CHALMERS

To achieve Zero Defects at SKF Logistics Services Sweden loading area and hub area

MASTER OF SCIENCE THESIS

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ABSTRACT

The expected outcome from the thesis was to identify, verify and document recommendations to SKF Logistics Services (SLS) Sweden. This to reduce errors in the loading process, improve productivity and diminish non-value added activities.

Solutions and suggested improvements emerge from a Six Sigma project and benchmarking performed at SLS Germany. An extensive pre-study named Baseline was basis for the presented results. The pre-study additionally includes validated costs and time spent for activities. Some of the cost savings in the thesis are excluded because of confidentiality.

The current loading process has been measured through a six sigma calculator and the total level was stated to 4.30. There is also an improved loading process presented with three major differences compared to current. The first is managing goods equal whether internal/external or cross-docking. Secondly, each pallet has its own pre-advised storage place in loading area. The last is about clarifying responsibilities, change and standardise working routines. Additional, calculations have been made on utilizing the storage area around loading. It resulted in great improvement possibilities in terms of enabling more space and cost savings.

A database was implemented during the research period to improve the managing of deviations. The database improves the communication and information flow between departments within the organisation. Clear responsibilities for the employees are established for managing deviations in the future.

The thesis proposes an implementation sequence consisting of ten phases optimised for SLS Sweden. There are several suggested improvements presented, some are minor but the overall is about completely implementing scanning operation in the loading process. The time gain is estimated to 25 minutes per truck. There are four alternatives recommended for the process flow. Three are short-term solutions while one of them is a long-term suggestion of reconstructing the conveyor system. A Gantt schedule is developed for roughly time estimating the implementation of the different phases.

After an implementation of the suggested improvements, the number of errors caused at the loading process and non-values added activities (waste) will be reduced.

Keywords: SLS Sweden. Six Sigma, scanning, WASS, mapping, flow analysis, implementation strategy, logistics, transportation.

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GLOSSARY

Baseline	Pre – study Excel document
DER	Delivery Error Report
DEV	Deviation Report
DTS	Daily Transport System
HUB	International Hub
ICSS	International Customer Service System, Computer system for order handling, dispatching and invoicing of export order
RFID	Radio Frequency Identification
SLS	SKF Logistics Services
TPE	Transport Process Error
TrMS	Transport Management System
WASS	Warehouse Administration Service System
Force Loading	Manually executing loading function in WASS
Trip Close	WASS function, closing shipment to generate documentation

1 INTRODUCTION

The introduction chapter aims to describe the background of SKF Logistics Services Sweden, their approaches of continuous achievements and improvements. The present problem statement is explained, research questions are specified to facilitate solving the problem and delimitations of the thesis are clarified.

This master thesis is executed on behalf of SKF Logistics Services (SLS Sweden). It is a part of the authors' final obligation before fulfilment of their Master of Science on Chalmers University of Technology for the department of Logistics and Transportation. The master thesis is 30 credit points.

1.1 Background

The unit SLS Sweden is located at SKF Gothenburg as the only operational Logistics Services unit within the SKF Group Demand Chain in Gothenburg.

SKF Logistics Services is an independent business unit which is providing Factory Material Handling, warehousing, and transportation world-wide services to customers within and outside the SKF Group, including support for the corresponding information flow. The main activities are related to distribution of finished products to final customers.

Figure 1.1 *Sweden Logistics Service Warehouse*

SKF strive for continuous achievement of Zero Defect (ZD) in the production. In the theory, ZD is a description of an ideal state but in reality though, there are constant confrontations with different kinds of disturbances that dramatically increase the risk of broken promises and customer complaints. SLS Sweden aims to have a Zero Defect loading process. The problem is the amount of errors caused at loading which are considered to be high. The errors can be related to wrong loading, poor communication resulting in short shipment, broken promises and customer complaints. The time spent on non-value added activities such as searching for goods are considered to be high and should be reduced.

A well-known term within warehouses is RFID and stands for Radio Frequency Identification. The technology uses radio waves to identify objects, the methods can vary but the most common is a microchip attached to the object and an antenna that receives the information (Aimglobal, no date). The technology is one solution to similar problems as SLS Sweden experiences and has been investigated in previous project to review the possibilities for implementation at the inbound and outbound areas. However, it is not solution for all problems and is an expensive technology. RFID is although not excluded as long-term improvement.

To reduce the number of defects and to achieve excellence in new and existing processes, SKF approaches the principles of Six Sigma in any project. In 2003 SKF decided to adopt Six Sigma as a unified approach for the entire SKF Group for continuous improvements processes.

Today, there are around 2.500 actively persons working as Six Sigma project leaders at SKF (SKF, no date).

The computer system used at SKF Logistics Services is called WASS (Warehouse Administration Service System). The system handles functions required in the warehouse such as goods inwards, goods replenishment, picking, packing and loading. WASS manages the warehouse operations in real time and is the link between the global distribution networks of warehouses within SKF (Fossum et al, 2004). It is additionally the link between other administrative systems, transportation management and warehouse operations

Figure 1.2 *Warehouse operations*

1.2 Purpose

The purpose of the research is to find suggestions to reduce the number of errors caused at the loading process in order to aim the targets of Zero Defect and reduce non-values added activities (waste).

1.3 Problem statement

The main problem at SLS Sweden is short shipment of goods. Simply, this means that the customers expect the goods but do not receive it according to the promised lead time, resulting in broken promises and customer complaints. Currently, there is no comprehensive statistics over the total number of defects in the loading process. SLS Sweden is aware of the non-value added activities regarding time spent of searching for goods related to the loading process. The reasons are assumed to be related to the location of goods, storage limitation and communication difficulties.

There are several departments interacting with each other and the communication/information flows from the administration level where the orders are received and processed, to the final step in the process which is the loading area.

The expected outcome from the research is to identify, verify and document recommendations to SLS Sweden, for reducing errors in the loading process, improve productivity and reduce non-value added activities (waste).

Research questions

1. Are there any critical factors in the current loading process causing short shipment?
2. What types of deviations are commonly appearing in the loading process and do they differ between the shifts?
3. What improvements can be suggested to improve the managing of deviations, to reduce the waste and common errors? Consequently, what implementation strategy should be applied for a successful implementation?

1.4 Scope and limitations

The scope of the project is from the point in time when goods have passed the pack-reporting process at loading, to the time the goods are loaded on the trucks. It might become visible that there are complications in other warehouse operations before the pack-reporting stage, affecting the loading process. If so is the case, those complications will be described and not in-depth analysed.

2 THEORETICAL FRAME OF REFERENCE

This section explains different concepts, tools and terms used. The frame of reference is elected after the purpose and problem statement. This chapter gives the reader insight in the various parts and opportunity to return and learn more about the concepts while reading upcoming chapters. Some of the described techniques are already used at SLS Sweden, for instance Zero defect, Six Sigma and WASS.

2.1 Zero Defect

The concept of Zero Defect (ZD) promotes a constant, conscious desire to do a job right the first time [Halpin, 1966], where the performance of the individual have a crucial role. A way to efficient performance is by constant awareness; where the workers task is important, the product the worker is working on is important and the effort by the worker is not neglected by the management. To strive against the concept Zero Defect five requirements must be fulfilled illustrated in the figure 2.1 below. In theory it describes the ideal state but in reality the process is confronted with different kinds of disturbances increasing the risk of errors in manufactured products (SKF Group, 2007).

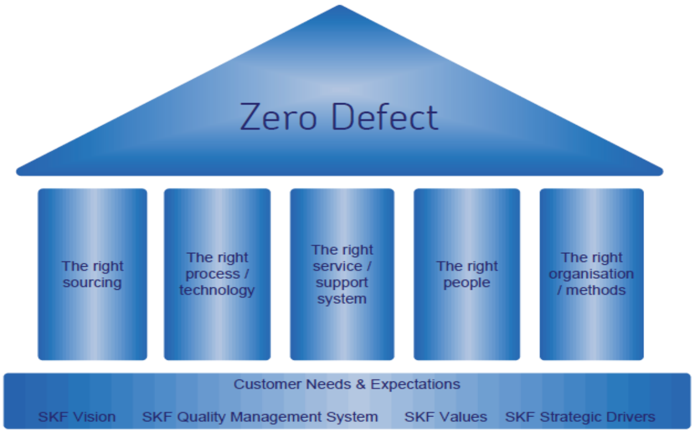

Figure 2.1 *The five requirements for achievement the concept Zero Defects (SKF Group, 2007)*

1. The right Sourcing – Concerning the quality of the purchased components, products or material.
2. The right Process and Technology – Accentuate the requirements on accomplishing key activities i.e. Process Improvement and Tooling Management.
3. The right Service and Support Systems – Focusing on support functions in manufacturing channels or cells.
4. The right People – Educating and developing personnel, competent staff can prevent more that defects occurs comparing to the installation of a new process or device.
5. The right Organization and Methods – Concentrate on the organization and management that operates the manufacturing process. Careful guidance and directions to increase efficiency of the employee on a day to day basis. (SKF Group, 2007).

The implementation of Zero Defects requires ability, skills, commitment and prioritizing to commence a time bound, goal-oriented work and to present ways and resources to accomplish the five dimensions of the concept

2.2 Six Sigma

According to Bergman and Klevsjö (2006), Six Sigma is an improvement tool that results in great gains in shape of both reduced costs and customer satisfaction. σ (sigma) stands for standard deviation. The term Six Sigma was introduced at Motorola during the 1980´s as an improvement program with focus on reduction of undesired variation. Undesired variation is an important source to costs and dissatisfied customers, General Electric express this as "our customers feel the variance, not the mean" (Bergman & Klevsjö, 2006). The objective of using Six Sigma is a measureable reduction of undesirable variation. The reliability implies reduced costs, improved customer satisfaction and can furthermore lead to improved delivery reliability which provides less customer complaints.

Summers (2011) stated that Six Sigma is about results; enhancing profitability and reducing costs through improved quality, productivity and efficiency. Six Sigma emphasizes the reduction of variation, a focus on doing the right things right. The goal is to reach 3.4 defects per million opportunities.

The UK Department for Trade and Industry defines Six Sigma as: *"A data-driven method for achieving near perfect quality. Six Sigma analyses can focus on any element of production or service, and has a strong emphasis on statistical analysis in design, manufacturing and customer-oriented activities."* (Bussinessballs, 2005)

General Electric (GE), seen as the first large-scale adopters of Six Sigma after Motorola, and considered by experts to have been the reason for Six Sigma's rapidly development, defines the concept as:

"Six Sigma is a highly disciplined process that helps us focus on developing and delivering near-perfect products and services. Why 'Sigma'? The word is a statistical term that measures how far a given process deviates from perfection. The central idea behind Six Sigma is that if you can measure how many 'defects' you have in a process, you can systematically figure out how to eliminate them and get as close to 'zero defects' as possible. To achieve Six Sigma Quality, a process must produce no more than 3.4 defects per million opportunities. An 'opportunity' is defined as a chance for non-conformance, or not meeting the required specifications. This means we need to be nearly flawless in executing our key processes." (Bussinessballs, 2005)

An essential part for a successful use of the Six Sigma methodology is structured training of team leaders and teams. The levels of expertise are: Master Black belts, Black belts and Green belts. Master Black belts work full time, teaching and guide improvement projects, Black belts work full time and organize improvement teams, Green belts work part-time on Six Sigma projects. (Bussinessballs, 2005)
Six Sigma project teams commonly use the DMAIC model which is a structured improvement cycle. DMAIC stands for:

D - Define opportunity
M - Measure performance
A - Analyse opportunity
I - Improve performance
C - Control performance

2.3 Business Excellence

The approach of Business Excellence is the structured use of quality management principles and tools in business management. In broad term Business Excellence is described as various business models with the purpose to increase the level and dependability of performance in the operation of a company. The approach is based on a set of eight fundamental concepts; Results orientation; customer focus; leadership and constancy of purpose; management by processes and facts; people development and involvement; continuous learning, innovation and improvement; partnership development; and public responsibility (Business Performance Improvement Resource, 2002). The models such as Baldrige and EFQM are frameworks used to assist the implementation of Business Excellence principles and a systematic and effective way measuring how methodically the adoption has been integrated.

A challenge encountered when using business excellence model is that the models do not provide any solutions. Even though understanding the conditions and responding with the organisation's practices or outcome, it should bring clarification relating to what the organisation should be considering. Business Excellence does not give precise guidance on how to improve performance, it is left to the user to find ways to improve (Business Performance Improvement Resource, 2002).

SKF approaches excellence by their own developed model consisting of four categories: Values and Drivers, Principles, Methods and Results. SKF defines Business Excellence as: *"Delivering values to our customer in the most effective and efficient ways possible, through fully utilising the knowledge of our people, our partners and our technology"* (Johnstone, 2011).

2.4 Benchmarking

Establishing operational benchmarks, senior managers can drive organisational improvements. When performing benchmarking the main purpose is to emphasize how key operational elements are shaped against best in class competitors, resulting in identification of key areas for improvement (Slack et al, 2002). An approach of benchmarking is to set realistic performance standards. The common types of benchmarking are listed below.

Non-competitive benchmarking – External organisation not competing within the same market.
Competitive benchmarking – A comparison between the competitors in the same, or similar market.
Performance benchmarking – A comparison between the levels of achieved performance in different operations
Practice benchmarking – A comparison between an organisation's operation practices and those adopted by another operation.

Karlöf & Östblom (1993) defines benchmarking as:

> *"Benchmarking is to systematically compare, evaluate and learn from good role models, regardless of industry and geographic location. The aim is to gain insight and knowledge and transform these into effective improvements in their operations."*

The company Xerox has developed a benchmarking model consisting of ten steps. Other companies have developed similar models with slightly different classification. The following describes the workflow step by step based on the Xerox model.

Step 1: What is to be compared?

Karlöf, Lundgren & Froment (2000) explains that benchmarking is applicable across the enterprise and can be used on products, sales, billing, design, production, quality, management practices and more. The first step is to map the own operations, its processes and outcomes, for example by making a flow image of the company.

Step 2: Identify Company to compare with

This is about finding the best possible business and organization to collect data from. A benefit is to find more than one company to compare with and the companies should have competing products, or similar processes (Karlöf & Östblom, 1993).

Step 3: Data collection

Step 3 is gathering information from other companies. To achieve good result, well preparations are needed before the data collection begins. One way is by doing a competitor analysis. The same carefully preparation is also necessary for a business visit or telephone interviews (Karlöf & Östblom, 1993).

Step 4: What is the difference?

Next step is to determine the competitive gap between the own level and the company which has the best results. If the comparing company is better, Camp (1993) says it should bring some questions as “why are they better?”, “How much better?” And “what can we learn from them?”

Step 5: Predicting the future

Assessing the future is not easy. However, it is necessary to attempt to measure future performance in order to set up internal goals (Camp, 1993).

Step 6: Provide information of the benchmarking

Camp (1993) claims that scepticism from the personnel while introducing new working practices are always to be reckoned with. Therefore it is of great asset of well-designed information campaign against the organisation to create acceptance for the introduction. An important aspect is to describe the benchmark findings and explain the working methods, not just explain the best methods.

Step 7: Set new targets

By using benchmarking conclusions, new goals can be formulated which provides a description of future performance. Benchmarking is in addition, not only following best practice, but also a good tool for establishing targets (Camp, 1993).

Step 8: Developing work plans

During the development of the action planning from the benchmarking conclusions, it is important to account two factors (Camp, 1993). The first includes the standard questions as who, where, when and how things are distributed and performed. The second factor refers to behavioural aspects of the employees at the introduction of a change.

Step 9: Implementation and monitoring improvements and results

There are different ways to implement the developed work plans. Executing changes by management themselves is one way. Another way is to form a project team for implementing the changes. The follow-up procedure is to review whether any progress has been made but also discern differences. The reasons for the differences must be determined and the significant should be addressed (Camp, 1993).

Step 10: Evaluate the result and reassessment

The last step in the improvement process is to evaluate whether the company has achieved its desired goals and how well it has been compared to the comparative enterprise. Benchmarking should eventually become part of the business. It is sought managers to benchmark themselves to search for best practices (Camp, 1993).

2.5 Communication/Information System

A successful information system (IS) has many advantages to offer for managing issues. Information system can gather information and make it easily accessible for users and make the work more efficient. It brings structure to the information within the organisation, serves, helps and supports the users (Yeo, 2002). Implementing information system improves the work within the organisation and makes it more time-effective. The business may prosper and make financial profit (Stewart et al, 2002).

There are critical factors that can contribute to an unsuccessfully use of IS. One disadvantage of using IS, is that it takes lot of time to develop a well-made information system for the specific organisation (Yeo, 2002). If the organisation does succeed in developing a custom-made information system, next fail factor is if users are able to handle the system. Those who are meant to work and use the information system need to be familiar with its techniques. Users have to be trained and prepared to perform their work properly. Simply dumping a system on an unprepared support team will not be appreciated. The amount of training will vary with the scale of the system. If the system is not very complicated, provision of user manuals and support manuals will be adequate. More complicated systems might require specific training guides and support material, such as tutorials or simulations.

Fox (1998) presents an investigation in the amount of training the employees are given in information systems. It shows that several companies do not have any training or not adequate training. It also appeared that obtaining training on managing an information system, the employees overall satisfaction of the system increases.

2.6 WASS – Warehouse Administration Service System

WASS is a computer system used to increase the efficiency of distribution and warehousing at manufacturers. The concept was developed by SKF with collaboration with MA Systems. WASS supports the main functions required in warehouse administration (Fossum et al, 2004):

- Goods inwards
- Goods replenishment
- Picking
- Packing
- Loading
- Inventory control

The outcome of WASS at manufacturers is increased productivity by more efficient workflows and high accessibility of the system. The computer system allows manufacturer to control the product flow from the point it is in production until it reaches the customer. WASS has eliminated paper work, and the logistics concept has enabled novel ways of working (Fossum et al, 2004).

2.7 Warehousing

The general description of warehousing is "the performance of administrative and physical functions associated with storage of goods and materials" (Businessdictionary, 2007).

Presented by Frazelle (2001), a set of principles are developed to separate successful warehouse operation with no class warehouse operations. These principles are common denominators according to Frazelle (2001) of successful projects and operations as described below:

- *Profile* – Create and maintain order and product activity profiles to identify bottlenecks and opportunities for improvements.

- *Benchmark* – Facilitate the opportunity for improvements and to define the reasonable investment in new material and information handling systems.

- *Innovate* – Reconfigure warehouse processes by eliminating and streamlining as much labour as possible.

- *Automate* – To computerise and mechanise warehouse operations.

- *Humanise* – To involve shop floor employees in redesigning warehouse processes by developing teams and individual goals and also implementing ergonomic improvements in every manual activity.

Warehouse procedures have essential set of common events which are explained briefly below (Frazelle, 2001):

- *Receiving* – Activities involving the systematic receipt of all inbound materials to the warehouse, providing guarantee that the quality and quantity of the materials are as ordered and distribution of materials to storage or other departments needing them.

- *Pre-packaging (Optional)* – When products are received in bulk from a supplier and subsequently packaged separately or in combinations with other parts to form kits or varieties, then pre-packaging is performed in a warehouse.

- *Put-away* – Is the performance of placing goods in storage, concerning material handling, verification, location and goods placement.

- *Storage* – It is the physical area for storing goods while waiting for demand. The method of storage is depending on the quantity and size of the items in inventory and the handling characteristics of the product or its container.

- *Order picking* – Is performed when items are removed from the storage to meet a specific demand. Most warehouse designs are based on the process and is the basic service a warehouse delivers.

- *Packaging and pricing* – Basically the same as the pre-packaging process, when separately goods or mixtures are containerised for more suitable use. An advantage though is when this process is performed after picking, providing increased flexibility in the practice of one-hand inventory. Pricing is done at this point as well.

- *Sorting and accumulation* – When an order includes more than one product and the accumulation is not made as the picks are prepared. Sortation of batch picks into individual orders and collection of distributed picks into orders must be fulfilled.

- *Unitising and shipping* – These processes are the last before the goods are delivered to the customer. The processes includes tasks such as checking if goods are right according to order, packaging goods in appropriate shipping mode, preparing essential documents including packaging list, customs and invoice. Finally weighing the shipment to determine the shipping charges and loading the trucks.

The benefit of warehousing is enabling storing of goods when their supply surpasses the demand and realising them when the demand is more than immediate productions. This leads to ensuring consistent supply of goods in the market and assist to stabilising the prices by matching supply with demand (Frazelle, 2001).

Warehouse Layout

To define a world class standard on layouts in warehouses it is important to have accomplished profiling, benchmarking, simplifying computerising and mechanising warehouse operations (Frazelle, 2001). By these five steps the importance is to assemble those processes and systems in a flexible and efficient way to construct an optimised layout for the warehouse. The requirement for the five-step methodology is activity profile of the warehouse, the goals and performance for the operation, the characterisation and configurations of the warehouse processes and the configuration of all material handling and storage systems.

According to Frazelle (2001), by using following principles insures that the warehouse will meet world class standards. The first step towards a world class standard is to determine the overall space requirements for all processes in the warehouse i.e. receiving staging, pallet storage, case picking, shipping staging, cross-docking, offices, restrooms etc. Next step is to decide the material flow, is the warehouse suited for a U-shape, straight through or modular overall flow design. The U-shape flows which are the most common have some benefits over other flow such as the excellent utilization of dock resources because the receiving and shipping processes share dock doors. The third step is adjacency planning which means to locate functions with high adjacency requirements close to one and other. For example, reserve storage ought to be situated close to receiving, since there is a lot of material flow between them. The fourth step is to distribute processes with high storage requirements to high-bay space and labour intensive processes in low-bay space. Final step is to document expansion and contraction strategies for each warehouse process, this to accommodate the rapid pace of change in the warehouse such as size of warehouse, lead-times and technology.

Computerizing Warehouse Operations

The main purpose for the computer in the warehouse operations is to assist the warehouse managers to manage and to help operators to operate (Frazelle, 2001). The computer in the manager's point of view should assist him/her on continuously profiling warehouse activity and help managers pinpointing and anticipate problem areas. For the operator the computer should facilitate hands-free and paperless activities.

2.8 Key factors for implementation

To accomplish a successfully implementation the organisation requires to merge general key factors such as workforce, communication, system and management (Fui-Hoon Nah et.al, 2001).

2.8.1 Workforce

To accept changes the workforce requires proper education to increase competence, the right motivation and dedication towards the organisation for the changes to be successful.

Awareness

As stated by Dooyoung (1998), understanding the need for change and the threats of continuing the process as usual makes the employees ready for accepting the changes. When employees have accepted the changes, the next step is motivating employees for making the changes this through educational program. The educational programs make employees more relaxed and less threatened by the coming situation.

Education

In general, it is believed that learning and practice improves an individual´s competence to accomplish a task. It raises the confidence in their abilities to do what they are supposed to carry out (Shea & Howell, 1998).

According to Kathawala (1994), Successful implementation in an organisation requires education from management level to the rest of the affected employees.
Yeh (2003) discuss about two major elements of learning and education. The first one, "employees project involvement", is about integration and participation in improvement projects. The second, "training received", implies the training provided from the organisation.

According to McQuater et al. (1995), by poorly designed education and support program causes inappropriate use of tools and methods. Resistance by employees to changes which leads to decreased motivation to apply the new tools and techniques.

2.8.2 Management support

For any kind of implementation or changes in an organisation, without top management's commitment and involvement the changes cannot fully emerge. Lee (2002)

As Levetto (1992) states *"Without an involved and active top management, changes in an organisation are impossible"*

Common approaches for top management to motivate employees and increase dedication are by different educational programs and promotions. The mentioned methods give the employees a chance to improve in skill and feel appreciated. By satisfying workforce, the implementation will become considerably facilitated.

2.8.3 Organisational Communication

Without communication, organisations cannot operate (learnmanagement2, no date). If the communication is not clear and standardised throughout all levels in the organisations, employees will not understand the objectives and cannot strive to achieve them. Therefore developing a clear and systematic communication channel diminishes the possibility for sending unclear information. The importance of standardised communication channel is that all employees communicates and receives information in the same way. If though the channel is poor, it can prevent all or some of the information being transferred resulting in unexpected outcome and misunderstanding.

2.8.4 System

In an organisation several different system are frequently used depending on the operation. For example there is system for invoicing, system for communicating between different departments and system such as WASS for performing warehouse operation. As Dean Mayer states (NDMA, 2011) "*Organisational system is stable, influence everyone's performance, and can be consciously designed*", it is therefore vital to create systems that are accessible and user-friendly to be completely operated.

2.9 Synthesis of presented theory

Zero defects, Six Sigma, Business Excellence

Zero Defect, Six Sigma and Business Excellence are already well known within the organisation of SKF. The aim of describing those concepts is to give the reader opportunity to refresh their knowledge and for readers less familiar in the subjects as an insight in the concepts. The thesis will strive to follow the DMAIC-model in Six Sigma as much as possible because of two main benefits. Primary because of maintaining current methodology for conducting projects within the organisation, instead of adopting new unknown concepts for the management. Secondary benefit enables to continue developing ideas with this report as basis. The current process will also be determined by Six Sigma level which enables measuring the difference before and after an eventual implementation of improvements.

Benchmarking model

The research will include a comparison between SLS Sweden and SLS Germany. There are several theories and literature of how to benchmark but Xerox ten-step model is chosen to be presented because of its simple arrangement. It is supposed to be an access, especially for the preparations before the visit, to learn more about benchmarking methods. However, the model is not meant to be followed entirely, just act like support. To follow step by step would need extensive effort with carefully planning from both organisations and it is believed to be excessively comprehensive in this research, particularly the implementation and monitoring step.

Communication/Information System, WASS

From the problem description in chapter one, it is assumed to be communication weaknesses related to the problems. This section of theory will work as reference for further discussions on how to solve the communication issues. Advantages and disadvantages are clarified by different authors regarding implementation of information system.

Warehousing

The warehousing theory aims to describe different warehouse operations in general. However, each organisation has its own structure and procedure and so does SLS Sweden. Each main activity at SLS Sweden will be presented in chapter four.

Key factors for implementation

The master thesis will provide an implementation strategy for suggested improvements. Therefore it is important to create awareness of key factors while implementing new working methods. The theory of key factors will be basis for developing crucial factors specified for SLS Sweden.

3 METHODOLOGY

The research includes literature study, interviews and documents study. This chapter describes the approach of obtaining an overall perspective of SLS Sweden, approach for information gathering such as observing, informal meetings, benchmarking and compilation of the data collected. Moreover, the Six Sigma project is explained, which is the chosen method for reducing the number of defects at the loading process. The research also includes an implementation of a database and an implementation strategy for other improvements suggestions, why the course of actions taken are established in this chapter, both for the already implemented database as well as the planning of the future implementation. Finally there is validation of the gathered information.

3.1 Research strategies

The information gathering process can be divided into three categories; observation, data collection and interviews/informal meetings. Birley and Moreland (1998) distinguish between quantitative and qualitative research methodologies, the former for reaching many people and the latter as a detailed research methodology. Denscombe (2004) describes quantitative data as collected data in form of numbers that can be presented in e.g. graphs or tables. It requires statistical analysis by using computer systems and software packages, and is used when there is a requirement of large-scale information.
The data collection below correspond quantitative research methodology while the qualitative research methodology was composed of informal interviews or like Dawson (2006) describes as unstructured interview. According to Dawson (2006) unstructured interviews consists of few questions by the researcher and the participant tells about a life experience instead. This method was preferable used to obtain in-depth information.

3.1.1 Observation

The research started with "walking the process" from beginning to end and dialoguing with the employees with the aim to get the overall picture of SLS Sweden. This is also known as Genchi Genbutsu which is a key principle for lean philosophy. In order to understand a situation one needs to "go and see" (Pereira, 2009). The preparations consisted of theoretical studies of the work instructions for each task in the process, this to get a perception of work performance. The observation began at floor 100 (goods receiving and picking), continued at floor 300, 400, 500 (goods picking) and ended at floor 200 (weighing, strapping, loading). Observation was also performed in the administration, within the Transport department and Customer Service.

Simultaneously, the opportunity was taken to identify any kind of problems. This was done by participating in the working tasks, according to following examples:

- Participated in the forklift drivers working task while picking goods from the warehouse.
- Participated in preparations for loading by inventory goods and scanning of the goods. Observed the loading procedure of goods in trucks.

Figure 3.1 *Genchi Genbutsu*

Upcoming problems were faced and discussed with the employees and other complications that employees experienced were noted. The participation was repeatedly done at the loading floor capturing all the working shifts.

3.1.2 Data collection

All documented deviations and data gathered connected to the loading process was compiled in a excel document which represents the Baseline (pre-study) part of the research. The included parts:

- DEV reports – Deviations documented in loading
- DER reports (Delivery Error Report) – Customer complaints to Quality department
- TPE reports (Transport Process Error) – Action report made by Transport department

The data from the reports were further traced in TrMS, an internal search tool, for gathering specific data needed to fulfil the reports. The deviation reports are conducted in paper form by the loading personnel. To be able to analyse the deviations together with other data, deviation were manually typed from physical to electronic form.

The objective with the information gathering was to generate answers for questions according to table 3.1.

Table 3.1 *Data collection*

Data collection	
Nr of errors? Type of errors? Type of goods? Type of customers? Type of Destination/Mode?	Nr of complaints? Type of complaints? Cost red money? Cost per complaint? Sigma level?

Responding the questions provides opportunity to discern typical patterns of collected data. Determining the Six Sigma level is essential to be able to measure current state with future state.

3.1.3 Interviews and informal meetings

Informal meeting were held periodically with persons from all over the organisation e.g. personnel from Transport department and Customer Service, the Production Manager and employees in the warehouse. It became a part of "learning the current process" and lasted throughout the entire project. Without meetings it would be difficult for the researchers to learn all terms and approaches used in the organisation. The method was especially exercised for specifying the current loading process and detailed information was obtained by discussions with area experts. Figure 3.2 illustrates informal interview with production manager at SLS Sweden.

Figure 3.2 *Informal interview with Production Manager.*

3.2 The Six Sigma project

Early in the research it was decided to approach the Six Sigma principles. The research follows the DMAIC model; the ingoing parts in each section are stated according to table 3.2. The included elements aim to result in improvements that fulfil the purpose of the research and facilitate answering the research questions. Using the Six Sigma problem solving model will, among other things, identify problems occurring in the process and generate ideas for reducing the errors.

Table 3.2 *Six Sigma Methodology - DMAIC*

Define	Measure	Analyse	Improve	Control
Project Charter				
Pre-study (Baseline)				
SIPOC				
Process map - P Map				
	Flow Mapping (Visio)			
	Cause & Effect Matrix			
	Potential Failure Mode and Effects Analysis - pFMEA			
		Benchmarking SLS Germany		

The project charter is a definition of the objectives for the research. It describes where improvement opportunity exists in the process, i.e. the process where defect occurs. The project charter is found in appendix A. Pre-study is a data collection for defining the current defects and the extent of them. SIPOC is the voice of customer and helps to set the boundaries for the project. Process map is a graphical illustration of the current process with inputs and outputs. Flow mapping is similar to process mapping but does not show inputs and outputs. On other hand it displays decisions along the process and alternative ways. C&E matrix and P-FMEA analysis are rating procedures of critical factors and the latter also aims to recommend actions. Benchmarking is a methodology for comparing organisations processes within the same or from different markets. Calculations on cost savings is a part of the project but have been excluded from the DMAIC model because of confidentiality from SLS Sweden.

By approaching Six Sigma methodology is seen as huge advantage in many ways. Firstly, it brings clear structure and strategy from the beginning of the project with detailed planning. According to Hartman & Ashrafi (2004), poor project planning is the main reason to project failure, common reasons are fail to meet the stakeholder's expectations or not accomplishing the project in time. A project success depends therefore very much on the initial planning.

Another advantage is the awareness of the Six Sigma terms within the organisation. Like mentioned in the introduction chapter, SKF Group adopts Six Sigma as a unified approach for continuous improvements in any project. That to say, the chosen methodology may be the most important reason of why it is adopted in the research. The stakeholders will be able to follow and recognise tools and methods used. Moreover, the outcome enables to measure the process before and after implemented improvement suggestions. Practical implementation of the results from the Six Sigma project is however out of the context for this research. Therefore the responsibility lies on the organisation to measure the future state and compare it with the current.

3.2.1 Six Sigma project team

After the Baseline section was done, a six sigma project group was created. The team members were selected after competences in different areas, each of one contributing as specialists in their area of responsibility. The project team members consisted of 6 persons as following:

1. Master student 1
2. Master student 2
3. Six Sigma coordinator
4. Customer service – Area controller
5. Transport coordinator
6. Production Manager

Figure 3.3 *Sig Sigma meeting with focus on tools.*

The objectives for the project were to continue with the established six sigma elements with the pre-study as basis. The first meeting, see figure 3.3, was held after a couple of weeks of data collection. Initially, the project team stated procedures for coming meetings and agreements in objectives. Furthermore, clarify and agree in the process map which is a step by step description of the work process at the loading area and hub area.

The second meeting was about agreeing on the inputs and outputs for each step in the process map. The result was then transferred to a Cause and Effect Matrix for weighting the inputs in relation to the customer requirement. Considerable amount of time was spent to discuss and state the customer needs and rating the importance of them.

In the third and last meeting each group member answered for their own area of responsibility in the weighting procedure of the inputs. This was important due to obtain a truthful rate as possible. The next tool, P-FMEA, the highest rated inputs were further processed.

As summary, it could be said that the project team performed two major elements of the planning model: Process map and Cause & Effect matrix. The purpose was to utilize the expertise within the group and in such way obtain correct description of the Process map and relevant and trustworthy outcome of the Cause & effect Matrix. Thus, the research gained benefits in creating a project team.

3.3 Brainstorming

Brainstorming is an effective way to generate creative ideas for problem-solving and during the process those involved have free hands to be creative, no ideas are being criticised. The best way to approach brainstorming is according to Mindtools (1996) a combination of individual and group brainstorming, though group brainstorming requires a set of rules to be efficient. An advantage with individual compared to group brainstorming is the quality of ideas because different behaviours can affect the creativity of the brainstorming session. But when an individual member get stuck with an idea, other member's creativity and experience can evolve the idea to the next level resulting in a more depth analysis compared to individual brainstorming.

The method was commonly used when suitable, mainly when identifying the problems in the loading process and when providing suggestions for solutions. A mixture between the two types of brainstorming was performed, involving the employees from different departments. Instead of post-it notes on a whiteboard the brainstorming was performed electronically in Microsoft Visio. For the different suggestions solutions, brainstorming was combined with SWOT-analysis to get a broader perspective. SWOT-analysis is used for identifying Strengths, Weaknesses, Opportunities and Threats in an organisation.

3.4 Benchmarking SLS Germany

The benchmarking was performed at the SKF warehouse in Schweinfurt, during a 3 day visit. The arrival day consisted of a tour in the logistics warehouse, where "we walked the process" from the goods receiving until the pallets were loaded on trucks. A guide was held through the different departments such as Customer Service, Transport, Quality and IT.

Notable information was received on:

- How the documentation is made from the customer order until the truck driver collects the documentation when departing.
- Reporting deviation in loading.
- How departments communicate and handling the error.
- Distribution of work tasks and working hours.

The assistance person during the whole visit was the Manager for System Support, Quality and Environment whom described the process, answered and explained questions and considerations. Another employee, the Quality Manager, presented Qd, follow-up of deviations and Visio charts of working standards.

After every shop floor visit, the gathered information was discussed and summarised with the Manager for System Support, Quality and Environment. Lot of time was spent on brainstorming and working with our project between the different scheduled activities.

To facilitate the observation a camera was used to take pictures and video sequences in interested parts of the process (goods receiving, picking, pack-reporting, storing, collecting pallets and loading). Huge part of the information gathered were made both by informal interviews and prepared question sheet for the personnel at Customer Service, Transport, Quality, IT and Supervisors of picking/packing and loading.

The reason of choosing SLS Germany as benchmarking company was an obvious option. According to Slack et al. (2002) this would be a practice benchmarking, a comparison between an organisation's operation practices and those adopted by another operation. In other words, the great benefit is that SLS Germany is within the same corporate group doing same operations and equal purpose. But in extended range which means that the inbound/outbound amount are more than the amount at SLS Sweden.

Regarding the information gathered, Karlöf & Östblom (1993) presents alternative methods i.e. through surveys, telephone interviews or direct company visit. For this research, the last mentioned was preferable because of the significance of observing equal procedure from another perspective. As mentioned above, lot of information was collected by informal interviews. However, these interviews were limited in time because of daily tasks by the employees. In addition, some of the employees were not available during the visit, if so more information could have been received.

3.5 Implementation of database

During the project it became visible that some improvements could be done immediately. This was the case regarding the constructed database. Yeo (2002) states some potential failure factors while implementing information systems. One is that the users cannot handle the system. To avoid this scenario, the prospective users were given the opportunity to impact the structure of the database. The purpose was to create awareness of the system as well as raise the satisfaction among the users by involving them during the construction phase.

Even though the database is not very complicated, it was carefully taken in mind with information to the users and education during the implementation. According to Yeo (2002) it is not appreciated by the users to present a new system without information and education. To suppose that the users will be able to manage the system is easily expected but in most cases wrong way to go. To prepare the personnel, information was spread and education was given to the affected users. Support was also given after the implementation.

3.6 Implementation strategy for improvements

For potential improvements regarding SLS Sweden, an implementation strategy was developed. It is based on literature as well as electronically research and brainstorming with competent personnel. The strategy is self-designed optimised for SLS Sweden, though inspired from a combination of different models for implementation in warehouse and production environment. The implementation strategy includes key factors for implementation, different alternatives for process flow and the sequence for implementation.

3.7 Validation and Reliability

The researchers considered validation of submitted information during the whole master thesis. It was done by continues consultation with the supervisor at SKF. The supervisor is Six Sigma coordinator and Quality responsible and is well versed in the whole process. Calculations made in the thesis are verified by the supervisor and SKF controller. The Six Sigma project (rating processes within the project etc.) and interviews was performed together with proficient personnel from Transport department, Customer Service, Production Management and at the same time verified to be reliable. The SKF Controller in the organisation confirmed all cost savings to be correct.

The data collection was validated by a Master Black belt employee and the supervisor at SKF, this to make sure that the data will be adequate for the research.

Calculated Six Sigma level consists of different parameters e.g. Total number of defects and total number of outbound goods. The former numbers are documented defects and the latter number has been received from internal system. Both are assumed to be reliable.

An additional validation will be performed by SLS Sweden of the whole report before publishing. The aim is to make sure that the context is fully reliable and validated. Validation will be performed by three employees well acquainted in the process.

4 EMPIRICAL FINDINGS

The following chapter gives a comprehensive description of the entire process at SLS Sweden, from goods receiving to goods are loaded on truck. The first sub chapter describes the process flow in whole. Thereafter, the different warehouse operations and complications occurring at each activity are explained. The Complications are identified by observations and employees own experience of problems in the different warehouse operations. Current loading process is explained in-depth with a detailed figure. The figure illustrates, among other things, possible decisions and alternatives along the process. Continuing, there are illustrations of Transport department and Customer Service role concerning the loading process. In next subchapter (4.2) the results from the different tools used in the Six Sigma project will be presented. Initially there is a summarizing figure of the Six Sigma project. Finally, the benchmarking made at SLS Germany is presented in terms of similarities and differences.

4.1 PROCESS – Central Warehouse SLS Sweden

The Warehouse in SKF Sweden is built on five floors. Because of its rare design the material flow is described as a modular overall flow design according to Frazelle (2001). Goods moves by a conveyor system to the different floors. The conveyor system has three tracks where one of them has the functionality to transport goods to every floor and remaining two tracks are for the second floor where the loading area is located. Most of the forklifts are equipped with monitors, scanning device and printer for articles connected to WASS. SLS Sweden is in addition responsible for managing Gunnebo Lifting products such as stock keeping and picking assignments. Daily Transport System (DTS) managed by SKF Logistics Services is based on road freight transports, operates the European distribution of finished products, see appendix B.

The different warehouse activities at SLS Sweden are:

- Floor 100 – Goods Receiving, Picking
- Floor 200 – Goods Receiving, Picking, Packing & Weighing & Strapping goods, Loading Area, Cross-docking
- Floor 300 – Picking
- Floor 400 – Picking
- Floor 500 – Picking, Inspection & Customer Returns & Administration

4.1.1 Warehouse Process Flow

Figure 4.1 displays an overview of the flow for material and information at SLS Sweden, from receiving an order until the goods are loaded on trucks. It starts with Customer Service receives order from customers in the ICSS system, a system for managing orders and invoicing. Orders are forwarded to the production owner in this case SKF Gothenburg, Mekan, Poznan and Nilai with desired date for receiving the products. The production owner determines if the order can be completed within the time frame and informs the customer on the terms. The transport department then prepares shipment list containing destinations, weights and departure time for each truck or container. Customer Service receives the shipment list and generates loading list, describing included goods and transport mode. The employees access picking assignments through WASS. Pallets have specific status from the point of picking until it is loaded on truck, see appendix C for more information about statuses. When the pallets have passed the pack-reporting station, forklift drivers dispose the pallets in the loading area according to different countries or continents. Customer service begins generating documents for the truck driver containing loading list, invoicing and customs. When Customer Service closes the trip in WASS, the loading personnel prints the loading list from WASS and begins searching for the goods and checks them according to the list. The pallets are organised and loaded on the truck or container. When loading is completed the documents are given to the chauffeur. The chauffeur confirms received goods by signing a document.

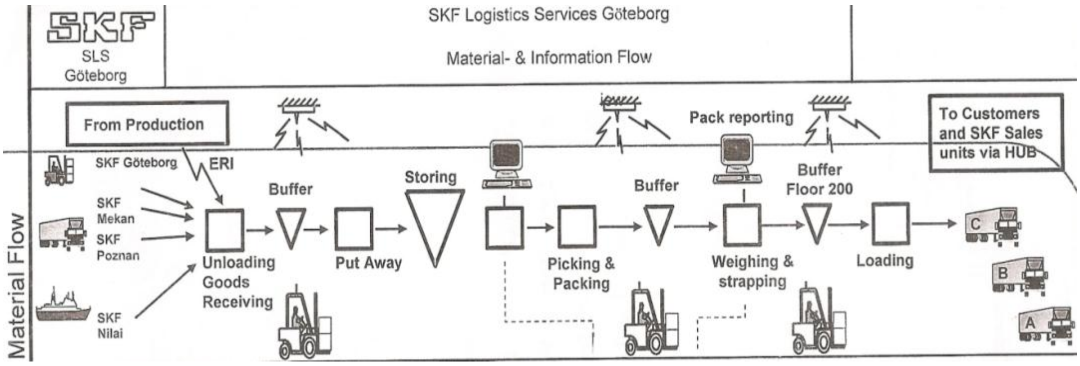

Figure 4.1 *Material and Information flow at SLS Sweden. (SKF, 2005)*

4.1.2 Goods receiving

Goods arrive from various production units with different transport mode to floor 100 and floor 200. The production units providing goods to logistic department are:

- SKF Göteborg
  - D - Factory (Medium bearings) by forklifts
  - E - Factory (Large bearings) by internal trucks
- SKF Mekan & Poznan & Lüchow by Truck
- SKF Nilai by sea freight

Floor 100 has two gates for incoming trucks and the warehouse is connected with a tunnel to the D- factory in the basement. Products from D- factory are sent to the floor by a specific elevator. The incoming goods are attached with a production label with unique package number which is pre authenticated to WASS. The label scans and the package places under fixed pre-set areas. The goods receiving gate at floor 200 is commonly used for inbound goods from external customers.

Complications

There is risk for taking wrong pallet because of label numbers are similar to each other, in most cases it is only a letter or digit discerning. If labels are missing from the production, the pallets article number is manually entered in WASS which can create possibility to enter wrong article number. Pallets of different type are stored in the same area resulting in time spent of searching for goods. When the forklift driver gets a pre-set area for the pallet and notice the area is occupied, it results in creation of new spaces without entering it in WASS.

4.1.3 Picking

Pallets are placed in racks for stocking and for picking tasks. Depending on customer order, picking tasks can include several different products. A picking assignment can be containing several different components or a complete pallet handling, therefore picking operation can occur at different floors. Picking on floor 500 is on low frequent goods. The products can be picked in proof boxes, kits, and components. Forklift driver prints a picking label and scans the barcode for initiating picking assignment. Products are displayed in WASS, where the included products in the pallet are listed. The forklift driver finishes picking assignment by scanning the pallet and printing a label. The pallet is placed on conveyor system and transported to the pack-reporting station at floor 200.

Complications

Duplicated label cannot be registered in WASS and the pallets are not available to proceed to next stage.

If a rarely manufactured product gets damaged when picked and there is no available in stock, the customer will not get the product in time. The damaged product will be sent for inspection.

When the forklift driver finished the picking assignment, the pallet is placed on the conveyor system to be transported to the pack-reporting station. If the conveyor is occupied for the moment, the forklift driver places the pallet in a temporary buffer zone until the conveyor is available. Notice that every pallet has its priority. Next time the forklift driver wants to place a pallet and the conveyor is unavailable; the driver places the pallet in front of previous pallet in the temporary buffer zone. The consequence is disrupting the priority and pallets which should have been placed first on the conveyor system are placed last instead. This failure mode can affect the loading process.

4.1.4 Inspection & Customer return

When pallets are damaged during operations or if customers receive damaged pallet, they are sent to floor 500 for inspection. The inspector checks if the product is damaged and depending on the inspection, certain actions are made. When goods are for re-storing, information on quantity, type etc. is send to Quality Service. Quality Service adds the products in WASS, prints out label for each package and the package returns to its specific floor. When repacking the product, requisite packaging needs to be obtained (carton box, label) according to SKF requirements and the repacked products are sent back to customers. Before re-sending the products to customer the inspector needs to inform the Quality Service of actions made, for right crediting to customer. When a product has been damaged, the product is scrapped and supervisor informed.

Complications

After the pallets are inspected and proper decision has been made, the pallets can remain at floor 500 without further actions. For example if a pallet have failed the inspection and given status goods for scrapping, the pallets are left at floor 500 in batches of scrapped goods resulting in occupying space.

4.1.5 Pack-reporting & Loading Process

The pallets arrive to floor 200 through the pallet elevator and by a conveyer system to the pack-reporting station. Controlling the weight of the pallet occurs at a weight station where the total weight of the pallet is measured and compared with the predicted weight. If the weights correspond, the pallet is approved and a transport label is attached by the employee. A non-confirmed pallet will be controlled and adjusted by respective pallet picker. After weight station the pallet continuous to the strapping machine where it is strapped. When the pallet is finished a forklift driver places the pallet in a temporary buffer zone formed as a half-moon awaiting disposition. Pallet disposition is done by a forklift driver, who manually reads the transport label and places the pallet in its right alignment together with other goods of same destination.

The loading process can be divided into five different sub processes (Andersson, 2008).

1. Goods loaded on trailer for distribution mainly to Europe
2. Goods loaded on container for distribution world wide
3. Flight goods disposed to carrier for transportation by air
4. LCL – Less than container load, disposed to carrier for transportation by sea.
5. Goods collected by customer

SLS Sweden loading process

Mapping of the current loading process is illustrated in figure 4.2. The mapping explains the process from point goods are pack-reported or inbound external goods, to the point goods are loaded on trucks. Managing documentation for the process is included as well.

SKF goods (internal goods) and external goods are managed separately. Internal goods pack-reports and a forklift driver move the pallets from the conveyor system to a temporary buffer zone next to the conveyor system where it is sorted and stacked. Parallel, the external goods are placed in different temporary buffer zones. All external goods are scanned as arrived with a portable scanner. Depending on destination, goods are then scanned once again but this time as loaded.

Next operation is to dispose the goods in the loading area. Goods are sorted by destination as long there is available place. Otherwise the forklift driver must improvise and release space.
When loading is approaching, loading personnel usually print an incomplete loading list from WASS and begin to search for the goods and gradually deselect the found goods in the list. An incomplete loading list consists of a number of non-pack-reported goods. The trip is yet unclosed which means that modifications still can be done. Checked goods are then moved and stacked close to outbound gate. At this point the trip should be closed by Customer Service, however it is rarely done because awaiting goods to pass the pack-reporting stage. This forces the loading personnel to initiate loading of trailer or container according to time table (see appendix B). To avoid unfulfilled schedule a loop process is started which proceeds until the trip is closed, see appendix C. The loop proceeds accordingly to search-stacking-proceed loading. Before loading the pallets, loading sequence is calculated to correctly dispose the pallets on truck or container according to weight and lockups. "Force loading" is done in the WASS system by Customer Service to be able to generate needed documents. It is meant to correspond with the scanning operation before loading. Eventually the loading process is completed, the truck

departures with documents and deviations are reported in paper form. Finally, Transport department retrieves signed papers from the loading office.

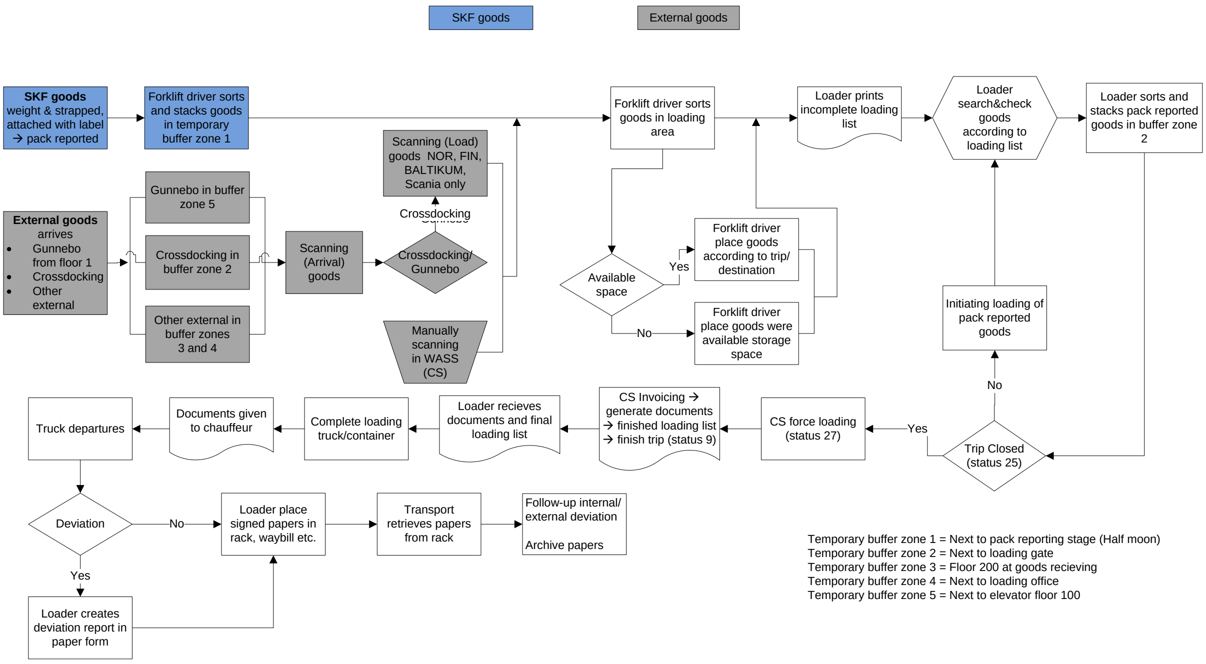

Figure 4.2 *Mapping of the current process at loading.*

External Goods

The external goods managed by SKF are:

- External customers by truck – Piab, Cejn, Gunnebo, Johnsons Pump Sealpool, OSTP, SKF Coupling, Outokumpo etc.

All external goods except Gunnebo are scanned with a portable scanner. Because Gunnebo stocks their goods in the warehouse, the goods are manually scanned in WASS. External goods are stacked in different buffer zones before initiated for loading.

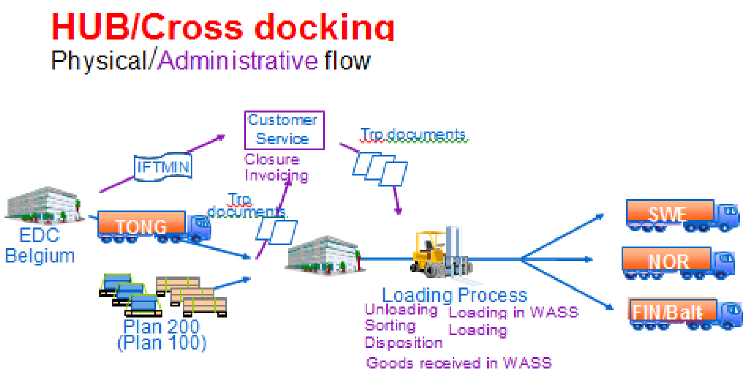

Figure 4.3 *Main process for International hub or cross-docking, (Andersson, 2008)*

The main process for International HUB/Cross-docking, see figure 4.3, including managing of cargo sent by DTS truck from Belgium (Tongeren) to SKF Gothenburg (Loading area). Cross-docking goods are unloaded, sorted and reloaded on outbound units to Sweden, Norway, Finland and Baltic. The shipments can include a mixture of internal and external goods.

Complications

Different complications occurring in loading process are structured in bullet-form below. The structure was selected because problems might not be related to each other and there is no classification between them.

- Varying volumes of goods causes that the intended area is not adequate. The goods are disposed where there is available space which results in pallets being mixed. The forklift driver by his initiative releases space when needed.
- When pre-set areas for destinations are missing, the loading personnel waste time on searching for goods.
- The current storage area at floor 200 is limited, there is lot of unnecessary batch of material for strap machine spread out on several areas at floor 200. Huge area is occupied by long-term storing of large bearings and house bearings.
- Pallets are of different reasons such as withdrawal from customer left at floor 200 for extended time without any clear actions.
- Example of an error is when 20 pallets of a specific type are arrayed in an area. The employee counts the quantity and controls them according to loading list. Notable is that there might be a pallet of different type or destination mixed among the pallets. It can cause wrong loaded goods because the employee does not control each pallet.
- In some occasions the loading personnel prints an incomplete loading list in advance, this to prepare the loading procedure of truck or container. The loading process is already begun before the completed loading list is generated. The problem is when the incomplete compared with completed loading list do not match e.g. goods could have been added or erased from the list. The loading personnel has planned the loading sequence according to weight, size and security resulting in neglecting goods added or erased from list.
- If the prioritising of goods are deranged somewhere in the warehouse operations, it can cause that goods are not available for loading according to planned lead time.
- A picking assignment can vary on products with different weight and size. If a number of components are neglected when picking there is a probability of not discovering the defect in the pack-reporting station, although the pallet is within the tolerance level of weight. The pallets confirm to be according to specification and it is up to the employee to verify the pallet.

4.1.6 Administration

Customer Service

Figure 4.4 is a simplified explanation of working responsibilities and documentation flow regarding Customer Service concerning the loading process. Depending if the goods are internal or external there are different procedures, from the point Customer Service receives a shipment list from Transport department until finished documents are given to the truck driver.

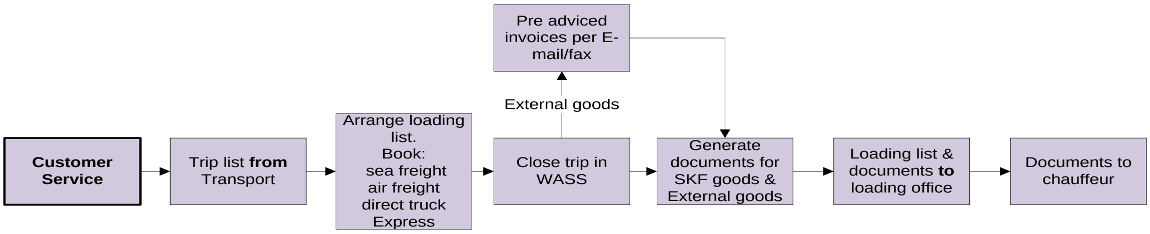

Figure 4.4 *Customer Services work responsibilities and documentation flow*

Transport Department

Figure 4.5 is a basic explanation of working areas for the Transport department concerning the loading process. Transport department arranges trip list which is a preliminary planning of destinations and total weight for shipments.

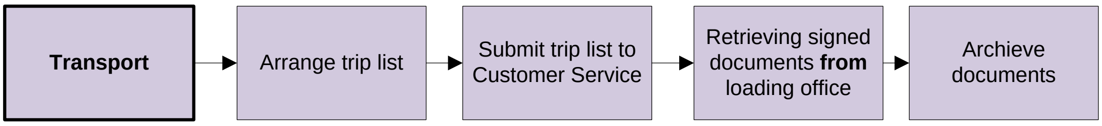

Figure 4.5 *Transport units work responsibilities*

4.2 Six Sigma project

Six Sigma represents a great part of the methodologies used in this research. Figure 4.6 aims to give an overview of the Six Sigma tools and the order of adopting them. Before using the six sigma tools, a pre-study called Baseline was constructed and the outcome is presented under table 4.1. The funnel illustrates the amount of identified inputs and outputs in the current process (78), further down the number of exceedingly interesting problems to investigate more in-depth (13). The primer goal with evaluating a certain amount of problems is to concentrate in a few problems with good solutions instead of attempting solving everything with a poor outcome.

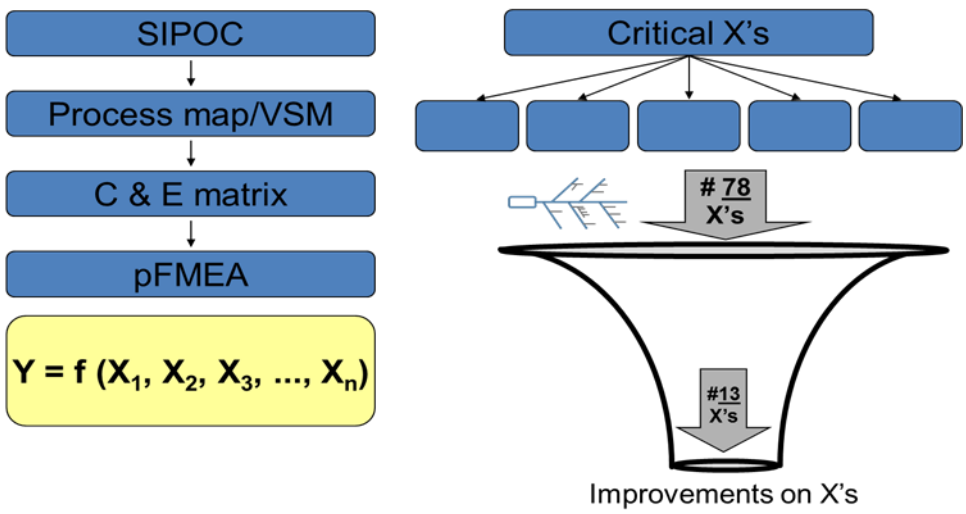

Figure 4.6 *An overview of the Six Sigma tools used and the order of adopting them.*

4.2.1 Pre-study (Baseline)

The Baseline is a compilation of all documented errors the past fifteen months at SLS Sweden. Basically it is an excel file with all the collected data and is a part of "Define" and "Measure" in the DMAIC model. Table 4.1 shows a clipboard from the file, because of its size it was impossible to present the whole file and all columns. The topics in the Baseline were determined after relevance of what the authors of this thesis considered as essential. The objective is to answer questions as "number of total errors?", "common type of errors?" etc. All questions are found in table 3.1 in methodology chapter. The total number of identified deviations from the pre-study ended in 1.694. Further down, the chosen topics in the table are individually explained.

Table 4.1 *Clipboard of the Baseline in pre-study stage.*

TYPE OF DEVIATION	CATEGORY	TYPE OF ERRORS	SHIFT	DEPARTURE TIME SLS SWEDEN	TRANSPORT	SKF/ External	CUSTOMER	DESTINATION	HOUR SPENT	COST PER COMPLAINT (SEK)
Deviation report	MISSING GOODS	Not found	NIGHT	04:00	TRUCK	SKF		USA	0,33	158
Deviation report	QUALITY	Damaged Pallet	NIGHT	04:00	TRUCK	External	CEJN	XFRA	0,33	158
DER	DOCUMENT	Missing documents	DAY	07:00-22:00	SEA	SKF		CHN	3	1434
DER	TIME	Late Delivery	###	###	FLIGHT	SKF		CHN	8	3824
TPE	DATA TRANSMISSION	Wrong trip used	NIGHT	04:00	TRUCK	SKF		DEU	0,5	239
TPE	TRANSPORT	Goods lost	EVENING	16:30	TRUCK	External	BERGQVIST JÄRN&BYGG	SWE	0,5	239

Type of deviation

SLS Sweden is today working with three ways of documenting errors regarding delivery of goods to customers. One of them, Deviation report, conducts by the loading personnel. So to say, when error occurs of any reason in the loading procedure, it is reported in a pre-filled sheet where the report is collected, processed and archived by Transport department. Another type of deviation is Transport Process Error (TPE). Transport department are responsible of this report which is an action report of internal and external errors that has been managed. The third type is Delivery Error Report (DER) or customer complaints which commonly uses in the organisation. Quality department are responsible for DER reports which usually are received by mail sent by customers with oppositions or simply not received expected goods. The responsible department is Quality. Deviation reporting accounted for 84% of the deviations, TPE for 12,5% and DER for 3,5%.

Category

In this column the defects were categorised under one of ten different main reasons for error according to table 4.2. The idea of categorising type of errors was to merge similar errors with each other and to reduce the number of types identified from the different reports. The main categories are considered to be suitable. “Missing goods” proved to be heavily dominant among deviation reporting while the reasons varied among TPE and DER. Missing goods stood for 89% in total.

Table 4.2 *Main reasons for error and their categories.*

Categories	**Type of Error**
TIME	Departures Booking
MISSING GOODS	Short shipped Not found Not available
DATA TRANSMISSION	Missing file Wrong TMC Wrong order nr/trip nr Wrong label File wrongly sent
PACKAGE	Wrongly loaded packages Put in collective without registration
DOCUMENT	Missing/wrongly documents Old label not removed
LOADING	Bad loading No space Wrong transport mode Loaded wrong pallets Wrongly loaded
QUALITY	Damaged pallet/package
NOT DELETED FROM LOADING LIST	Not updated loading list
DESTINATION	Wrong end destination Wrong harbour
TRANSPORT	Goods lost

Type of error

The column is closely related to the category column but with more specific description of the reason for each error. The underlying reasons are occasionally difficult to distinguish from each another but somehow lot of them leads to short shipment at the end. In other words, it is confirmed that majority of the defects can be connected to short shipment, whether the reason is “not found”, “not available”, “no space” etc. However, it can be deduced that “not found” is most often appearing in compiled document. Figure 4.7 illustrates the common types of errors in percentage.

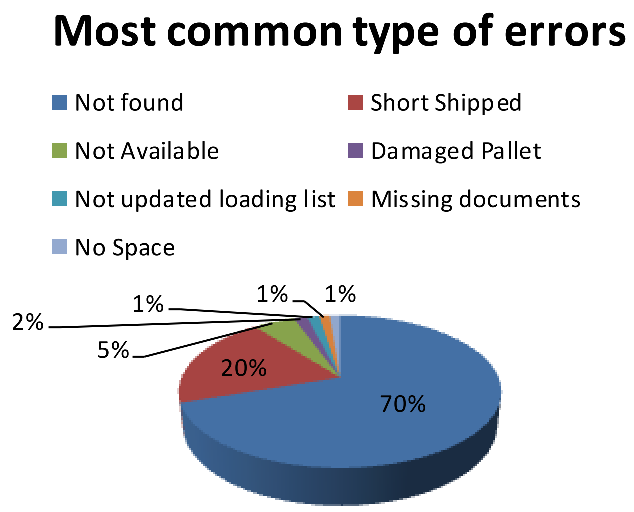

Figure 4.7 *Most common type of errors occurring in loading process.*

Working shift

As the loading process at SLS Sweden progresses around the clock, it was of great interest to discern any differences when defects usually occur. The working hours are covered by day-, evening-, night- and weekend shifts. The outcome shows that 93 percentages occurs during the night shift. The root causes will be discussed more in coming chapters.

Departure time SLS Sweden/Transport mode

Like stated above, approximately nine out of ten defects occurred during the night loading. There are three night trucks scheduled for loading at night, see appendix D for an overview of the time table. The night shift manages two 04:00 trucks, Schweinfurt respective Tongeren, while the evening shift loads Tongeren 05:00 couple of hours ahead. The gathered information revealed that defects most likely are caused during the Schweinfurt truck 04:00. But Tongeren 04:00 is not far behind according to the data collection.

Transport mode is separated into three categories, namely truck (trailer), sea freight (container on truck) and air freight. Truck transports are within the DTS system and enables to follow the truck in the transport chain. Even railway is used as transport mode but only in small amounts. Sea transport departures during day/evening but exact time were difficult to track, so the time range 07:00-22:00 was set for all container loading. Around 97% of the defects showed to be related to truck according to figure 4.8.

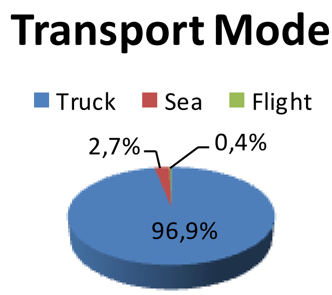

Figure 4.8 *Different transport mode used by SLS Sweden.*

Internal (SKF)/External goods

The data collection distinguishes between SKF goods, external goods and cross-docking. The percentage distribution is displayed in figure 4.9. SKF goods are basically internal packages from the warehouse. External on the other hand are goods coming to the warehouse from other destinations/customers. Cross-docking is included as external goods, where the goods are reloaded in the same or next coming day on other trucks. Therefore, cross-docking goods demand a temporary storage area at floor 200.

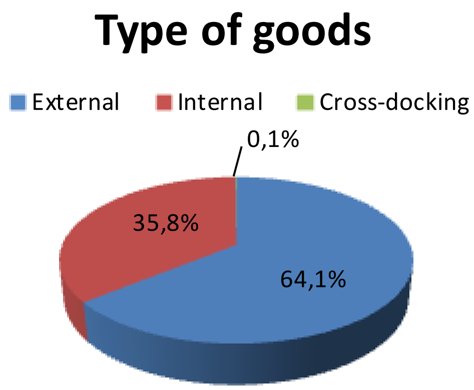

Figure 4.9 *3 Different type of goods managed by SLS Sweden.*

Customer/Destination

The destination for departure goods from SLS Sweden could either be intermediate warehouse or direct to end-customer. Destinations beginning with “x” are cross-docking goods meant to be reloaded in receiving warehouse or already been cross-docked at SLS Sweden. There are lot of different destinations; mainly it is delivered to Schweinfurt in Germany or Tongeren in Belgium at first stop. Review over all affected external customers could be found in appendix D. Top two customers’ appeared to be Sealpool and Piab with around twenty percentages each.

Hour spent/Cost per complaint

The last two columns presents the hour spent/cost per defect. The standard cost per hour is 478 SEK, received from SLS Sweden. The stated time spent for each defect differ after action made and can be all from time spent on searching for goods to managing the defects like investigations and conversations with customer.

4.2.2 SIPOC

SIPOC is an abbreviation of; Supplier, Inputs, Process, Outputs and Customer and provides a template for defining the process, before mapping, measuring and improving it (Improvement Skills Consulting, 2008).

SIPOC is the first tool used in the Six Sigma project, aiming to get a high-level understanding of the scope of the process. The tool helps the project team and owner to decide the boundaries on what the team will be working on. Before rushing off and drawing the process map. SIPOC in a structured way provides a discussion of the process and getting a consensus on what it involves.

The team members in the Six Sigma project were from different department concerning the loading process, resulting in the SIPOC displayed in figure 4.10 was validated and within the project boundaries.

Process Name: To achieve Zero Defects at SKF Logistics Services Sweden loading area and hub area
Process Owner: Production Manager

S	I		P	O		C
Suppliers	**Inputs**		**Process**	**Outputs**		**Customers**
Providers of the required resources	Resources required by the process	Numerical requirements on inputs *Requirements*	Top level description of the activity	Deliverables from the process	Numerical requirements on outputs *Requirements*	(Stakeholders who place the requirements on the outputs)
	Competent staff - Workforc	Frequency, flexibility	Goods are weight, strapped and attached with	Invoice to customer	Customer get their product	
				Completed loadlist	Right goods at right time with the right transport mode	
	IT System:ICSS,WASS	Availability				SKF Sales Units
	Storage area	Large enough area		Loaded truck/container	Compentence staff	Customer Service
	Packed goods	Pack reported	Goods placed in loading area (floor 200)	Information on trms - track the goods	Know the tripnr or package nr	External customers
Customer Service	Correct label (information)	As specified		Transport/customes (Export) documents	Personnel arrange the documents	
Transport	Forklift	As specified	Collect goods according to loading list	Available (free) storage area		
SLS Warehousing	Equipment	Scanner				
	Loadlist by areacontroller	Updated loadlist				
	Booked transport mode	Punctuality (goods available for loading)				
	Transport conduct trip list	Right transport mode chosen	Load the goods on trucks/ containers			

Figure 4.10 *SIPOC, broad understanding of the process.*

4.2.3 Process Map

As described in the methodology chapter, the process mapping was performed by the involved persons in the project team. Part of the result is presented in 4.11 and illustrates the current procedure for the loading process. The full version of the Process Map is found in appendix E. Process mapping is similar to the previous flow mapping executed (presented in figure 4.2) but now there are inputs and outputs added. The yellow highlighted boxes are key steps in the process. The status within brackets indicates WASS status when the step is accomplished. For each process step there are inputs needed to be able to perform the step, and similarly there are outputs after the process step. Every output is then transferred as input in next process step.

The researchers' preparations before starting the process map consisted of e.g. walking the process. The different team members' expertise was important to from validation perspective, to ensure that the whole process is covered with correct information. Interaction and discussions within the team facilitated generating the following result.

SKF Six Sigma	Process Map
Project Title	To achieve Zero Defects at SKF Logistics Services Sweden loading area and hub area

Input	Step	Output	Notes
Trip i WASS Pre advice weight goods Transport: book capacity DTS (1 day before) CS: book sea (same day) CS: book flight (same day) Excel planning list tool Book direct truck	**Prepare trip list (Status 1)**	Trip list via mail Truck booked DTS Sea freight booked Flight booked Direct truck booked	
Trip list via mail Truck booked DTS Sea freight booked Flight booked Direct truck booked Available buffer zone Forklift driver Forklift Packreported SKF goods Arrived external goods Scanning device WASS label	**Goods sorted in temporary buffer zones (status 6)**	Occupied buffer zone at floor 1 Occupied buffer zones at floor 2 Sorted by trip Initiate loading of packreported goods (Incomplete loading list printed) Scanned (arrival) external goods (status 24) Scanned (loaded) external goods (Int. Hub NOR,FIN, BALTICUM,Scania) Non scanned goods Scanned Gunnebo as arrived CS (manually in WASS)	
Occupied buffer zone at floor 1 Occupied buffer zones at floor 2 Sorted by trip Initiate loading of packreported goods (Incomplete loading list printed) Scanned (arrival) external goods (status 24) Scanned (loaded) external goods (int hub NOR,FIN, BALTIKUM,Scania) Non scanned goods Scanned Gunnebo as arrived CS (manually in WASS) Distributed area Available area	**Goods sorted by destination in loading area (status 6)**	Sorted goods according to trip and destination Free storage in buffer zones Occupied loading area Left goods at buffer zones Loader prints an incompleted loading list with updated goods Mixed trips in destination area due to variation of volumes External goods in several areas	

Figure 4.11 *The Process Map is a tool used in Six Sigma to identify inputs and outputs of different operations steps in the process.*

4.2.4 Cause & Effect Matrix

The result of the Process map is basis for the next tool which is the Cause & Effect matrix. Process steps and inputs are here transferred and further processed, see figure 4.12 (an excel extract from the matrix, full extract in appendix F). The aim of following model is to rate each input against importance to customer. Notable is that inputs are rated according to the Process step AND importance to customer. In other words, some inputs may be considered as important to the customer at one point but not in the actual process step, which ends in lower rate than expected. Following rating alternatives were used:

0 – No relationship
1 – Process input (x) has vague impact on customer need (y)
3 – Process input (x) has moderate impact on customer need (y)
9 – Process input (x) has direct or high influence on customer need (y)

The rating alternatives were set together with the Six Sigma coordinator in the project team. The numbers were selected to obtain proper dissemination of end values. Each input variable resulted in a total value by a calculation formula. The total value receives by calculate the product summary e.g. (10×9) + (6×9) = **144** (for trip in WASS in the figure).

		1	2	
	Rating of Importance to Customer (Y)	10	6	
	Key Process Outputs	**Receive expexted collies in time**	**Receive proper documentation/data transmission**	
Process Step (X)	**120**			**Total**
Prepare trip list (Status 1)	Trip i WASS	9	9	**144**
	Pre advice weight goods	3	1	**36**
	Transport: book capacity DTS (1 day before)	9	1	**96**
	CS: book sea	9	1	**96**
	CS: book flight (same day)	9	1	**96**
	Excel planning list tool	0	0	**0**
	Book direct truck	3	1	**36**
Goods placed in temporary buffert zone (status 6)	Trip list via mail	0	0	**0**
	Truck booked DTS	0	0	**0**
	Sea freight booked	0	0	**0**
	Flight booked	0	0	**0**
	Direct truck booked	0	0	**0**
	Available buffer zone	0	0	**0**
	Forklift driver	0	0	**0**
	Forklift	0	0	**0**
	Packreported SKF goods	0	0	**0**
	Arrived external goods	0	0	**0**
	Scanning device	0	0	**0**
	WASS label	0	0	**0**
Goods sorted by destination in loading area (status 6)	Occupied buffer zone at floor 1	3	0	**30**
	Occupied buffer zones at floor 2	3	0	**30**
	Sorted by trip	3	0	**30**
	Initiate loading of packreported goods (Incomplete loading list printed)	9	9	**144**
	Scanned (arrival) external goods (status 24)	3	3	**48**
	Scanned (loaded) external goods (int hub NOR,FIN, BALTIKUM,Scania)	1	0	**10**
	Non scanned goods	9	9	**144**
	Scanned Gunnebo as arrived CS (manually in WASS)	9	3	**108**
	Distributed area	9	1	**96**
	Available area	9	1	**96**

Figure 4.12 *Cause and Effect Matrix based on rating towards customer.*

“Receive expected packages in time” is considered as most important for the customer and therefore awarded with the constant value of ten. “Receive proper documentation/data transmission” is given lower constant (value six). Similarity to the process map, interaction and discussions within the team became fundamental for rating input/outputs.

Higher total value provides greater influence. The highlighted grey values are the ones selected to be analysed in the P-FMEA. Some of the highly rated values are neglected because of irrelevance for further analysing.

4.2.5 P-FMEA

The steps in the DMAIC model have now reached the Potential Failure Mode and Effect Analysis, P-FMEA. Table 4.3 illustrates the result of the analysis. However, beyond the table there are efforts in form of rating the process inputs on scale 1-10 considering three questions, namely:

How severe is the effect to customer?
How often does cause or failure mode occur?
How well can you detect cause or failure mode?

The values are thereafter multiplied to each other resulting in a total value which is the Risk Priority Number (RPN) column. The assessments procedure of ranking was based on fact from the Baseline. In some cases the rating questions were appreciated especially last question. How well you can detect a cause or failure mode was not always easy to determine. The thirteen highest rated are listed in the table. The aim of the P-FMEA was to once again reduce the number of inputs from the Cause and Effect Matrix. Subsequently to analyse the highest rated in-depth. At the start there were 78 potential causes of failure detected but to solve and find recommendation action for every single error is believed to be impossible. The effort would require a huge project in terms of size. Therefore the inputs have been reduced out of 78 to 13 by adopting the P-FMEA tool.

On the other hand, it is not unlikely that some of the neglected errors automatically will be solved by implementing the recommended improvements.

Recommended actions emerged by analysing the information in the P-FMEA. In addition, generally from the Six Sigma project. It includes the Benchmarking outcomes parallel performed with the Six Sigma tools. Recommended actions will be further discussed in coming chapters.

Table 4.3 *P-FMEA tool illustrating the 13 highest rated.*

Six Sigma Potential Failure Mode and Effects Analysis

Process Step	Input	Potential Failure Mode	Potential Cause(s)/Mechanisms of Failure	RPN	Recommended Actions(s)
Goods sorted by destination in loading area (status 6)	Sorted by trip	Mixed goods in destination	No didicated destinations	700	1. Scan all outbound goods in trips and destination area 2. Establish clear responsibilities for weight staff and loader staff
Goods sorted by destination in loading area (status 6)	Occupied buffer zone at floor 1	Goods left in buffer zone	Unclear responsibilities	490	1. Scan all outbound goods in trips and destination area 2. Establish clear responsibilities for Gunnebo staff and loader staff
Goods sorted by destination in loading area (status 6)	Non scanned goods	Searching for goods	No didicated trip area	300	1. Scan all outbound goods in trips and destination area
Goods sorted by destination in loading area (status 6)	Occupied buffer zones at floor 2	Goods left in buffer zone	Too many temporary buffer zones	100	1. Scan all outbound goods in trips and destination area
Goods sorted by destination in loading area (status 6)	Initiate loading of pack reported goods (Incomplete loading list printed)	Deviation between complete and not complete loading list	Unfullfilled deadlines	100	1. Clear deadlines for all trips 2. CS close trip at deadline and move not pack reported goods
Goods sorted by destination in loading area (status 6)	Non scanned goods	Searching for goods	Goods not found	100	1. Scan all outbound goods in trips and destination area
Goods sorted by destination in loading area (status 6)	Scanned Gunnebo as arrived CS (manually in WASS)	CS scan goods which has not arrived physically	Goods not scanned in real time	100	1. Staff at floor 2 arrival scans goods 2. Establish clear responsibilities for Gunnebo staff and loader staff
Goods sorted by destination in loading area (status 6)	Distributed area	Mixed goods	Unclear visualization Not optimized area	100	1. Scan all outbound goods in trips and destination area 2. Signs and alignments etc
Goods sorted by destination in loading area (status 6)	Available area	Occupied area	Not optimized area	100	1. Scan all outbound goods in trips and destination area 2. Barcodes, sort material, enable new storage area
Loader check, pick and stack the goods according to loading list for the actual trip (status 6)	Mixed trips in destination area due to variation of volumes	Goods mixed in wrong destination area	Not fixed/flexible areas	100	1. Scan all outbound goods in trips and destination area
CS invoicing, close trip and complete documents (status 25)	Checked loading list	Loading before trip closed	Fulfill time schedule for truck departure	100	1. Start loading after trip closed 2. CS close trip at deadline and move not pack reported
Loading on truck/container (status 27)	Forced loading in WASS (status 27) CS	Goods not scanned physically	Not scanning goods in real time	100	Forklift driver scans goods before loading/ Forced loading when trip collected next to loading gate
Loading on truck/container (status 27)	Forced loading in WASS (status 27) CS	Goods recieved loading status but not loaded in reality	CS needs time for generating documents Avoiding waiting chauffeurs	100	Generate documents when loading finished/ Forced loading when trip collected next to loading gate

4.2.6 Benchmarking SLS Germany

The major benefit of studying other organisations is creation of new ideas. It makes it easier to formulate realistic goals and above all competitive goals, i.e. goals that can be measured and compared with others. Common objectives in a company create large degree cooperation among employees, since all striving in same direction.

Benchmarking SLS Germany is a part of the Six Sigma project and this section attempt to break down all information gathered from the visit into similarities and differences between the two warehouses. Focus is laid on the loading process and surrounding factors related to loading. The overall perception is perceived as many differences in some key factors, despite belonging same concern. SLS Germany has well-developed methodologies for managing the warehouse that SLS Sweden can take advantage from to reduce the number of short shipment of goods.

The visit at SLS Germany was instructive and is a great asset to the project. It showed how another warehouse within SKF Logistics Services with equal purpose and goals, differs in work performance, work responsibilities and outcome.

Similarities SLS Sweden versus SLS Germany

Storage area – Limited storage area is common for both businesses. The consequence is time spent in replacing goods and importance of careful planning and holding all kind of deadlines.
For SLS Sweden it is stated as big problem because of time spent on non-value added activities and that it creates disorder at the loading area which in turn leads to more non-value added activities in form of searching for goods. The problems at SLS Germany are not such vast as in Sweden because all goods have its own specific place registered in WASS but it becomes complicated in moments of increased volumes.

Working hour's administration – Deviant working hours is necessary at both warehouses. At SLS Germany, one of the personnel in administration starts at 05.30 to manage the morning trucks which departures 07.00. Rotation is used among the personnel to achieve a fair sequence. The same is applied at SLS Sweden but the extended working time is at evening instead to manage the coming night trucks. The extended time can vary from day to day.

Working tasks warehouse - Personnel rotate into different working tasks within the warehouses considering such as goods receiving, picking and packing except loading personnel which are concentrated to just loading.

Differences SLS Sweden versus SLS Germany

Volumes – The volumes differ very much the two warehouses, where SLS Germany manages more volumes and is a bigger business in general. This adds a benefit when benchmarking, to observe and take lessons of well doing functions and not at least eliminate scepticism and doubts of conceivable improvements that can be done in the own business.

Loading area - Just authorized personnel are allow in the loading area in Germany; forklifts drivers belonging loading and chauffeurs. In Sweden there is no such rule and other forklift drivers, not only loading drivers, are entering this area. Thou there is unwillingness to the system but sometimes difficult avoiding because of limited storage space which makes it necessary for other forklift drivers to stack goods in the loading area.

Supervisor – SLS Germany has a person that possessions supervisor role which has a direct contact with his "working team" at loading. Some of the responsibilities are: Give documents to truck driver, coordinates gate number to trucks, organise shift teams, release area for goods if insufficient space for the trip row given, organise temporary locations for goods in loading area, report eventual deviation and hand it over to the personnel in the International Hub, responsible for disposition of goods for different trips (storing). An available supervisor facilitates much, especially at urgent changes.

Communication methods - General communication between the different departments SLS Germany; Messenger (Also with customers around the world), telephone and WASS messages.

SLS Sweden does not use messenger (MSN) as communication resource but Lotus mail, telephone, WASS and face-to-face information are common, particularly last mentioned. However, partly of the information disappears somewhere along the way. Recently, SLS Sweden appointed a new role in loading and will hopefully improve the communication flow between administration and loading. Then there is one responsible person instead of several as today.

Deadlines – The deadlines for goods and trips in Germany are very strictly followed. There is always couple of hours assimilated before loading starts. If any problem appear e.g. while picking or packing, the status of the goods is immediately changed in WASS to "not ready to be loaded" and the goods is scheduled in another trip. Otherwise the deadline follows the "ready time" in WASS. Container goods are usually 24 hours ahead. Because holding the deadlines, urgent matters are easily solved and short shipment prevented.

The contrast to SLS Sweden is major. The warehouse in Sweden faces deadline issues on daily basis. Underlying problems earlier in the warehouse activities and prioritizing of goods are assumed to play significant role for not fulfilling the deadlines. The effect is that the loading employee initiate loading on truck with available goods to then continue retrospectively with the rest. Otherwise it would be impossible to hold the deadlines for truck departure. In these cases, the employee prints an incomplete loading list which means that the list contains non pack reported goods and that it at this moment still could be changes. This event would never been possible in Germany as the loading starts after pack-reporting of all goods and receives status for loading.

Time schedule – SLS Germany has tight schedule for arrivals and departures of trucks, therefore important with trucks in time. It is not unusual of waiting chauffeurs close to the gates. SLS Sweden on other hand deals with late arrivals which can cause stress and mistakes among loading employees.

Follow-up and responsibilities – The comparison showed that SLS Germany is ahead SLS Sweden considering monitoring and working responsibilities. Both businesses have measurements for the process, quality etc. but the responsibilities are more clarified at the first mentioned business. Each department and each individual knows their tasks and in such way misunderstandings are avoided. The feeling at SLS Sweden is that some of responsibilities are vague formulated or missing completely. Monitoring deviation reports from loading is another weak point. There is no statistic over this type of deviations and some of them can result in DER complaints from customer if the processing time becomes too extended.

Scanning goods at loading – An opportunity was given at the visit to observe the unloading and loading process at 04:00 on trucks arriving from SLS Sweden where notable observation was; how the forklift driver scanned the goods to/from specific areas, checked it against the WASS monitor and unloaded/loaded the goods. Simply it works like following: The goods has specific intended place where it once has been registered by scanning a barcode. The employee then knows where to find it through the WASS system. The employee scans the goods just before loading on truck and the goods erases from the loading list in WASS. So come the goods double checks against the system and the risk of loading wrong unit is minimal. Well prepared circumstances and order and clarity allow an immaculate loading process. Because of planning ahead and the fact that entire goods for a trip is collected in time, enables to perform needed documents in a correct way and in time.

The scanning operation in loading process at SLS Sweden is managed differently depending on goods. Internal goods are physically controlled, external goods are arrival scanned while cross-docking goods are scanned at arrival and loading point.

A useful observation from the visit was also a picture is taken of the finished loaded truck that confirmed the loading was correctly done because of complaints regarding damaged packages from customers. Thereby there is evidence and business can avoid compensations and arguing with customers about who is responsible for the damage.

5 ANALYSIS

This chapter begins with analyse of the Six Sigma outcomes which primary focuses on the pre-study. Initially the Baseline is summarised from chapter four and further discussed in-depth. The first part ends with presenting the current Six Sigma level. Next subtitle analyses the current loading process, where S.W.O.T-analysis and a fishbone diagram are utilized. A suggested loading process with considered improvements is analysed, where important requirements are clarified. The "new" loading process is well-illustrated in a swim lane describing how the flow will be if scanning of all goods are implemented throughout the process. The idea of scanning origins from, among other things, the Six Sigma project and the benchmarking made at SLS Germany. There are calculations of utilizing storage area by adopting the suggestions for improvement. An evaluation of benchmarking between SLS Sweden and SLS Germany is presented. Finally a database which is a developed improvement made on the deviation report in the loading process. The improvement was implemented during the master thesis while it was seen as simple but valuable improvement that could be implemented immediately.

5.1 Analyse of Six Sigma outcomes

The following section tries to analyse the presented data from the empirical finding chapter. Figure 5.1 demonstrates the top level factors of the investigated problem identification. The Baseline phase indicated in 1.694 defects. What can be said about the number is that there is high probability of duplicates. So to speak, same defect could have been aroused more than once but it is not a miscalculation. An example to proof this is when a defect is reported as "not found" on floor 200, the loading personnel devote time on non-value added activity in form of searching for the goods and performing the report. In next turn same defect may occur as DER complaint and x amount of time spent again in searching for goods and investigate the defect.

The number of 1.694 defects is total documented deviations from the three deviation reports (DEV, DER, TPE) during the time period January 2010 until April 2011. The total divided to number of working days, gives an average rate of four defects per day.

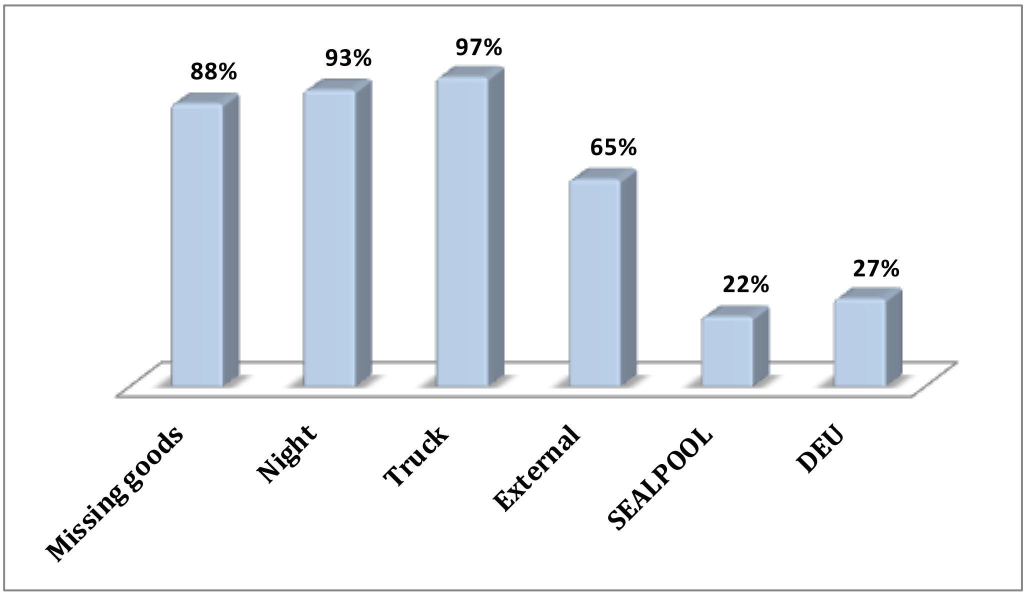

Figure 5.1 *Top level factors of investigated problem identification from the pre-study.*

It is important to emphasise that identified problems are documented defects and does not give the reality of the situation. The amounts of DER complaints are far more than presented but only the confirmed are chosen as identified. Confirmed means the defect is related to SLS Sweden while not confirmed still are in progress and source of failure not clarified.

Another picture of reality has been seen by observing the loading process and by discussions with employees. During day shift the current routine is to solve deviations direct by face-to-face exchange or telephone call between loading personnel and Customer Service or Transport department. Therefore, no deviation is documented although there is deviation, so the reality is vast more problems than the documented ones. During night shift there is no such opportunity for support and solving occurring deviations. This is one clarification of the enormous difference in reported deviations between day (7%) and night (93%). The loading for night trucks is prepared in forehand with loading list for the shipment and associated documents for the goods. There are two reasons behind this. First, ICSS system closes 21:00 for night updates and prevents to make any adjustments in the system. Secondly, the working hours for Customer Service personnel differ to loading personnel meaning that loading is in process without any administration personnel during a certain time period in night.

New solution has been investigated to improve managing deviation reporting. A better managing process of deviations should report all deviations to obtain a correct picture of the total amount in future. It will probably provide more even result of defects during day and night. A managing tool will enable to follow-up defects in an effective way. Today there is no statistics on deviation reports regarding time, cost and action statement (information of what has been done). However, the Baseline is a great document as a start-up strategy for continuing this follow-up process.

Better follow-up work would provide more detailed reason for failure. Now the main cause is "missing goods" with short shipment, not found and not available as variable causes for deviation reports. But the question "why" is still remaining because of neglected follow-up, and the fact that "missing goods" brings many diverse effects. That it has resulted in short shipment is there however no doubt about. TPE and DER reports include in-depth analysis of reason for defect and action statement. Therefore the reasons vary considerably more which facilitates bringing them into detailed categories. But still there is dominant part under category missing goods and the explanation is the majority of deviation reports among the identified problems.

All defects whatever reason, is an additional cost for SKF Logistics Services. Costs are divided into soft and hard savings for the organisation. Soft savings can be hour spent on non-value added activities, i.e. the time wasted that could have been utilized better. Hard savings are direct costs paid out due to the failure. Table 5.1 illustrates an example of what cost defects can bring:

Table 5.1 *Example of what an error can cost the organisation.*

TYPE OF ERROR	SKF/ EXTERNAL	DESTINATION	HOUR SPENT	COST PER COMPLANT (SEK)	ADDITIONAL TRANSPORT COST	TOTAL COST
Late Delivery	SKF goods	SKF China	1	478	77858	**78336**

This defect ended with extra cost of nearly 80.000 SEK because of late delivery caused at loading in SKF Logistics Services. The example is extracted from Baseline where there are other worse cases that ended in over 100.000 SEK in unnecessary costs. In presented example the goods has been left in the warehouse until a DER complaint was received from customer. Consequently the goods were delivered by air freight with a large additional transport cost as outcome, where cost is based on delivered weight. This scenario is not unusual and once again proves the weight of well follow-up work of short shipment. Another important factor is clear responsibilities. Left goods on floor 200 indicate lack of responsibility and communication among personnel. The goods are eventually ignored and left for long time, occupying valuable storage capacity before any actions are made. Common scenario of expensive cases is short shipment of goods when it is planned for sea transport across the world which can take several months. If it is detected too late it might become urgent for the customer which in turn can demand air freight instead. This is exactly what happened in the example above and brought additional cost for the warehouse and late delivery to customer. Another issue is the communication between personnel managing Gunnebo Lifting at floor 100 and loading personnel at floor 200. Unclear responsibilities results in left goods at floor 100, often found too late and causing short shipment.

Defects of this kind are not only fateful in cost perspective but also affecting the reputation in long term.

Like already stated, it is most likely for defects occurring during night trucks. Looking at the most affected goods whether it is internal or external showed that 2/3 is external goods. Some of the external goods arrive with trucks in the evening between 20:00-22:00. The goods are sorted by loading personnel and reloaded on other trucks at night. So come, it is not difficult to draw the conclusion that there are lot of problems with incoming goods at this point. Moreover, the main reason is "missing goods" and like discussed before it is difficult to investigate any more detailed information because of the lack of follow-up work of defects. This allows the authors of this research to speculate instead and the result might prove that there is either misunderstanding, communication problems, planning difficulties with customers or simply as human mistakes caused by stress. The general experience among loading personnel is higher rate of stress during night trucks because of several tasks and much to take in mind. Another guess is that external customers are responsible for not delivering the goods as planned which results in short shipment for SLS Sweden. In worst case other customers waiting for the goods blame SLS Sweden, because goods are planned into shipments before actually arrived from other destinations.

5.1.1 Sig Sigma level

The Six Sigma level is calculated by a pre-set formula. Dividing the number of defects found to the number of outbound units results in Defects per Unit (DPU). The result times one million gives Defect per Million Opportunities (DPMO). But the formula is not simple as that, other constants contributes to the final calculation of the level. The level is estimated from four perspectives, one with all units accounted for the whole process and the remaining others internal, external and cross-docking goods are calculated individually.

Total level (Internal and External): **4.30** (660 864 units)
Level external goods: **3.60** (62 141 units)
Internal goods: **4.54** (503 414 units)
Cross-docking goods: **5.6** (95 308 units)

The higher the value is of Six Sigma level, the better result for the organisation. Comparing the internal and external values indicates in great difference when talking in terms of Six Sigma. The lower value on external goods is however expected, considering that 65% of all defects found concerned external.

According to the theory the goal is to reach 3.4 defects per million opportunities. By putting 1.000.000 units and 3.4 defects into the formula results in a Six Sigma level of 6.0. Regarding the external value, there are 62.141 units and 1.097 defects. To approach Zero Defects and the goal of Six Sigma, it would require around 0.25 defects per 62.141 units. The total level of 4.30 seems to be reasonable level but in order to reach Sigma 6.0 means 2.2 defects per 660.864 units. Currently there are 1.694 defects so the value can be misleading. A point to highlight is the Cross-docking level with its value of 5.6, which is considered as the only good value.

After implementing improvements the process should be measured again to be able to state how much the process is improved. However, Six Sigma level is not the only manner to measure the process. There are several analyse models, though an interested model is Minitab which is a computer software for exploring data and well known within SKF organisation. Black belts, denote people with higher level of expertise, works with this type of analyses.

5.2 Analyse of current loading process

The current loading process in SLS Sweden is summarised in a SWOT analysis according to figure 5.2, a known framework for evaluating the organisations Strengths, Weaknesses, Opportunities and Threats. It involves specifying the objective of the process and identifies the internal as well as the external factors that are supportive and unsupportive to accomplish the objectives.

The strengths in the loading process is the competent personnel, it demands special training to load trucks and the employee requires to specifically calculate every truck on how to dispose the pallets according to weight and size. There is a willingness by the personnel to improve the process and they are well prepared to accept the new working routines.

Current loading process has weaknesses which can affect the organisation. The working procedure as well as the communication between shop floor and administration is not standardised, every employee performs tasks and informs in different ways. In the loading process there are many temporary buffer zones resulting in pallets being spread out in storage area. When pallets are spread out as they currently are, the employees put non-valuable effort on searching for goods causing an unnecessary waste.

There is potential of improving the loading process. Scanning procedure is currently used for external goods where the pallets are scanned with a portable device. Cross-docking goods are scanned twice, as arrival and as loaded, while other external goods are scanned once (arrival only). The problem is that scanning of arrival and loading are done at same point, this means that scanning procedure of loading is performed in advance and not in real-time. However there are minimal defects on cross- docking goods when looking at all identified defects. The result is 0.1% defects connected to cross-docking. It proves scanning does an improvement even though recent managing should be questioned.

The storage area can be optimised by organising the pallets and relocating consumable material. By process improvement the errors will be reduced, diminish customer complaints and hence the vision for Zero Defect. RFID is an opportunity as well, but perhaps not convenient as short-term improvement.

To proceed with the current process there is a possibility in affecting the customer. Results of short shipment can lead to reduced demand of orderlines and in worst case scenario the change of logistic partner by customer. Increased volumes should be considered and can cause complications with the current disposition of storage area.

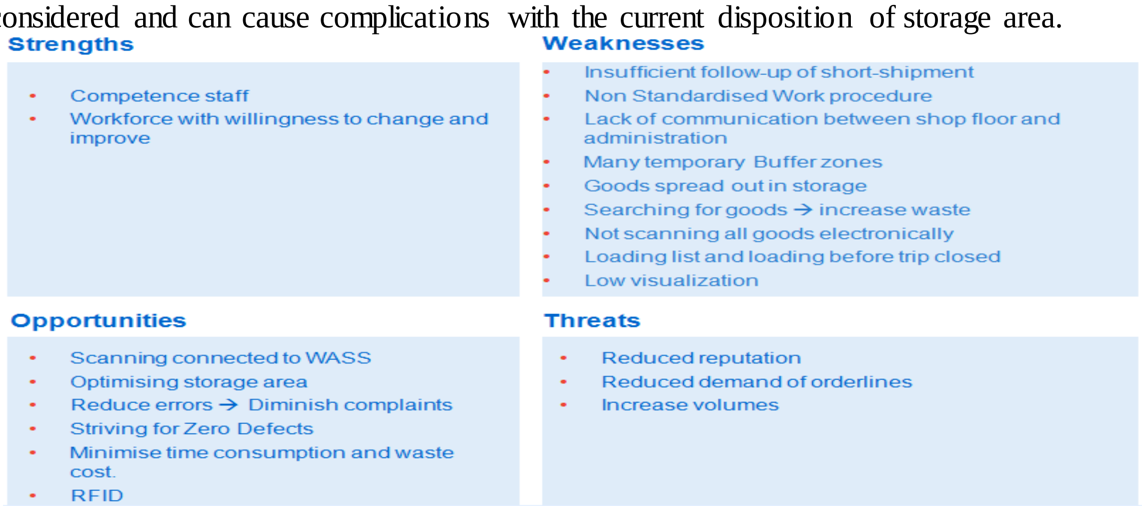

Figure 5.2 *SWOT analyse of the loading process.*

Deadline and prioritise issues with warehouse operations before pack-reporting stage causes disorder of prioritising and affect goods to be ready in time for loading. An identified problem is at goods receiving on floor 100. When conveyor systems are occupied goods are stacked temporary in rows. At this point the prioritising is already unbalanced because first incoming goods are placed back in the rows so forthcoming goods are the ones placed first, when the conveyor system is available. Another problem is that the deadline is set to 09:30 in general for all goods whether departure time is 14:00 or 18:00. Briefly explained, there are unclear deadlines for goods and whole shipments.

The consequence in loading is incomplete loading list and gradually awaiting rest of the goods included in the loading list. But the more waiting, the less room for loading personnel to prepare and perform the loading before truck departure. To avoid stress and break departure time, loading personnel begin preparation and loading according to incomplete list.

Simultaneously there are document issues because unclosed trip. Closed trip indicates that no modifications are possible. Customer Service is not able to generate documents until the trip received closed status (status 25 in WASS). The decision lies on Customer Service on when to close the trip and usually it is done when all included goods has been pack-reported. Closing the trip in early stage would result in left goods, thus awaiting goods into last minute.

The current approach with loading before the trip is closed complicates a scanning operation before loading. Scanning is consequently performed by visually controlling goods by reading the labels. Because of non WASS controlled scanning, current process allows Customer Service to manually change status in WASS, so called "force loading". According to WASS the goods are loaded on truck, though physically the goods are not yet loaded and can be found somewhere in the warehouse. This manoeuvre must be performed to be able to finish the trip in WASS.

There are storage issues because of varying volumes of shipments causing difficulties in storage planning. Today there is no clear or standardised method for stacking goods at floor 200 and the visualisation is poor. When intended storage area is full, loading personnel creates new areas and the facts that everyone´s working routine distinguish, result in mixed goods regarding destination and creates disorder. Additional issue is on inbound goods to floor 200, the goods are stocked in advance which occupies storage area.

As can be perceived, it is not easy to point out one cause for short shipment and one issue leads to other problems. Many of current issues have been presented in previous chapter and further analysed in this chapter. An attempt to simplify the understanding through a fishbone diagram, also known as **Ishikawa diagram** which is presented in figure 5.3. The fishbone diagram highlights main causes and sub causes for short shipment.

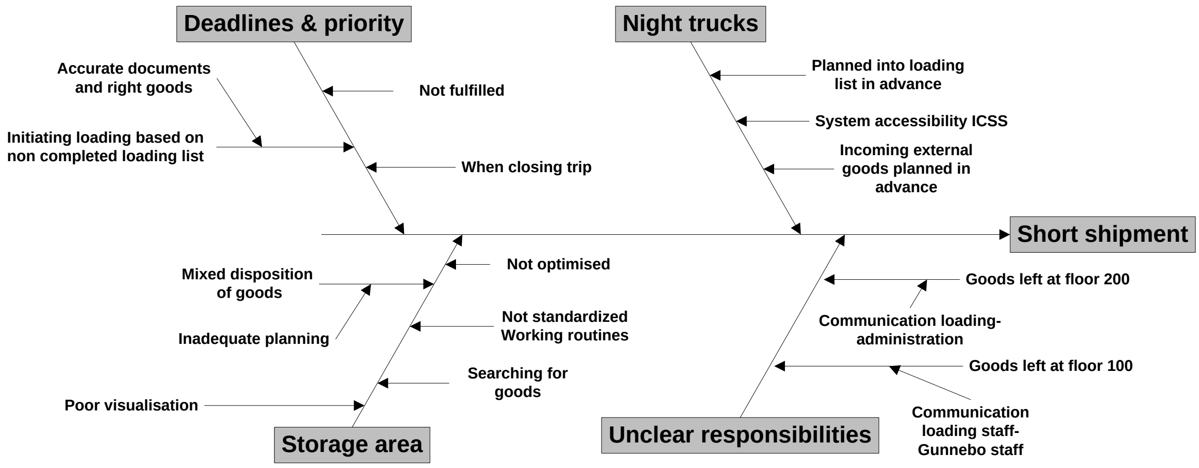

Figure 5.3 *Ishikawa diagram on main causes for short shipment.*

The fishbone diagram summarises the weaknesses in current loading process. All contributing factors must be investigated and solved to be able to diminish short shipment and enable to achieve zero defects.

5.3 Suggested process flow

Scanning of all goods in the loading area has been discussed several times in the organisation before. The warehouse is familiar with this kind of operations whilst it is used in goods receiving, picking and packing. It is partly applied at loading on floor 200 on external goods by using a portable scanner. Otherwise, the scanner is normally connected to the forklift. Early in the project during the observation period information gathering phase, the scanning operation was discussed with loading personnel and personnel in the administration. An emotion was built that employees considers scanning as solution for eliminating huge part of the deviations. Simultaneously, there is awareness of the complications it brings with the current procedure of working.

By standardise scanning operation for all goods in loading, the potential of eliminate short shipment of goods are great. Conclusions for following discussion are formulated based on P-FMEA and benchmarking results. Recurring solutions to potential failure modes in the loading process emerge from P-FMEA. The recommended actions are: (see table 4.3)

- Scanning all outbound goods in shipment areas which include re-arrangement of storage area.
- Establishing clear responsibilities
- Clear deadlines for all shipments
- Scan goods before loading
- Begin loading after trip closed

With this in mind and the result from Six Sigma project respective benchmarking, the authors of this research suggest that scanning is necessary to improve the process regardless needed efforts and sacrifices. The new procedure of working by implementing scanning entirely would be as illustrated in figure 5.4. The figure clarifies responsibilities and tasks for the involved divisions, Loading, Customer Service and Transport. The illustration should be compared with the current loading process in previous chapter.

Process Name	Loading Process - SLS Sweden
Objective	Process Flow when implementing scanning in the loading process
Scope	Implementation of scanning in loading process
Process Owner	Production Manager

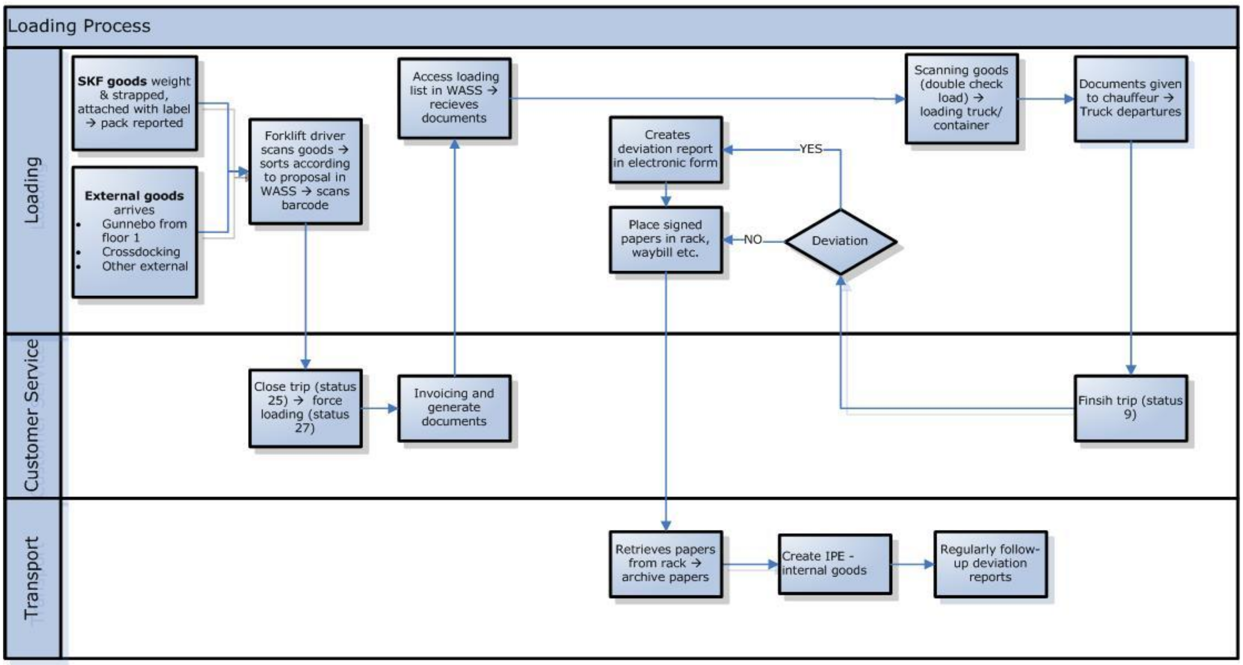

Figure 5.4 *The process flow between departments when implementing scanning procedure completely.*

The scanning operation implies scanning before loading when goods arrive from pack-reporting stage (SKF goods) or from other gates at floor 200 (external goods). Scanning will enable “new” space in the storage area because tighten everything together and eliminating the space between the goods. Today the pallets are placed with a gap between each other this to allow the employee to read, control and manually scanning the labels. More about area optimising is found under chapter 5.4.

For loading personnel it involves to scan the goods at arrival point and sort it after intended area (pre-advised in WASS) and then scan it into a barcode for the specific place. Different operation alternatives will be suggested in chapter 7. When the shipment is completed with all goods and the trip is closed, loading personnel is able to access the loading list in WASS and start loading on truck by scanning the goods. It is suggested to report deviations electronic and in paper form. A more detailed procedure of electronic managing will be presented in subchapter 5.6. Customer Service and Transport department will not face any significant changes. Customer Service is responsible for closing the trip, invoicing customers, generate documents and finish the trip. The role for Transport department is primary to collect and archive signed documents from the loading office. General for both departments is to adopt the new methods of managing deviations in electronic form.

Customer Service will have two options of when to generate documents for the trip. First alternative is to generate documents whilst loading is in progress. But the risk for human mistake remains, of loading wrong goods or truck which provides incorrect documents. This factor is one of the current problems but the difference is now that the trip is collected with right status and double checked at loading. Second alternative is to finish the loading on truck and generate documents after the process. It may be the most secure routine but circumstantial way because the truck is ready for departure but cannot leave without documents. It could be short of time for Customer Service to generate documents between loaded truck and departure schedule.

Implementing scanning needs great efforts and carefully planning. Scanning does not solve all problems and there are other factors that must be improved as well. Together with deadlines and priorities the most important issues are responsibilities, night trucks and storage planning. Deadlines for shipments must be determined and above all strictly followed to get a clear and effective loading process. When deadline passed, the trip should be closed immediately. By standardise this, facilitates for involved departments and personnel. There will be only one loading list which is completed from beginning and loading on trucks starts after trip closed. Goods that not fulfil its deadline must be “moved” to another trip to avoid short shipment. Customer Service will be given the chance to generate accurate documents for the trip without concerning any initiate loading before trip closed. But once again, deadlines issues have to be investigated in-depth otherwise there is risk of delivering half- full trucks.

Unclear responsibilities must be clarified for the implementation to be successful. To avoid left Gunnebo goods at floor 100 it is suggested to give loading personnel the responsibility to move, scan and distribute the goods to floor 200. It can be facilitated by installing a camera at the buffer zone at floor 100. Thus, loading personnel can be updated of ready goods for loading.

Issues with the night truck can be solved by avoiding planning goods in advance. External goods should be included in a loading list first after arrival. Thus, the organisation makes sure that goods are available before invoicing next receiving customers. Likewise, SKF goods must be established with earlier deadlines. The whole trip should be completed and pack-reporting during the day shift so everything is prepared when the night shift begins.

Order and clarity in storage area is optimal for improvement opportunities. As mention previously every single pallet must be scanned into an intended area. So come, searching for goods at floor 200 will be excluded entirely and planning will be based after available goods visible in the WASS system. It will demand precisely planning of the storage area. Because of storage limitations, it probably requires planning on daily basis and reserve storage area by looking at volumes. The current storage capacity cannot afford storing goods too much in advance before departure. It is important to continuously fully utilize the storage area and therefore high rate of flexibility is to endeavour not to reserve more storage area than required. There are some alternatives for how to organise the dispatch areas. One is to establish a number of fixed and flexible areas. Fixed areas could be for destinations with low variety in volumes but of course it requires going back in time and investigate this more before any decision taken. If the organisation could manage high flexibility, it would be preferable and worth striving for. Visualisation is also important e.g. clear alignments on floor and signs on walls. Information monitors are suggested around the loading area to increase the flexibility and to improve the information distribution.

Expected outcome by scanning operation is to reduce the number of short shipments and reduce the time spent for personnel in the loading operation. The present time for loading personnel to prepare one specific shipment before loading is appreciated to 35 minutes. No forklift driving is included, only the time for checking and finding the goods according to loading list. The estimated time is based on an average of loading personnel and the production manager assumptions on time spent for this kind of activities. The new time by adopting scanning is estimated to 10 minutes. By an easy subtraction it gives a time gain of 25 minutes in form of soft saving.

Current loading process differs in three major points from the suggested loading process:

- Managing goods equal whether internal/external or cross-docking
- Each pallet has its own pre-advised storage place in loading area (dispatch area)
- Loading process with one complete loading list, without repetitively searching for goods, clear deadlines and loading after closed trip.

5.4 Evaluation of storage area

The storage efficiency has been calculated on floor 200, were the following calculations are based on the current situation at floor 200 and the potential capacity of storage area when scanning is implemented. There are several different package types used for packaging, therefore specific calculations are calculated on potential package types that can be improved when implementing scanning. There are a total of 48 dispatch areas on floor 200 where 18 are in the main hall and remaining 30 in the loading hall. Of them 18 dispatch areas, 12 areas are considered optimal for improvements and the remaining 6 are used for stocking package type Q01 and house bearings. There is surely potential improvement on stocking, relocating consumption material to free up space, due to the time frame this has not been investigated, however could be evaluated in the future.

The calculation for each package type indicates an improvement of 57 %. Since it is very rare that one type of package are stored in the loading hall, a common mixture of package types are calculated showing a 57% improvement potential. The variety of package types complicated the calculation and therefore there are some different examples made. The number of 57% comes from an assumption of combined package types to obtain a reliably result. However, the calculation was almost even when using just one package type instead of a combination of several. Despite package type there is space for improvements.

An implementation of scanning goods into dispatch areas will enable 183 square meters in new storing area. The volume of pallets will increase with 75 per dispatch area in the main hall and 655 pallets for the entire loading hall, In total, the potential to improve storage area is 68%, saving the company 96 012 SEK.

The calculation has been validated by quality department.

5.4.1 Storage Efficiency Floor 200

Dimension 1 pallet	0,800 x 0,600 x 0,340
Area of pallet	$0{,}8 \times 0{,}6 = 0{,}48\ m^2$
Number of Dispatch Areas	48 areas

Main Hall

Current Capacity

1 dispatch:	5 strings 5 high 7 packages/ string
Area	$5 \times 7 \times 0{,}48 = 16{,}8\ m^2$
Number of packages	$5 \times 5 \times 7 = 175$ packages

Potential Capacity

1 dispatch	5 strings 5 high 10 packages /string
Area	$5 \times 10 \times 0{,}48 = 24\ m^2$
Number of packages	$5 \times 5 \times 10 = 250$ packages
Improvement	$24-16{,}8 = 7{,}2\ m^2$ per dispatch 250-175 = 75 packages $(250 \times 12) - (175*10) = 1250$ packages
10 dispatch area	$7{,}20 \times 10 = 72\ m^2$
2 new dispatch areas near strapping	$2 \times 0{,}48 \times 5 \times 10 = 48\ m^2$
Total Area	$72 + 48 = 120\ m^2$

Loading Hall

Current Capacity

30 strings
7 packages in a string
5 height

Area	$30 \times 7 \times 0{,}48 = 100{,}8\ m^2$
Number of packages	$30 \times 7 \times 5 = 1050$ packages

Potential Capacity

11 packages in a string

5 height

31 strings

Area	31×11×0,48 = 158,4 m^2
Number of packages	31×11×5 = 1705 packages
Improvement	158,4 -100,8 = 62,88 m^2 1705-1050 = 655 packages
Total Area Floor 200	120+62,88 = 182,88 m^2 (1705+3000)÷(1050+1750)= 68%
Savings:	183×525kr/m^2= 96 012 SEK

Package Type	**Current**	**Potential**	**Improvement**	
P01	1 String	1 String		
	7 Deep	11 Deep		
	8 High	8 High		
Number of packages	56	88	32	57,1%
P02	1 String	1 String		
	7 Deep	11 Deep		
	5 High	5 High		
Number of packages	35	55	20	57,1%
P03	1 String	1 String		
	7 Deep	11 Deep		
	4 High	4 High		
Number of packages	28	44	16	57,1%
P04	1 String	1 String		
	7 Deep	11 Deep		
	3 High	3 High		
Number of packages	21	33	12	57,1%
Only P02 package type	30 Strings	31 Strings		
	7 Deep	11 Deep		
	5 High	5 High		
	1050	1705	655	62,4%
Mixed package types				
P01	5 Strings	5 Strings		
P02	20 Strings	20 Strings		
P03	3 Strings	3 Strings		
P04	3 Strings	3 Strings		
Total	1127	1771	644	57%

5.5 Estimation of benchmarking

A success factor while benchmarking is how well the company knows and understands its own operations. The more the company knows about themselves the more they can get out of the comparative business, with the simple reason that nobody wants to share something without anything in return. Therefore, avoid examining things in comparative business that you yourself are not willing to share. The success and outcome depends greatly on its ability to absorb other´s experience and willingness to change their own operations. The aim should be to learn other applications and approaches. Therefore it is important to find companies that are competitive and leaders in its own activities or simply review other units within the company who are known to be effective in similar work.

The benchmarking performed at SLS Germany did not include any measurements because it was meant more like visit and one way benchmarking. So to say, SLS Sweden benchmarked SLS Germany and not each other. This would probably not been possible in a competitive company, to absorb such information without anything in return. Both businesses must be awarded for their willingness to cooperate and in future attempt to develop the collaboration to share knowledge.

According to Camp (1993), the gap should be determined between working practices in step four of Xerox benchmarking model. Though the result is not presented in numbers, the gap was easily stated as negative. Meaning, external working practices are superior, see table 5.2.

Table 5.2 *Types of performance gap (Camp, 1993)*

Type	Description	Consequence
Negative	**External working methods superior**	**Benchmarking based on external findings**
Equivalent	No major differences between working methods	More analysis required
Positive	Internal working methods superior	Benchmarking based on internal findings

The negative state was confirmed by using data collection and identified problems from SLS Sweden and comparing those to SLS Germany. Faced problems were not recognized at the compared company and the numbers of defects occurring in loading were almost non-existent. The comparison showed superior working methods in holding deadlines for goods and scanning system for loaded and stored goods.

The performed benchmarking indirect followed Xerox ten-step model. The structure is not step by step presented but mostly is covered anyhow together with other outcomes from this thesis. The first 8 steps are managed while last two steps are out of the range of this thesis. Next chapter will present an implementation plan but step nine is an actual implementation of improvements according to Xerox model and that is the difference. Step ten is evaluating desired goals managed after the implementation stage.

The final step in theory also covers benchmark to be used continuously within the company. It is indispensable for the company to understand the importance of this and also that competition constantly develops and customer requirements increases. This, together with commitment from management is considered as most important success factors. Without involvement – poor result of study, and without continuous use of benchmarking – no development or improvement in future.

Benchmarking is based on experience, the more it is used, the greater experience obtained and the more received out of the method. Does other companies succeed in equal operations, it should also be possible within the own organization.

5.6 Improvement of reporting deviations – Database

Under the period while collecting data for the Baseline and working the different shifts, the idea came up on improving the report for managing deviations occurring in loading area. Managing the report varied resulting in an incomplete reporting of deviations, follow-up statistics and extension of processing deviations. The information generally neglected in the reports was the date, customer and responsible employee for writing the report. The cause for neglecting cannot be pointed out precisely; the employees may not been informed how significant it is to have a complete statistics, tight time schedule causing stress for the employee or it can be due to the indolent of the employee. The solution for effectively managing deviations and enhancing communication between administration and shop-floor is by creating deviation report electronically, in form of a database. The constructed database compared to the paper form is more user-friendly and has additional information relevant of handling the deviation. To entirely completing a deviation, specific instructions have been formulated and a set of rules have been added to diminish loading personnel to neglect filling in all data.

The database compared to the previous deviation report has been extended with additional data; the content of the database was validated with personnel from all levels in the organisation.

The information added:

- Transport mode – Truck/Container/Flight
- What type of error – Not found/Not arrived/Not available/Damaged pallet or goods
- Status – Blank/In progress/Finished

The loading personnel has specific instructions illustrated in figure 5.5 on how to work in the database when a deviation has occurred. It is of great importance that all boxes are filled to have a complete statistics and authenticated follow-up. To prevent loading personnel from not following the instructions, the database have rules such as if date and who reports the deviation is not typed, the deviation cannot be saved. When the employee has finished the reporting, deviations are gathered in a report and accessible for Customer Service, Transport department and Quality Service. The deviations are divided between Customer Service and Transport department, depending on internal or external deviation. The administration task in the database is to update the status according to the three choices of selection: *Blank* – no action by administration, *In Progress* – the deviation is managed by a unit, *Finished* – write the date when the deviation have been completed and add comments on what action have been taken.

Loading personnel and departments within the administration have been educated on how to use the database and maintenance of the database is done by the IT department.

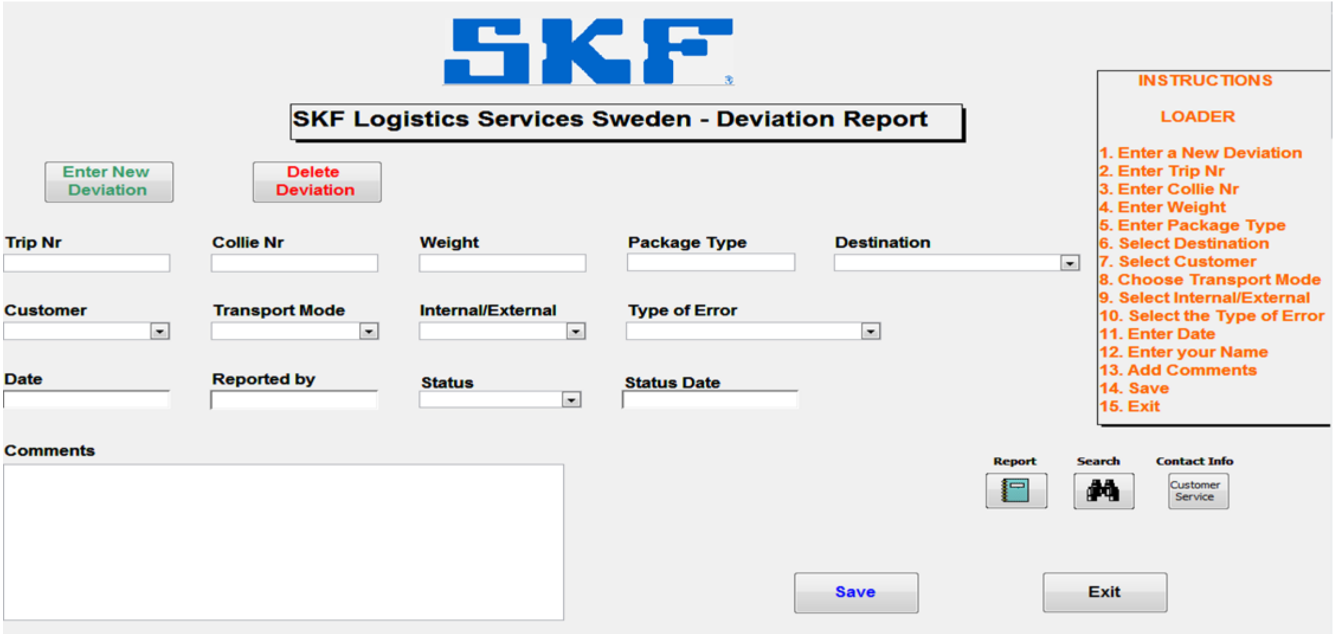

Figure 5.5 *The constructed database for enhancing communication between departments*

Figure 5.6 displays the flow on how deviation in the database is managed between the different divisions. Due to the database the responsibilities between the departments in the administration is considerably clearer and enables the deviation to be managed earlier, notifying customer on the status of the goods and in some cases preventing customer complaints.

Process Name	Loading - Deviation Report - SLS Sweden
Objective	...
Scope	...
Process Owner	Production Manager

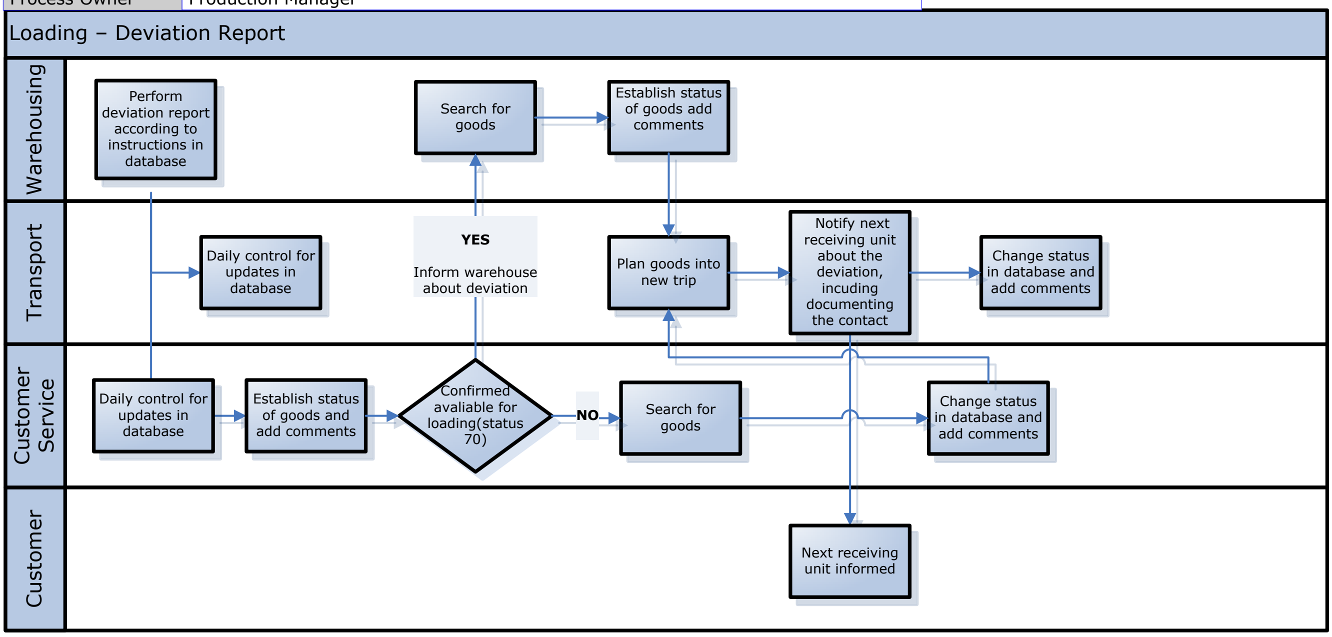

Figure 5.6 *The flow for managing database between departments.*

5.6.1 Implementation of database

In the beginning of July the database have partly been implemented at SLS Sweden, the reason why is because all personnel except Customer Service did get the education. Temporarily the Transport department manages the database until Customer Service is educated. The database was fully implemented in August after all employees were educated.

Construction of the database for managing deviations have led to clearer work routines, improved communication and information flow between the departments. Information will be constant accessible for administration to review deviations, this will further on result in a standardised work procedure. It is up each employee to take responsibility and follow the new procedure for managing deviations for the database to have an impact. Previous problem with left goods at floor 200 will be improved by the database. Each area-controller has responsibility to monitor updates in the database and to manage left pallets.

The loading personnel needs to follow the instructions and register every deviation arising. The administration needs to regularly monitor the report and changing status on deviation, so the deviation will not led to customer complaints.

Figure 5.8 is an example of the old deviation report used in loading area. As mention earlier the report was manually performed where in some cases the data was inconsistent. Compared to the report from the database, see figure 5.7, the report is complete and the employees work according to standard procedures.

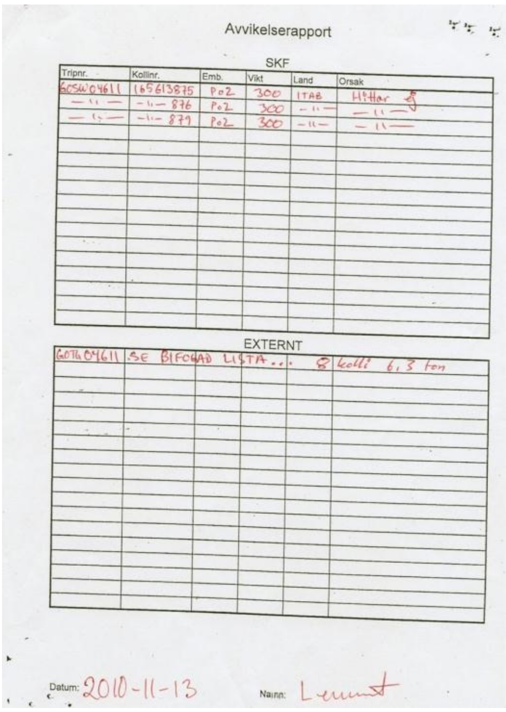

Figure 5.8 *Old deviation report*

Trip Nr	Collie Nr	Weight	Package Type	Destination	Customer	Transport	Internal/ External	Type of Error	Date	Reported by	Status	Status Date	Comments
GOTG13021	031269877	9,0	USE	FRA - Pia Lindin	CEJN - Mats Ågren	TRUCK	EXTERNAL	NOT FOUND	2011-07-26	Lennnart	FINISHED	2011-07-26	Flyttad till XFRA 11-07-27
GOTG13021	031267626	10,0	USE	NLD - Jan Henriksson	CEJN - Mats Ågren	TRUCK	EXTERNAL	NOT FOUND	2011-07-26	Lennart	FINISHED	2011-07-26	Flyttad till XNLD 11-07-27
GOSW13021	031274274	89,0	P03	ITA - Emelie Nordqvist	A-FÖRPACK - Ylva Henryz	TRUCK	EXTERNAL	NOT ARRIVED	2011-07-26	Lennart	FINISHED	2011-07-26	Flyttad till XITA 11-07-27
GOSW13021	140313919	2,0	609	DEU - Marc Johnstone	SEALPOOL - Marc Johnstone	TRUCK	EXTERNAL	NOT FOUND	2011-07-26	Lennart	FINISHED	2011-07-26	Flyttad till XDEU 11-07-27
GOSW13021	031274219	400,0	AFO	AUT - Jan Henriksson	A-FÖRPACK - Ylva Henryz	TRUCK	EXTERNAL	NOT ARRIVED	2011-07-26	Lennart	FINISHED	2011-07-26	Flyttad till XAUT 11-07-27
GOSW13021	031274220	346,0	AFO	AUT - Jan Henriksson	A-FÖRPACK - Ylva Henryz	TRUCK	EXTERNAL	NOT ARRIVED	2011-07-26	Lennart	FINISHED	2011-07-26	Flyttad till XAUT 11-07-27
GOSW13021	031274275	89,0	P03	ITA - Emelie Nordqvist	A-FÖRPACK - Ylva Henryz	TRUCK	EXTERNAL	NOT ARRIVED	2011-07-26	Lennart	FINISHED	2011-07-26	Flyttad till XITA 11-07-27
GOSW13021	031274273	89,0	P03	ITA - Emelie Nordqvist	A-FÖRPACK - Ylva Henryz	TRUCK	EXTERNAL	NOT ARRIVED	2011-07-26	Lennart	FINISHED	2011-07-26	Flyttad till XITA 11-07-27
GOSW13021	031274272	89,0	P03	ITA - Emelie Nordqvist	A-FÖRPACK - Ylva Henryz	TRUCK	EXTERNAL	NOT ARRIVED	2011-07-26	Lennart	FINISHED	2011-07-26	Flyttad till XITA 11-07-27
GOSW13021	031274271	89,0	P03	ITA - Emelie Nordqvist	A-FÖRPACK - Ylva Henryz	TRUCK	EXTERNAL	NOT ARRIVED	2011-07-26	Lennart	FINISHED	2011-07-26	Flyttad till XITA 11-07-27

Figure 5.7 *Database report*

6 IMPLEMENTATION OF IMPROVEMENTS IN LOADING

To perform an implementation it requires a thorough research of the process, this to create a valid and unique strategy for the procedure. In this following chapter the key factors for implementation in the loading process are explained. A set of alternatives for the process flow will also be analysed. Next step is an implementation sequence on how to proceed with the implementation at SLS Sweden. Finally a time frame on the activities for the implementation is presented.

6.1 Key factors for implementation at SKF Logistics Services Sweden

The factors illustrated in figure 6.1 are central pillars in the organisation. For an implementation to take place the different pillars require to be merged and managed from shop-floor to top management. Each pillar has its importance and without the support from the other pillars the alteration will not be effective, the point of improving a process is to make it last in long-term. As explained in chapter 2.8 about key factors implementation, the workforces requires having the right motivation and competence, the commitment of top-management, standardised communication channel, and accessible system for accomplishing an implementation.

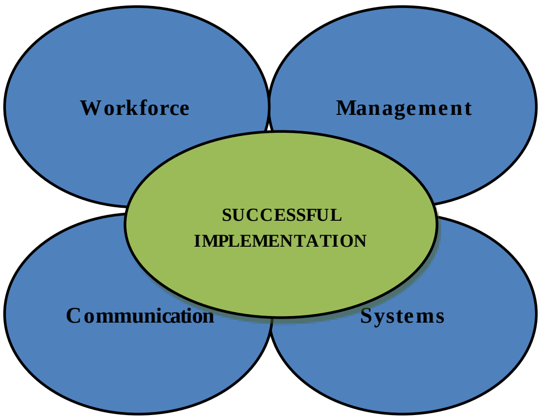

Figure 6.1 *Key factors in the organisation.*

6.2 Process flow

In chapter five an overall process flow by implementing scanning operation was illustrated in a swim lane but the objective with following section is an in-depth insight in important factors. Suggestions for different alternatives are established on the working procedure, and it is up to the management to agree in best alternative to adopt. For the implementation to be successful, detailed working procedures and clear responsibilities among personnel must be established. Otherwise there is risk for poor or non-improvements and dissatisfaction by employees of the new working methods.

The alternatives are describing the flow of the process from the point goods are pack reported, for internal goods, until the goods are loaded on trucks and each alternatives have its advantages and disadvantages. General for all alternatives is that scale personnel manages the pack reported goods from the conveyor system while loading personnel are suggested to be responsible for managing external goods incoming to floor 200. So to say, no changes are made on this point compared to the current method.

When loading trucks the loading personnel have the option to prepare the load by moving the pallets close to the gate or directly from dispatch area into the truck. It should be a decision taken from the loading personnel to build up a comfortable procedure by practise. But by choosing primer method, it requires available area close to gate to be able to collect goods before loading.

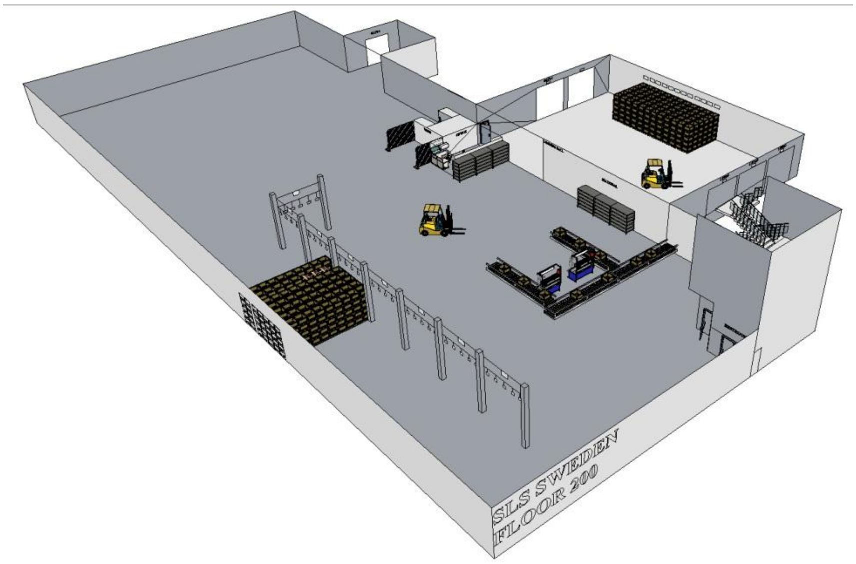

Figure 6.2 *3D-layout of floor 200 at SLS Sweden.*

Despite which alternative is adopted, the scanning procedure is in general. The employee scans the pallet and receives a pre-set dispatch area in WASS, displaying the name of main barcode and its number belonging to that specific shipment for example ES-1,2,3. ES is the main barcode and 1, 2, 3 are lanes planned for the shipment. When the worker places the pallet in its dispatch area the forklift driver scans the main barcode and the sub-barcode. If by mistake the worker scans the wrong sub-barcode, an error occurs in WASS clarifying that it is not in the right lane. If the worker attempts to place a pallet in a full lane, the system notifies and redirects the worker to place the pallet on other lanes for the shipment. When it is time for loading the truck, loading personnel scans the pallet from dispatch area and before loading it in the truck, the gate barcode is scanned and the pallet is removed from the loading list in WASS. The gate barcode is added to diminish the possibility of placing the pallet on wrong truck.

Another general aspect to consider is managing external and internal separately or not. Instead of mixing internal and external goods into same dispatch area and according to shipment, the option is to create a dispatch area dedicated only for external goods. Independent decision, it is applicable on all alternatives below. The benefit of managing separately is facilitation of planning and stacking of internal goods. The fact is that external goods can vary in shapes and volumes and complicates stacking opportunities. Separation will make it easier for the responsible person for planning the storage area to predict needed area for the internal goods because of its standardised shapes. Potential complications with reserving unnecessary much or insufficient area can accordingly be eliminated. The disadvantage is for shipments that include both internal and external goods will be spitted.

To make sure of loading goods on right truck, additional scanning operation before loading is suggested in form of scanning a barcode placed above each gate. The reason is because there has been couple of DER complaints regarding human mistakes where goods has been loaded in time with accurate documents but on wrong truck resulting in wrong destination.
Flight goods are suggested to be managed separately with an appropriate fixed area for dispatching with the aim to keep everything as clear as possible. The air freight is regularly used in urgent cases and is higher in cost perspective compared to other transport modes. This is why it is important to eliminate any potential failure opportunities. Current separation is not clear enough and the idea is to construct fenced area for air freight.

The following alternatives are:

6.2.1 Alternative 1 – "one by one"

Internal goods: After the pallets have been strapped the forklift drivers belonging to scale personnel scans, receives a location in WASS and moves every pallet one by one to its pre-set dispatch area.
External goods: After the pallets have arrived, forklift drivers from loading scans, receives a location in WASS and moves every pallet to its pre-set dispatch area.

Advantages:

- Minimal risk of error
- Structured storage area

Disadvantages:

- Time-consuming
- Possible stacking complications
- Repetitive driving
- Risk for queues on conveyor system

6.2.2 Alternative 2 – “buffer zone”

Instead of driving pallets one by one, scale personnel uses temporary buffer zones, where the pallets are scanned in and stacked. When the forklift driver moves the stacked pallets from buffer zone to its dispatch area, scanning procedure is repeated and the movement is registered in WASS to track where pallets are located.

Advantages:

- Less driving
- Preventing queues on conveyor system
- Possibility to sort and stack goods

Disadvantages:

- Several scanning procedure
- Buffer zones occupies space which can be instead used for dispatches
- Risk for pallets to be left in buffer zones, unfulfilling the shipment deadline

6.2.3 Alternative 3 – “loading hall buffer”

Adopting alternative 1 or 2 but not allowing scale personnel to enter the loading hall. The solution is to create a temporary buffer zone for goods with pre-set dispatch area in loading hall. Loading personnel are responsible to re-place goods from buffer zone to the loading hall. This alternative advocates a loading hall with loading personnel only.

Advantages:

- Clear interfaces between loading personnel and scale personnel
- Less distance for scale personnel
- Less traffic in loading area

Disadvantages:

- Circumstantial procedure
- Area consuming alternative

6.2.4 Alternative 4 – “conveyor system”

Alternative 4 is an extension of the conveyor system see figure 6.3. The conveyor system is divided into two main tracks and the system is linked to departure times. The first track is for pallets loaded daily, if the first track is full the pallet continuous to the next track. The loading personnel are responsible for scanning and placing the goods on dispatch area in loading hall. The second track is for goods departing in a few days and scale personnel are responsible for scanning and placing goods in pre-set dispatch areas. Incoming pallets to floor 200 from different floors on the conveyor system are scanned and depending on its departure the pallet is move to track one or two.

Figure 6.3 *3D-layout displaying the extended conveyor system.*

Advantages:

- Reduce manually operations
- Automated process
- Increased productivity
- Less traffic in loading area
- Clear interfaces between loading personnel and scale personnel

Disadvantages:

- Expensive alternative
- Radical change

6.3 Implementation Sequence

The following implementation sequence is a self-design, based on a mixture of different models (Junwei, 2006) (B.C.I Corporation, 2010).The implementation is divided into 10 different phases, where the sequence is optimised for the loading process at SLS Sweden. Here follows a description of the different phases.

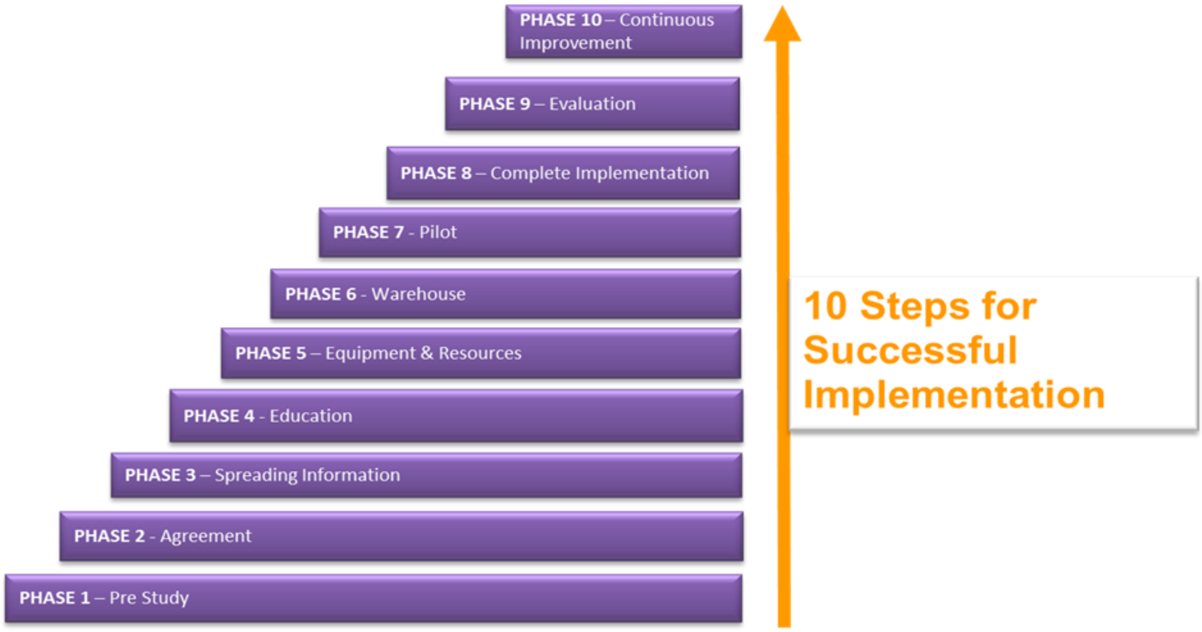

Figure 6.4 *Developed a 10 step model for implementation at SLS Sweden in loading area.*

Phase 1- Pre-study

The pre-study includes a mapping of the current process and identifying critical factors involving the process. From reviewing the process, the identified factors which are not initiated in the loading process but further back in the chain are crucial for accomplishing a reduction of errors and successfully implementing improvement suggestions. The factors are *deadlines* for finishing goods, *prioritising* goods in queues, receiving goods from *external customer* and *systems accessibility*. Therefore the management are responsible to decide the optimal solution for the factors and in-depth analyse of goods receiving. A set of conceivable alternatives are presented but requires to be reviewed.

Phase 2 – Agreement

The managements are to agree on the right alternative to adopt for the process based on options presented in previous sub-chapter on the process flow. In the organisation there are ambiguities between departments concerning responsibilities for extracting Gunnebo goods from floor 100 to floor 200 and processing short shipped goods. Regarding Gunnebo goods, when scanning is implemented the loading personnel will be more available and can extract the goods to their pre-set dispatch area. Finished Gunnebo goods are stacked in a buffer near elevator at floor 100; by scanning the goods in the buffer zone, it allows the loading personnel to track the position of the goods. A supplementary suggestion can be to install a camera so the personnel can easily monitor the goods.

When short shipped goods occur it is up to the area-controller for the destination to take action. The database constructed have improved the communication and assisting the area-controller to manage the goods.

The management therefore requires to determine clear interfaces between the departments and informing their staff on the new routines and additional tasks when the responsibilities are agreed.

Phase 3 – Spreading Information

Information according to Johnson et.al (2008) is a key resource for building organisation's core capabilities. When management have decided, the information is spread through the organisation to create awareness regarding the planned implementation and for the upcoming changes on working tasks and routines. According to Dooyoung (1998), to understand the desires for change and the threats of continuing the process as usual makes the employees prepared for accepting the changes. To begin with the information is spread in general through the weekly magazine, updating the employees on the upcoming future. Then will management gather all personnel from the different departments in the organisation. The implementation plan/procedure is in detail explain and the essential educational program. The purpose of the meeting is to share opinions, enhance motivation and show willingness (support) for change. Uniting the employees diminishes uncertainties, remove organizational inertia and create a common vision, the vision to strive for zero defects.

Phase 4 – Education

Education as a key factor in implementing new methods or systems has a great important role in learning and accepting the new system, though the knowledge and experience of the people can be key factors for the success of change.
A starting point for management is to create educational programs, and arrange instructors. The programs can be divided into:

- System functionality
- Standardized work procedure
- Strategic Storage planning

Every employee in SKF Logistics Services is well known with the basics of WASS system and the fundamentals of scanning procedure. For most this educational program on system functionality will be as refreshment and for others as a complete education course. The instructors responsible for system functionality are the IT unit. The course's learning objectives are WASS functions for dispatching goods with scanning.

When implementing a new system in an organisation it results in most cases into new work procedure for the employees, where the intention is to standardise. A standardised work procedure eliminates the employee's inconsistency, variability from the process. It ensures process stability, increased productivity and diminishes waste.

"A process should be performed the same way every time by every employee".
(Industrial time study institute, Accessed 2011)

A common way for learning is to organise different groups were the instructors use documents explaining in detail the tasks for the procedures. However, by complementing with videos and computer-based programs enables the employees to thoroughly study and clearly understand the details of the procedure.

Strategic Storage planning is about the learning essentials on how to plan goods with diverse volumes in a storage area. The course is intended for supervisors and production manager, where instructors for the following programme can be within the organisation or hired.

To empower employees increases their abilities to carry out what necessitates being accomplished (Kleiman, no date). By various educations the employees will improve their competence, increase confidence and willingness to improve. Result in higher flexibility and dedication towards the organisation.

Phase 5 Equipment & Resource's

To implement new system can be expensive depending on the magnitude of the improvement and the available resources. In this case, the alteration does not imply any larger effort since SLS Sweden already has the necessary resources and equipment. The modification required is installation of monitors with WASS, full utilisation of WASS functions, and scanning equipment on the forklifts in the loading area. The competence for executing phase 5 is in IT-department.

Phase 6 – Warehouse

When the employees are educated and the right equipment installed, it is time to visualise the warehouse to provide efficiency with clear signs and alignments. As explained previously the improvement procedure is based on scanning goods into dispatch areas. Therefore main barcodes are set up hanging down from the roof for every dispatch area, and additional sub-barcodes with number structure from 1-5, see figure 6.5. The added sub-barcode is to increase the flexibility and not constrain the whole area for just one shipment since the variability of volumes on goods for different shipments differs daily. Additional barcodes are set up for every gate that manages loading. The current signs can instead of displaying destinations, show were the different barcodes sections are located and adding signs for material, customer returns and internal returns. The demand for flight transportation is not high from customers; therefore a fixed area can be set in the warehouse for flights. Drawing the alignments on the floor includes the five strings for a shipment, safety precautions and for pedestrians. 3D pictures on floor 200 in appendix.

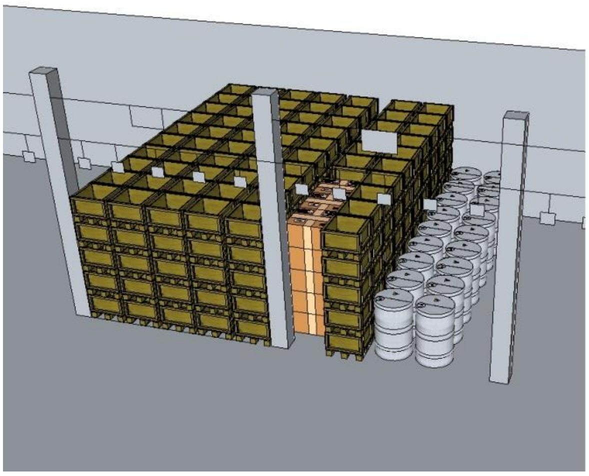

Figure 6.5 *Illustrates dispatch areas with varied goods.*

Phase 7 – Pilot

Implementing the whole system directly is not an optimal suggestion, though it can lead to various failures costing the organisation time and money. Perform a pilot project during a period e.g. on one of the transport modes, Sea freight which is loaded on separately gates. Performing a pilot is for testing the performance and functionality to assure that the process performs and meets the plan specification. Depending on the measurements and information obtained from the pilot, the implementation procedures can be modified to get the most suitable system for the organisation.

Phase 8 – Complete Implementation

Completing the implementation is to complement scanning of goods on the remaining transport modes. To ensure a successful implementation it should be performed when minimal movements of goods are in the warehouse, under semester time or on weekends. However in modern warehouse this is not always possible, therefore overtime by personnel or additional warehouse resources are needed to keep shipping products during implementation.

Phase 9 – Evaluations

For a period of time after the system has been implemented, regular reviews for ensuring the system is working and there are no operational problems occurred due to the new system.

Phase 10 – Continuous Improvement

Continuous improvement is a never ending effort to reach perfection (Inman, 2011). Although perfection is a vision it maintains the organisation on alert and competitive in its market. The concept of continuous improvement involves incremental small-step improvements rather than overwhelming innovation (Inman, 2011). The small improvements concerning the loading process to increase visibility and communication are:

- Installing monitors for every dispatch area
    - Which shipments in dispatch area
    - Not pack-reported packages
    - When to be loaded
    - Deadline for loading
    - Departure time

- A TV including:
    - Today's shipments
    - Updates made by supervisor or administration
    - Deadlines for shipments/packages
    - Incoming trucks
    - Screenshot of camera on floor 100

- Extend conveyor system

Through continuous improvement the organisation can create enhanced services, in this case getting the goods out in time and to customer at right time. This will result in customer satisfaction and increased trust. As mentioned in theory SKF is well-known with working towards customer satisfaction and continuous improvement by Business Excellence.

6.4 Time Estimation on implementation

The following Gantt schedule, see table 6.1, on implementation of the different phases at SLS Sweden is a rough estimation. The duration of the phases are validated by the supervisor at SLS Sweden and are considered to be realistic. The implementation can approximately be completed in February 2012.

Table 6.1 *Gantt schedule on implementation.*

Nr	Phase	Duration	2011									2012				
			apr	maj	jun	jul	aug	sep	okt	nov	dec	jan	feb	mar	apr	maj
1	Pre – Study	30w														
2	Agreement	2w														
3	Spreading Information	2w														
4	Education	4w														
5	Equipment & Resources	1w														
6	Warehouse	2w														
7	Pilot	3w														
8	Complete Implementation	1w														
9	Evaluation	3w														
10	Continuous Improvement	0w														

7 DISCUSSION

The overall purpose of this master thesis was to reduce the number of errors caused at the loading process and to reduce non-value added activities. The scope was concentrated to activities after the pack-reporting stage at loading area. During the problem identification it was noticed that one problem leads to more problems. Initially it was difficult to point out specific causes to the end-result. But the more the researchers became familiar with the process, the more everything became clear. It was attempted to get as detailed knowledge as possible and notable is that the learning process lasted during the whole project. Several meeting were needed with employees around the organisation to discuss and study specific operations.

The thesis has been unique for the researchers because it goes all the way from problem identification to generate solutions, to the final step implementation. The involvement of the Six Sigma project team together with the benchmarking at SLS Germany has been very useful techniques for building up the overall perception and for producing suggestions for improvements.

Looking back to the P-FMEA, there is great potential of solving the out sorted inputs/outputs with the proposed improvements. The research focused in the 13 highest rated factors. But the potential failure modes resembled each other even for the out sorted ones. Even if the researchers would choose to manage all critical inputs/outputs, the recommended actions would be similar.

The thesis confirms 4 documented defects per day. Another way of measure is through the Six Sigma level. Different values are presented depending on type of goods. By measuring the total process the value is 4.30. As explained earlier, the responsibility lies on the organisation to measure future state. The implemented database will hopefully help the organisation to document all defects. Consequently, there is a risk of increased number of defects per day and decreased Six Sigma level at the beginning. Therefore the process should be measured first after the entire implementation. It is important to be aware of the contrasts regarding the level. A minor change of the level can imply great improvements. For example, to half the defects from 1.694 to 847 gives the rate of 4.52. Thus, the level is improved with just 0.22 units although twice as good process. Simultaneously it makes clear that it requires an enormous effort to approach desired state.

In the introduction chapter three questions were formulated, believed to help reaching the thesis purpose. The questions are responded and discussed as following.

1. Are there any critical factors in the current loading process causing short shipment?

To identify critical factors in the current loading process, the process flow was mapped in Visio chart and in a traditional Six Sigma process map. The Visio chart showed alternative ways and decisions along the process. The researchers asked themselves whether all alternatives and decisions are necessary. It resulted in identifying three main weaknesses. The first is managing goods different depending on type of goods and variety in scanning procedure. The second is that the order in storage is deranged when dispatch areas are occupied. Personnel adopt different working routines which creates disorder. The third critical factor is coping with uncompleted loading lists because of unclear routine for closing the trip. It causes initial loading and repetitive searching for goods and the risk factor for issues increases.

Already before executing the thesis, SLS Sweden was aware of the non-value added activities regarding time spent of searching for goods related to the loading process. The Baseline investigation confirmed that lot of the sought goods never been found at loading moment. The deviation has been reported as missing goods and led to short shipment. In other words, the customer except the goods but no goods has been delivered according to lead time and loading personnel have wasted time in non-value added activities. But the searching activity does not always stop at this point. Personnel from administration could in some cases continue searching if no information appears regarding the deviation.

The process map describes input and outputs in the process. Those were rated after importance and ended in an amount of critical inputs according to the P-FMEA. It resulted in various potential failure modes and recommended actions were similar for all.

The fishbone diagram presents deadlines/priority, night shift, storage area and unclear responsibilities as main causes for short shipment. Main causes are followed by different sub causes that all can contribute and interplay to defects in the loading process.

To retrospect to the Baseline, some aspect could have been analysed more than this thesis offers. By studying external inbound goods in-depth might have resulted in useful information of why some customers are more affected than other. Is it because of SLS Sweden or customers themselves? Equally investigation could be done for the night loading. However, the researchers consider it unnecessary to dive too deep at the moment. By concentrate in doing right operations from beginning will improve the process. Scanning goods into barcodes will do the most influence and together with adjustments in working routines, large of current defects will be eliminated. The importance of planning shipments based on available goods is crucial and must be highlighted once again.

2. What is the most common type of errors in the process and do they differ between the shifts?

To be able to answer the question, the researchers performed a comprehensive pre-study, called the Baseline in the thesis. Types of errors were classified after similarity into ten different categories. Unfortunately, the most common type of error resulted in "missing goods" with 89%. Included in this category were short shipment, not found and not available goods. The information did not give any detailed cause for error which the researchers desired to obtain. At the same time the result was expected, based on the fact that much time is spent on searching for goods.

The outcome origin from neglected follow-up of deviation reports (DEV-reports). Recent follow-up is primary to solve the deviation and not to investigate and document causes. DEV-reports accounted for 84% of the data collection. Remaining 16% responded for DER- and TPE-reports. SLS Sweden is proposed to pursue same documentation for DEV-report as for DER and TPE. Especially when viewing the amount of error reported in DEV. The Baseline document ought to be utilised for future statistics.

The Baseline showed remarkable difference in working shift in relationship to occurrence of errors. The night shift was consistently affected with 93%. The main reason is planning goods into loading list in advance without actually knowing if goods are available for the night trucks. It is assumed that SKF goods will make its deadline and external goods arrive as planned.

To reduce the night defects, one solution is to change planning routines. The crucial is to be ahead with pack-reported goods. Invoicing customers and planning the loading list should be based on available goods only. In order to succeed it is needed with earlier deadlines for SKF goods, night goods should be ready during the day shift. Inbound external goods in the evening should be planned for next coming day.
Optionally is to extend system accessibility and working hours for administration. The data system for order managing and invoicing of export orders is currently not available during the night. The possibility of changing the accessibility is still unknown.

3. What improvements can be suggested to reduce the waste and common errors? Consequently, what implementation structure should be applied for a successful implementation?

The researchers focused on several weaknesses in the current loading process. Numerous weaknesses were connected to each other and by solving one weakness could result in eliminating other automatically. The main weaknesses discussed are the lack of communication, unorganised storage area and not scanning all goods in dispatch areas.

The usual routine for communication between the administration and loading personnel is either face-to-face exchanges or telephone conversations. Deviations during day shift are normally reported by telephone without documenting the deviation, hence the big difference between day/night in previous question. The disadvantage with face-to-face exchanges is time wasted in moving between the floors. Administration is located at floor 500 while loading takes place at floor 200. Both administration and loading personnel spend lot of time searching for goods. Interfaces between administration and loading personnel are unclear resulting in unnecessary many persons involved in searching and without awareness of each other's effort. Short shipments of goods left in loading area are an obvious evidence of lack of responsibilities. If nobody takes responsibility, there is a risk of left goods for excessive long time and eventually involuntary ignored.

To improve the communication and information accessibility between the departments, a database was constructed and implemented during the master thesis. The database improves the flexibility and possibility to access information in an effective way. All deviations are intended to be reported included defects occurring during the day shift. Clear responsibilities are established between the warehousing, Customer Service and Transport department for managing the database. To avoid ignored goods in loading, each area-controller (depending on destination) is responsible to manage the deviation. A comment field was created in the database and aims to spread information about actions made from each and one. It reduces time wasted in e.g. repeatedly searching for goods. The database also enables to do status updates of deviations e.g. "in progress", "finished", for constant control and minimise the risk of ignored deviations. By reporting deviations electronically facilitates follow-up work and maintaining statistics.

A series of inventories was performed of the storage at the loading area. A huge part of the storage capacity occupies of long-term storage of e.g. large bearings and house bearings. It brings less space for short-term storage of goods and simultaneously higher demand of flexibility. The first sensation anyone obtains is space issues with too limited space and disorder. But is this true? Maybe it can be reversed, is the storage area fully utilized and organised? Moving the long-term storage goods would facilitate much but it requires available space in other buildings around the warehouse. It might require radical changes with reconstructions. To avoid radical changes it is opted to investigate the opportunities with the current structure of the storage area. Ignored goods have been discussed, such issues must be eliminated in the future to stay flexible and utilize the area optimally. A change as in this case with clarifying responsibilities is occasionally.

The researchers focused in several single improvements by reviewing the current space and resulted in many improvements possibilities. One storage improvement is by scanning goods into specific areas. It allows tighten goods together and remove the left space between goods. The space is 20-30 cm and uses today to be able to read, control and scan the labels on the pallets. Another storage improvement is by re-organise such as consumption material for packing. Material was found in several places around the loading area and the idea is to collect all material into one area and if possible improve the stacking. The calculations made of the area improvements enables 183 square meters of "new" storage places. The calculations are based on both scanning and re-organise material.

It is suggested to improve the visualisation, implies refilling of alignments to create security alignments for pedestrians and erecting clear signs around the loading area. By implementing scanning operation, there is need of barcodes respectively sub barcodes. In long-term the idea is to replace signs with information monitors. Additional storage improvements could be done by changing routines of managing goods. Temporary buffer zones are today very area consuming and should be reviewed more. The thesis does not find an optimal solution for how to manage temporary buffer zones but there has been different alternatives presented in previous chapter. Each alternative has its advantages and disadvantages. The best solution might be to reduce the area for temporary buffer instead entirely elimination.

By adopting suggested improvements above will create a sense of order and clarity which expectantly reduces the number of not found goods.

Clear responsibilities and order in storage can both contribute to less searching. In order to reduce waste, goods must be registered as physically arrived at the loading floor. By scanning all goods into pre-advised places in WASS makes it possible to exactly deduce the location of goods. It precludes searching operations completely.

During the thesis, other type of waste has been identified. By adopting scanning in loading procedure, loading personnel save 25 minutes per truck. The time spent on check and control goods before loading are reduced from 35 minutes to 10 minutes which is the total time for scanning the trip. Whether it is waste or an improvement can be discussed. Definitely it does equal feature but with time gaining method. Recent method is not seen as "non-value added activity" but with perception after the fact, seen as waste. The released time can rather be seized to other activities.

The second part of the question is about implementing suggested improvements. The sequence consists of ten phases where emphasis should be laid on the first phase, pre-study. This thesis is an essential part of the pre-study but it requires additional pre-studies according to phase one, for the implementation to become successful.

8 CONCLUSION AND RECOMMENDATIONS

This research has identified issues, mapped and measured the current loading process. The data as well the current process has been analysed which generated in ideas, alternatives and solutions for issues. The expected outcome of identify, verify and document recommendations to SLS Sweden has been accomplished and the research questions have successfully been answered. Suggested improvements are expected to reduce errors in the loading process, improve productivity and reduce non-value added activities. The drawn conclusions from the Master thesis are listed as following in different categories:

Six Sigma

- Insufficient follow-up of DEV-reports resulted in unclear causes for defects. The most frequently type of error was missing goods.
- 1.694 defects or rather 4 defects per day were identified. Insufficient deviation documenting during day shift contributed to fewer amount of defects and to the vast difference between day/night shifts.
- Current Six Sigma level is 4.54 for internal goods, 3.53 for external, 5.60 for cross-docking and 4.30 for the total process. Cross-docking goods are scanned with portable device and prove benefits of scanning operation.
- The relationship between deadlines/priority, night loading, storage area and unclear responsibilities are main causes for short shipment of goods.

Scanning procedure

- Improved loading process with complete scanning of all goods connected to WASS is suggested. It implies two scanning operations: scan goods into barcodes and scan goods before entering truck.
- The time gain of scanning outbound goods is 25 minutes per truck. The manual operation of read, check and control goods is transferred to electronic operation.
- The current portable device for scanning is replaced with scanning devices attached to the forklift.

Improvement suggestions

- Current and suggested loading process differs in: Managing goods equal whether internal/external or cross-docking, each pallet has its own pre-advised storage place in loading area, loading process with one complete loading list based on available goods without repetitively searching for goods, clear deadlines and loading after closed trip.
- Calculations on utilization the storage area around loading resulted in possible improvement of 68% and save over 96.000 SEK for SLS Sweden.
- Managing reporting of deviations has been changed from physical to electronically by implementing the database. The gain for the organisation is ensuring of documenting all defects, flexibility of managing deviations, information source for interacting, clarified responsibilities for departments, minimise risk of duplicate work and source to keep statistics.

Implementation

- The developed 10 phase model for implementation sequence is suggested to be followed for successfully applying improvements.

Recommendations to SLS Sweden

- Investigate deadlines and prioritising issues in-depth before implementing the suggestions in the thesis.
- Utilize internal resources as much as possible for implementation.
- In short-term implementation it is suggested to perform pilot projects to investigate best alternative of process flow.
- In long-term perspective it is suggested to investigate alternative four, reconstruction of conveyor system, to partly automate the process. Also investigate opportunities of implementing RFID gates.
- Follow-up this thesis by control. Measure improvements made after implementation. Designate responsible person for measure.
- Establish continuous cooperation with SLS Germany to take advantages from each other's superior methods.
- Review the options to move long-term storing, such as large bearings, away from floor 200 in order to prepare storage area to meet an eventual increased volume.
- Keep the concept of continuous improvement, phase 10 of implementation sequence.

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Appendix A

The complete Project Charter – Defining the projects objectives.

Element	Description	Charter
1. Problem Statement	State project's problem and background. ("What, where when, who, why, how.")	SLS Sweden aims to have a Zero Defect loading process. Today the amount of errors caused at loading is considered to be too high. The errors can be related to wrong loading, short shipping which resulting in broken promises and customer complaints. Time for searching for gods etc. and also the time spent on non-value added activities such as searching for goods are considered to be too high and should be reduced.
2. Defect Definition	Describe undesired result or failure to meet requirements.	Wrong loading and short shipping results in broken promises, customer complaints and non-value added activities.
3. Process Impacted	Describe the Process where improvement opportunity exists, i.e. the process where defect occurs.	• Loading- Scanning at loading process • Loading –Deviation reporting • Loading-Follow up short shipped goods • Warehouse, Transport and Customer Service- Communication and documentation. • Warehousing – Structure and visualisation • Transport- Follow up deviation reporting • Customer Services – Follow up deviation reporting • Customer Service-Follow up short shipped goods
4. Benefit to Internal and External Customers	Define the customers and their most critical requirements. (Include the projects "CTQ's".)	<u>External customer</u>: Right goods in right time with right shipment. <u>Internal customer</u>: Right goods in right time with right shipment.
5. Benefit to the SKF Business	Describe Project relevance to the business strategies and objectives; i.e. increased profit margin by; reduced cost by; increased sales/market share by; reduced customer complaints by; improved customer satisfaction by; etc.	• Reduced cost by less complaints • Save man hour • Improve productivity & reduce non-value added activities • Better utilization of warehouse space and resources • Better predictability in goods flow
6. Constraints	Describe any constraints which influence the project.	• 100% availability, • 100% reliability
7. Project Scope	Define the part of the process (start and end point) or product(s) that will and will not be investigated. Describe how the project conditions are when it is finished, e.g. proposal, investigation, full or partly implementation, etc.	<u>Included</u>: The scope of the project is from the point in time when goods have passed through the pack-reporting process at SLS Sweden to the time the goods are loaded. <u>Excluded</u>:

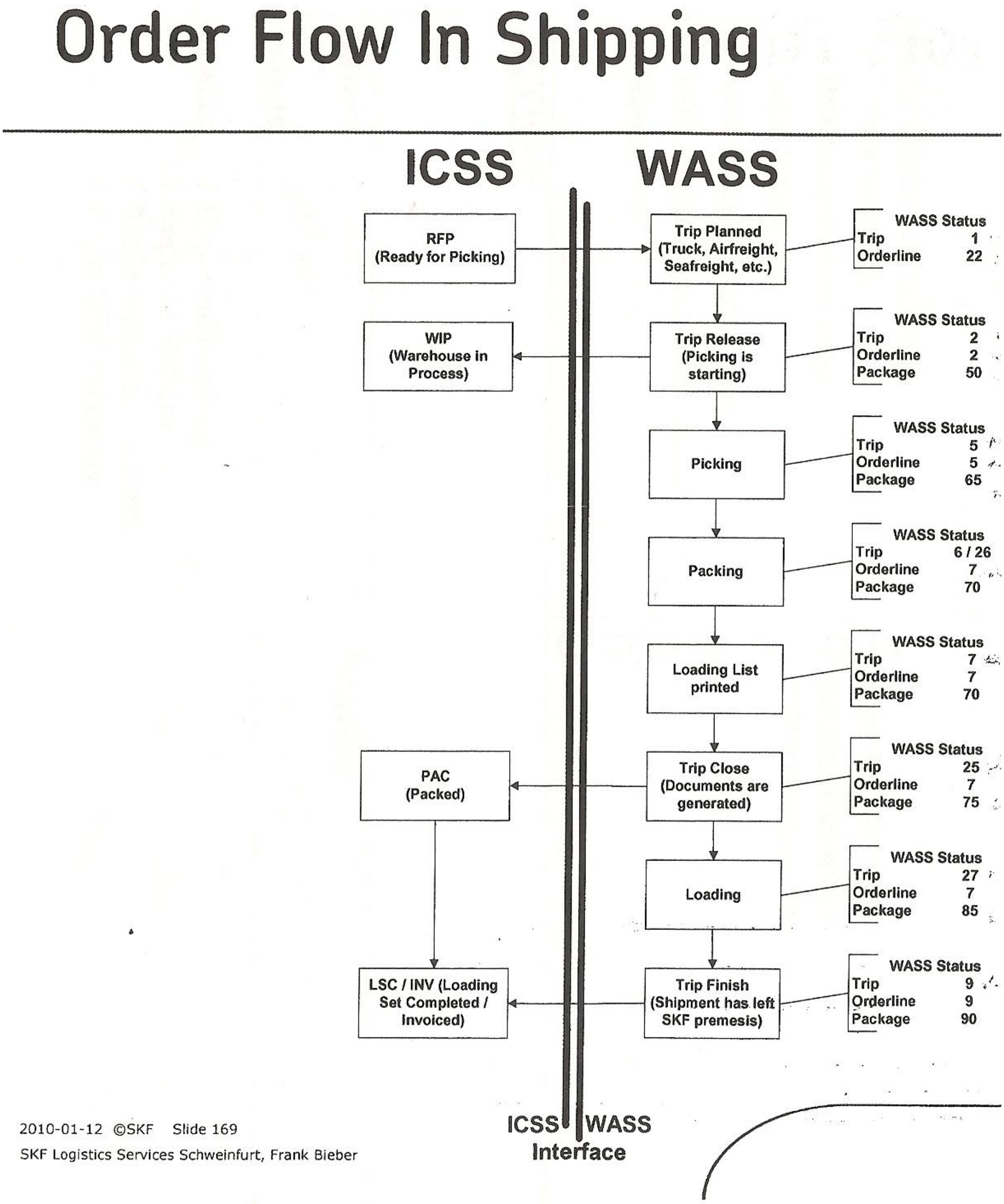
Appendix B

Daily Transport System (DTS) Time schedule for Western Europe.

DTS TIMETABLE - DTS ROAD - EUROPE - WEST							
			DEPARTURE		ARRIVAL		
From	To	Trip	SKF	IntHub	SKF	Int hub	Dom hub
Gothenburg	**Airasca**	GOAI	16.00				12.00
	Copenhagen	GOCO	14:00	14:00			18:30
	Gothenburg	GOGO	10:30			11,00	
	Helsinki	GOHE	12.00	12:00		15.00	13.00
	Oslo	GOOS		12:00			17.30
	Madrid	GOMA	16:00				12:00
	Paris	GOPA	16:00				10:00
	Schweinfurt	GOSW	04.00			04.30	06.30
	2nd truck	GOSW	11.00			11.30	13.30
	3rd truck	GOSW	14.00			17.00	17.00
	Tongeren	GOTG	04:00 (0)	n/a	n/a	03:00 (+1)	n/a
	2nd truck	GOTG	05:00 (0)	n/a	05:00 (+1)	04:00 (+1)	n/a
	3rd truck	GOTG	15:30 (0)	n/a	13:00 (+2)	n/a	n/a
	4th truck	GOTG	16:30 (0)	n/a	14:00 (+2)	n/a	n/a
	5th truck	GOTG	17:30 (0)	n/a	15:00 (+2)	n/a	n/a

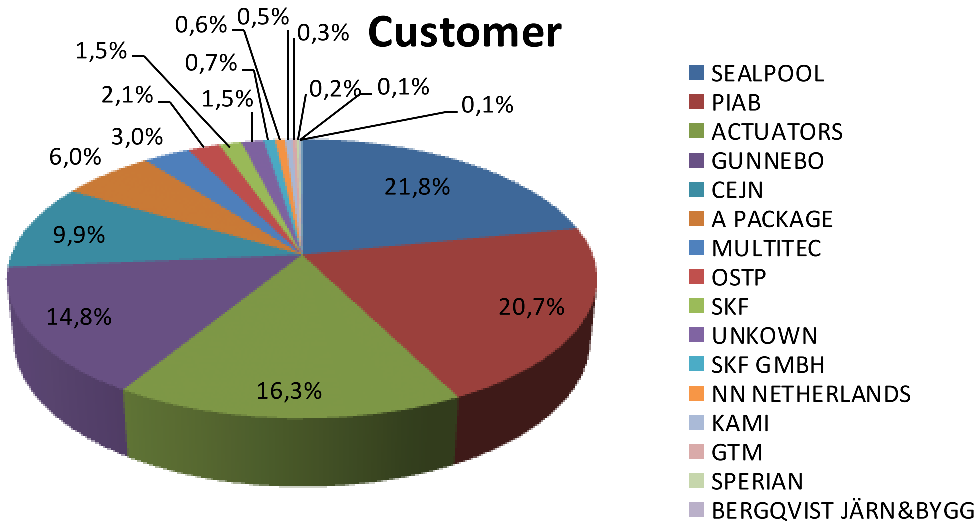
Appendix C

Order flow in shipping – Different status in WASS.



Appendix D

SLS Sweden's external customers concerning deviations. The amount is presented in percentage for each customer.



Appendix E

Six Sigma Tool – Complete Process Map

	Process Map
Project Title	**To achieve Zero Defects at SKF Logistics Services Sweden loading area and hub area**

Input	Step	Output	Notes
Trip i WASS Pre advice weight goods Transport: book capacity DTS (1 day before) CS: book sea (same day) CS: book flight (same day) Excel planning list tool Book direct truck	**Prepare trip list (Status 1)**	Trip list via mail Truck booked DTS Sea freight booked Flight booked Direct truck booked	
Trip list via mail Truck booked DTS Sea freight booked Flight booked Direct truck booked Available buffer zone Forklift driver Forklift Packreported SKF goods Arrived external goods Scanning device WASS label	**Goods sorted in temporary buffer zones (status 6)**	Occupied buffer zone at floor 1 Occupied buffer zones at floor 2 Sorted by trip Initiate loading of packreported goods (Incomplete loading list printed) Scanned (arrival) external goods (status 24) Scanned (loaded) external goods (Int. Hub NOR,FIN, BALTICUM,Scania) Non scanned goods Scanned Gunnebo as arrived CS (manually in WASS)	
Occupied buffer zone at floor 1 Occupied buffer zones at floor 2 Sorted by trip Initiate loading of packreported goods (Incomplete loading list printed) Scanned (arrival) external goods (status 24) Scanned (loaded) external goods (int hub NOR,FIN, BALTIKUM,Scania) Non scanned goods Scanned Gunnebo as arrived CS (manually in WASS) Distributed area Available area	**Goods sorted by destination in loading area (status 6)**	Sorted goods according to trip and destination Free storage in buffer zones Occupied loading area Left goods at buffer zones Loader prints an incompleted loading list with updated goods Mixed trips in destination area due to variation of volumes External goods in several areas	
Sorted goods according to trip and destination Free storage in buffer zones Occupied loading area Left goods at buffer zones Loader prints an incompleted loading list with updated goods Mixed trips in destination area due to variation of volumes External goods in several areas Goods available at floor 2	**Loader check, pick and stack the goods according to loading list for the actual trip (status 6)**	Checked loading list Prepared goods Goods not available at floor 2 Searching for goods Missing external goods Missing SKF goods Unmatched loadinglist (printed vs final list CS)	
Checked loading list Prepared goods Goods not available at floor 2 Searching for goods Missing external goods Missing SKF goods Unmatched loadinglist (printed vs final list CS) Available CS personnel Packreported trip (fulfilled deadlines) Available crossdocking goods Available external goods Invoices by external customers by mail within deadlines Available system (ICSS,CWW, etc)	**CS invoicing, close trip and complete documents (status 25)**	Completed documents Completed loading list (left by CS in rack) Load set closed status 25 Status in trms Unclosed trip Incompleted documents No invoiced package - Package moved late by CS Not available CS personnel Deadlines unfulfilled Forced loading in WASS (status 27) CS	
Completed documents Completed loading list (left by CS in rack) Load set closed status 25 Status in trms Unclosed trip Incompleted documents No invoiced package - Package moved late by CS Not available CS personnel Deadlines unfulfilled Forced loading in WASS (status 27) CS Goods available in loading area Plan for structure of loading (weight, volume) Available truck/container Sequence loading Securing goods on pallet Expert competence staff Chauffeur/Truck according to time schedule	**Loading on truck/container (status 27)**	Truck/container loaded with goods Goods according to loading list Sealed container/truck Confirmed load by chauffeur Sequenced load Secured load Deviation report TPE,DER Not within time schedule Not sequenced load Goods in time	
Truck/container loaded with goods Goods according to loading list Sealed container/truck Confirmed load by chauffeur Sequenced load Secured load Deviation report TPE, DER Not within time schedule Not sequenced load Goods in time Available chauffeur	**Completed documents (transport, customes) given to chauffeur - truck departure (status 9)**	Completed documents Chauffeur waits for documents Loader notes container nb, trip and signature Loader don't sign loading list Loader sign loading list Chauffeur signs	

Appendix F

Six Sigma Tool – Complete Cause and Effect Analysis

			1	2	
		Rating of Importance to Customer	10	6	
		Key Process Outputs	Receive expected collies in time	Receive proper documentation/data transmission	
	Process Step	**120**			**Total**
1	**Prepare trip list (Status 1)**	Trip i WASS	9	9	**144**
2		Pre advice weight goods	3	1	**36**
3		Transport: book capacity DTS (1 day before)	9	1	**96**
4		CS: book sea	9	1	**96**
5		CS: book flight (same day)	9	1	**96**
6		Excel planning list tool	0	0	**0**
7		Book direct truck	3	1	**36**
8	**Goods placed in temporary buffert zone (status 6)**	Trip list via mail	0	0	**0**
9		Truck booked DTS	0	0	**0**
10		Sea freight booked	0	0	**0**
11		Flight booked	0	0	**0**
12		Direct truck booked	0	0	**0**
13		Available buffer zone	0	0	**0**
14		Forklift driver	0	0	**0**
15		Forklift	0	0	**0**
16		Packreported SKF goods	0	0	**0**
17		Arrived external goods	0	0	**0**
18		Scanning device	0	0	**0**
19		WASS label	0	0	**0**
20	**Goods sorted by destination in loading area (status 6)**	Occupied buffer zone at floor 1	3	0	**30**
21		Occupied buffer zones at floor 2	3	0	**30**
22		Sorted by trip	3	0	**30**
23		Initiate loading of packreported goods (Incomplete loading list printed)	9	9	**144**
24		Scanned (arrival) external goods (status 24)	3	3	**48**
25		Scanned (loaded) external goods (int hub NOR,FIN, BALTIKUM,Scania)	1	0	**10**
26		Non scanned goods	9	9	**144**
27		Scanned Gunnebo as arrived CS (manually in WASS)	9	3	**108**
28		Distributed area	9	1	**96**
29		Available area	9	1	**96**
30	**Loader check, pick and stack the goods according to loading list for the actual trip (status 6)**	Sorted goods according to trip and destination	9	9	**144**
31		Free storage in buffer zones	0	0	**0**
32		Occupied loading area	9	9	**144**
33		Left goods at buffer zones	9	9	**144**
34		Loader prints an incompleted loading list with updated goods	9	9	**144**
35		Mixed trips in destination area due to variation of volumes	9	9	**144**
36		External goods in several areas	9	9	**144**
37		Goods available at floor 2	9	3	**108**
38	**CS invoicing, close trip and complete documents (status 25)**	Checked loading list	9	9	**144**
39		Prepared goods	3	0	**30**
40		Goods not available at floor 2	9	9	**144**
41		Searching for goods	9	1	**96**
42		Missing external goods	9	3	**108**
43		Missing SKF goods	9	3	**108**
44		Unmatched loadinglist (printed vs final list CS)	9	9	**144**
45		Available CS personnel	9	9	**144**
46		Pack reported trip (fulfilled deadlines)	9	9	**144**
47		Available crossdocking goods	9	9	**144**
48		Available external goods	9	9	**144**
49		Invoices by external customers by mail within deadlines	9	9	**144**
50		Available system (ICSS,CWW, etc)	9	3	**108**
51	**Loading on truck/container (status 27)**	Completed documents	1	9	**64**
52		Completed loading list (left by CS in rack)	9	0	**90**
53		Load set closed status 25	0	0	**0**
54		Status in trms	0	0	**0**
55		Unclosed trip	0	0	**0**
56		Incompleted documents	0	0	**0**
57		No invoiced package - Package moved late by CS	3	9	**84**
58		Not available CS personnel	9	9	**144**
59		Deadlines unfulfilled	9	9	**144**
60		Forced loading in WASS (status 27) CS	3	9	**84**
61		Goods available in loading area	3	3	**48**
62		Plan for structure of loading (weight, volume)	3	0	**30**
63		Available truck/container	9	9	**144**
64		Sequence loading	0	0	**0**
65		Securing goods on pallet	3	0	**30**
66		Expert competence staff	9	3	**108**
67		Chauffeur/Truck according to time schedule	9	3	**108**
68	**Completed documents (transport, customes) given to chauffeur - truck departure (status 9)**	Truck/container loaded with goods	9	9	**144**
69		Goods according to loading list	9	9	**144**
70		Sealed container/truck	0	0	**0**
71		Confirmed load by chauffeur	1	1	**16**
72		Sequenced load	0	0	**0**
73		Secured load	1	0	**10**
74		Deviation report	3	3	**48**
75		TPE, DER	0	0	**0**
76		Not within time schedule	3	3	**48**
77		Not sequenced load	0	0	**0**
78		Goods in time	9	9	**144**
79		Available chauffeur	9	9	**144**
Total			**3880**	**1710**	**49060**