analysis of logistics feedbacks at the end of 2015 needs to be made to be able to determine the accurate service level of KPOs and process quality. The financial benefits of the project can however be seen only at the end of 2015, when the feedback data is completely comparable with the data from 2014.

As the control stage of a Six Sigma project might last for several months, the documentation and follow-up of the actual implementation of the control plan is left out of this thesis. In the control-stage improvement plans and already made improvements to material handling and packaging are followed up on.

5 CONCLUSIONS

To conclude the Six Sigma quality improvement project, it was very clear that process related issues, which most commonly were related to the handling of materials, caused most of the defects in the supply chain. The most common supply chain stages having reports of damage were DCs and construction sites, which targeted the improvements externally to suppliers and the subcontractors of Logistic Partners'.

Package designs and materials were improved internally to be more durable for the long supply chain. Development for the processes and packaging functions were already started during the project to avoid further defects. Some improvement could already be seen during the improvement process as the amount of logistics claims reduced substantially. The final cost and benefits of improved quality are yet to be determined and need to be followed up on.

In the beginning of the thesis project, the methodology of Quality Management and Six Sigma were not at all familiar. Learning has developed consistently through the progression of the thesis process and the capability to use different Quality Control Tools has considerably improved. The process of DMAIC was also familiarized during the process, enabling its use in the future. Even though the case company's functions and the supply chain were already quite familiar, this thesis has provided a deeper look into the core functions of logistics and therefore a better understanding of what supply chain, logistics customer service and quality management really are in practice.

The lack of resources affected the data collection process. Even though induction e-mails were sent to Front Lines in the objective of explaining the importance of the project and the needs for reporting by the case company, not all was reported. This does not make the results less valid but only makes the total amount of reports smaller.

Whether damages are reported from DCs or construction sites, they often result to delays in construction schedules. This decreases the service level of logistics and therefore also the level of satisfaction of customers and contractors at the receiving end of the supply chain. The bad quality of processes and delivered products create costs, not only for the case company and its suppliers, but also to contractors and their customers.

This means that the entire supply chain is affected by defects, which could be avoidable by paying special attention to logistic functions such as packaging and material handling.

For a company with very big delivery volumes, the amount of damages and claims generated from defects is rather low. Even though it would seem that the current Sigma level of 3.47 would be satisfactory and close enough to the next level of 4 Sigma, which is the industries' average, there is still a long way to this level. Further, as the case company's goal is to have a superior supply chain in the industry, these problems need to be investigated and the processes and service levels of logistics need constant measuring and quality management.

6 RECOMMENDATIONS

Based on the obtained results I would recommend that the investigation of service levels and quality of the supply chain would be expanded into a wider area scope, also to overseas countries. This would give insight on area specific logistic problems caused by factors such as climate conditions and export regulations. Most probably, the case company will need a dedicated person specialized to further conduct these projects.

Even though the effect on sales of logistics customer service is quite difficult to determine, achieving a cost-efficient supply chain requires that the actual cost of non-quality needs to be known. Currently, the case company measures the cost of bad quality and damages only by material costs of claims. It does not take into account contributing costs such as reverse logistics, suppliers producing a replacement component, shipping the replacement material directly to site, as well as handling the claim, among many others. Therefore, I would suggest that the productivity of logistics functions in terms of damage and loss claims would be calculated as percentage of freight costs and sales also.

In addition to acknowledging the cost of bad quality, it is also crucial to know how much these costs are reduced by corrective actions. As a recommendation, I suggest that the expenses for old model versus new model, for especially internal packaging improvements, would be calculated. Also, the total effect of quality improvements in terms of reduces in bad quality costs needs to be determined. Without the proper measurement and understanding of all costs related to defects in the supply chain, its actual performance and the real effect of improvements made will remain unknown.

To be able to achieve top-level customer loyalty and satisfaction, it is also important not to only observe the quality of the company but also the quality of suppliers. This raises the relevance of SQM as a part of logistic customer service. I would suggest that also the cost of poor supplier quality would be measured to gather accurate data about supplier performance and thus take action when flaws are noticed. Quality management software could be used to support SQM for better interaction between the suppliers and the case company. By implementing best practices, the case company could improve the supplier quality and achieve their own supply chain objectives.

For improvements in processes, even though a new handling instructions manual has been created, its implementation by suppliers, Logistic Partners and their subcontractors should be audited. If local subcontractors are neglecting the instructions, a penalty in form of a fine from wrong handling could follow. There will be no changes in the situation by only auditing, giving notices and handing a new manual. All parties should be aware that they are not just suggestive guidelines, but mandatory to implement.

Lastly, I would recommend continuously and closely following up on the implementation and controlling of the changes made to processes and packaging within the first months. If the control stage of the DMAIC process is neglected, there is a great chance that the process will fall back to its old ways.

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APPENDICES

Appendix 1. Project Charter

Project Charter

IMPROVE DELIVERY QUALITY

Objectives

Need to avoid damages related to package and transportation quality, by putting under control handling, transportation and storage of packages trough the whole flow of materials, from arrival into Distribution Center until installation site. Also quality of package design and material need to be investigated to understand if it fits to our quality purposes.

Scope & Deliverables

IN SCOPE
Quality of deliveries arriving at terminals from suppliers
- Deliveries of elevators and TRB managed by KSU Logistics Europe
- Monitor Germany, France, UK, Italy deliveries
- Damages, near miss, processes, documentation

Quality of packages
- Quality of packages: design, materials, construction
- Damages, near miss

OUT OF SCOPE
Spare parts
Content of packages

TARGET
Root causes for deviations found, corrective actions defined and in place
-50% notifications in documents related to damages

Financial summary

000 €	PAST	2010	2011	2012	2013
Financial benefits					
Project costs					
RE 80 net impact					

Payback in years:

Main KPI: [as is] → [target]

Phases and activities

Explain the timing of key phases / deliverables.

Provide baseline plan for milestones.

K0 – Planning and preparation started
K1 – 03/12/2014
K2 – 15/12/2014
K3 – 15/01/2015
K4 – 15/02/2015
K5 – 15/03/2015
K6 – 30/03/2015

Organization

Project sponsor:

Project champion:

Project manager:

Project steering:

Internal reference group:

Key external partners and vendors:

Dependencies

Dependencies:

Damage and transport 2014 YTD
SOI: 36835,14
SOF: 4741,07

COPQ in FL 2014 YTD

Discreet, company internal data has been removed from the charter.

Appendix 2. Check Sheet

		Basic information		Delivery type	Moment of observation	Damage		Material	Additional information	Finding	
Date	Sales Ord	Feedback Ref	Co	DIR	(Inbound/DC/F	Package	Mater	Module	Open comment from site	Finding	Correcti
15.1.15	350014333	302070298	DE	DIR DEL	Site	Yes	Yes	Guide Rails	Fixing belts tightened	Wrong unloading	Prohibit usa
15.1.15	350042938	302061647	DE	RLP	Site	Yes	Yes	Doors	Forwarder damaged several	Bad quality of	Stronger pa
16.1.15	350028310	No FB opened	DE	Inbound	DC Inbound	Yes		Shaft Mechar	Fure shaft mechanics wood	Bad quality of	Reminder
2.2.15	350034473	302082663	DE	RLP	Site	Yes	Yes	Doors	Door package collapsed	Deficient package	Package to
4.2.15	350036231	No FB opened	IT	DIR DEL	Site	Yes		Doors	Glass package not protected	Plastic foil ripped off	Plastic foil c
4.2.15	350042086	No FB opened	IT	DIR DEL	Site	Yes		Doors	to wrong handling	Forklift Puncture	Unloading i
4.2.15	350049640	No FB opened	UK	RLP	RLP Inbound	Yes		Doors	Door package footing	Wrong handling	
6.2.15	350048525	No FB opened	FR	DIR DEL	Site	Yes		Signalisation	package looking bad and	Bad quality of	Supplier to
6.2.15	E8291668	No FB opened	DE	Inbound	DC Inbound	Yes		Door Railings	AMD LANDING DOOR	Wrong handling	
11.2.15	350050510	No FB opened	DE	Inbound	DC Inbound	Yes		Shaft Mechar	SMW pallet footing broken	Bad quality of pallets	Load
11.2.15	350034066	No FB opened	DE	Inbound	DC Inbound	Yes		Fronts	Supportive wood bar	Wrong handling	Load
16.1.15	350023517	No FB opened	UK	RLP	DC Outbound	Yes		Shaft Mechar	No edge protectors used -	Corner protectors	Topi To con
17.2.15	350009893	No FB opened	UK	Inbound	DC Inbound	Yes		Doors	Door railing package having	Forklift Puncture	Load
17.2.15	350045412	No FB opened	UK	RLP	Site	Yes		Doors	Pallet leg damaged under	Wrong handling	Load handl
17.1.15	350023517	No FB opened	UK	RLP	RLP Inbound	Yes		Shaft Mechanics		Corner protectors	Topi To con
20.2.15	350049640	No FB opened	UK	RLP	RLP Outbound	Yes		Doors	No edge protectors used,	Bad quality of pallets	
24.2.15	350004557	No FB opened	IT	DIR DEL	Site	Yes		Doors	To improve: doors packing to	Wrong stacking	Load handl
24.2.15	350054400	No FB opened	IT	DIR DEL	Site	Yes		Filler Bits	No edge protectors used	Filler bit pallet broken	Load handl
25.2.15	350037877	No FB opened	UK	Inbound	DC Inbound	Yes		Door operatoi	Door operator having fork	Forklift Puncture	Load
25.2.15	E8293288	No FB opened	FR	Inbound	DC Inbound	Yes		Cathead	Box damaged from top	Wrong handling	Load
27.2.15	350022453	No FB opened	UK	Inbound	DC Inbound	Yes		Door Railings	Box frames damaged with	Forklift Puncture	Load
27.2.15	350051920	No FB opened	DE	Inbound	DC Inbound	Yes		Fronts		Deficient package	Load
27.2.15	350052617	No FB opened	DE	Inbound	DC Inbound	Yes		Fronts	Band broken causing wood	Deficient package	Load
27.2.15	350053521	No FB opened	DE	Inbound	DC Inbound	Yes		Fronts	Package collapsed and	Deficient package	Load
27.2.15	350052487	No FB opened	UK	RLP	RLP Inbound	Yes		Electrification	Fork puncture in Slimpa	Forklift Puncture	Load
27.2.15	350046686	No FB opened	UK	RLP	RLP Inbound	Yes		Shaft Mechar	Carton box damaged under	Deficient package	Topi contac
27.2.15	350038466	No FB opened	UK	RLP	RLP Inbound	Yes		Car		Bad quality of	
27.2.15	350038477	No FB opened	UK	RLP	RLP Inbound	Yes		Car		Bad quality of	
27.2.15	350050646	No FB opened	FR	DIR DEL	DC Outbound	Yes	Yes	Electrification	Clandestines in trailer	Clandestine entrants	
27.2.15	350050430	302136287 & 30:	UK	DIR DEL	RLP Inbound	Yes	Yes	Electrification	350050430 - 350046717 -	Clandestine entrants	
3.3.15	350047027	No FB opened	UK	RLP	RLP Inbound	Yes		Guide Rails	3 SOI 350047027 -	Wrong stacking	Load
6.3.15	350024699	No FB opened	UK	DIR DEL	RLP Inbound	Yes		Shaft mechar	Shaft mechanics carton box	Deficient package	
6.3.15	350051931	No FB opened	UK	RLP	Site	Yes		Doors	Pallet legs collapsed,	Wrong handling	Unloading i

Appendix 3. Six Sigma conversion table

Sigma muutettuna DPMO:ksi ja saannoksi

Sigma	DPMO	Saanto	Sigma	DPMO	Saanto
6	3,4	99,99966 %	2,9	80757	91,9 %
5,9	5,4	99,99946 %	2,8	96801	90,3 %
5,8	8,5	99,99915 %	2,7	115070	88,5 %
5,7	13	99,99866 %	2,6	135666	86,4 %
5,6	21	99,9979 %	2,5	158655	84,1 %
5,5	32	99,9968 %	2,4	184060	81,6 %
5,4	48	99,9952 %	2,3	211855	78,8 %
5,3	72	99,9928 %	2,2	241964	75,8 %
5,2	108	99,9892 %	2,1	274253	72,6 %
5,2	159	99,984 %	2,0	308538	69,1 %
5,0	233	99,977 %	1,9	344578	65,5 %
4,9	337	99,966 %	1,8	382089	61,8 %
4,8	483	99,952 %	1,7	420740	57,9 %
4,7	687	99,931 %	1,6	460172	54,0 %
4,6	968	99,90 %	1,5	500000	50,0 %
4,5	1350	99,87 %	1,4	539828	46,0 %
4,4	1866	99,81 %	1,3	579260	42,1 %
4,3	2555	99,74 %	1,2	617911	38,2 %
4,2	3467	99,65 %	1,1	655422	34,5 %
4,1	4661	99,53 %	1,0	691462	30,9 %
4,0	6210	99,38 %	0,9	725747	27,4 %
3,9	8198	99,18 %	0,8	758036	24,2 %
3,8	10724	98,9 %	0,7	788145	21,1 %
3,7	13903	98,6 %	0,6	815940	18,4 %
3,6	17864	98,2 %	0,5	841345	15,9 %
3,5	22750	97,7 %	0,4	864334	13,6 %
3,4	28716	97,1 %	0,3	884930	11,5 %
3,3	35930	96,4 %	0,2	903199	9,7 %
3,2	44565	95,5 %	0,1	919243	8,1 %
3,1	54799	94,5 %			
3	66807	93,3 %			

(Karjalainen & Karjalainen 2002, 142)

Appendix 4. Feedback handling process

STEP	TASK	TIME PERIOD
1	Asking FL for transport documents (CMR) and Photos of damaged material	7 days
2	After receiving CMR and photo, the issue to will be addressed to Forwarder to confirm their responsibility	1-7 days
	2(a) Invoice will be sent to transporter, if they accept the responsibility, then feedback closed	
3	If no response for 1 week, the issue will be addressed with all documents to insurer with all documents as below 1. CMR 2. Photos of damaged material 3. Packing list 4. Original invoice 5. Copy of the mail which was send to Logistics Sevice provider 6. Letter of cargo claim 7. KONE Cargo Insurance - Notification of claim	1 – 20 days
4	Proforma invoice copy asked from invoicing Team	1-30 days
5	If invoice amount is high, Insurance company will ask to arrange site visit for surveying damaged materials. FL will be contacted for address and time.	1-5 days
6	After validation of all details which were provided in the insurance claim and site surveying, insurance company provide the acknowledgement payment and asked for SUBROGATION RECEIPT	1-5 days
7	Feedback team will provide the signed SUBROGATION RECEIPT to Insurer	