

Performance measurement system for warehouse activities based on the SCOR® model

A research study in collaboration with Consafe Logistics AB, Sweden

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ABSTRACT

Title: Performance measurement system for warehousing activities based on the SCOR model

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Background: SCOR is a worldwide accepted and renowned process reference model that is developed and endorsed by the non-profit organization Supply Chain Council. It's a cross-industry diagnostic tool for supply chain management.

Consafe Logistics wanted to know if a performance measurement system for warehouse activities could be developed based on the SCOR model, and how it could be applied in their organization to offer enhanced customer satisfaction.

Research issue: Previously, there's been no standardized model used to define warehouse metrics at Consafe Logistics. If more relevant and standardized metrics would be used, Consafe Logistics could arguably be more efficient, give better support to customers and consequently generate greater customer satisfaction. The research should investigate if the SCOR framework can be applied to the company's services within warehouse management. Furthermore, Consafe Logistics would like to gain a comprehensive picture of what metrics their customers currently measure in order to identify if metrics from the SCOR portfolio are applicable.

Purpose: The purpose of this study was to develop a performance measurement system for warehouse activities; the system should be based on the Supply Chain Operations Reference (SCOR) model.

Method: The method used in this study was a combination of many elements. First a situation analysis were performed to clarify the initially vague information and to be able to construct the research issue, the purpose and the delimitations for this study. Then a literature study was conducted to make sure enough knowledge was gained about warehouse management, performance measurements and the SCOR model. The empirical data was gathered in a combinatory approach between a qualitative pre-study and a quantitative and qualitative web-based survey. The main purpose of the pre-study was to gain relevant and in depth information from practitioners. The survey was a broader investigation and thereby gave more opportunity for generalization. The information was then analyzed and a performance measurement system for warehouse activities was developed.

Conclusions: This study has reached its purpose to develop a performance measurement system based on SCOR. A process model that focuses on the operational tasks within warehousing was designed. If Consafe Logistics implements this warehouse process model, a relevant set of metrics can be achieved for each customer. In this way Consafe Logistics could save a lot of resources in trying to figure out what clients want to measure.

Keywords: SCOR, performance measurement system, warehouse management, warehousing, processes, metrics, key performance indicators

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Lund, 2014-06-03

Lund, 2014-06-03

Per Axelsson

Jonathan Frankel

LIST OF ABBREVIATIONS

W&D – Warehouse & Distribution

CL – Consafe Logistics

KPI – Key Performance Indicator

SCOR – Supply Chain Operations Reference

SCC – Supply Chain Council

BI – Business intelligence

WMS – Warehouse Management System

DC – Distribution Center

SKU – Stock-keeping unit

ERP – Enterprise Resource Planning

PMS – Performance Measurement System

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1 INTRODUCTION

This chapter begins with a brief background to the research topic, which leads to an introduction of the case company, Consafe Logistics, and the research issue. The purpose and research questions will then be presented. Further, delimitations will be addressed and an insight in how the report is structured will conclude the chapter.

1.1 Background

In recent decades globalization, outsourcing, and information technology have radically changed how organizational networks are composed. Customers are also able to procure from an international market and they expect more from what they buy. This has led to very competitive markets and to find the best ways to manage the interconnected or interlinked organization have become much more complex.

Historically organizations focused a lot on internal processes and efficiency, however to optimize internally doesn't necessarily mean improved value to the end customer. For example full truckloads (FTL) are more economical on a cost-per-pallet basis compared to less than full shipments, however with FTL there will be increased inventory holding costs that may increase total logistics costs. To approach such trade-offs with a holistic view and look at the whole chain from raw material to end customer offers opportunities to find more efficient ways to manage the systems, and consequently add value to customers.

Around the turn of this century organizations increasingly realized that to be able to compete in the global market and networked economy the focus could no longer be on internal operational efficiency alone. (Olhager, 2012) They should rather compete as networks or chains of trading partners, e.g. they needed effective supply chains. (Baziotopoulos, 2004) (Huan, 2004) From the challenges in the new business environment the ideas and objectives behind supply chain management (SCM) were developed.

Further in the search for improved competitiveness and more efficient SCs organizations started looking for increased performance throughout the supply chain. Continues improvements and control of supply chain processes became central to stay competitive. The processes are controlled through metrics measurement, often referred to as performance measurement systems (PMS).

In somebody else's words:

"Supply chain strategies require a total systems view of the links in the chain that work together efficiently to create customer satisfaction at the end point of delivery to the consumer. As a consequence, costs must be lowered throughout the chain by driving out unnecessary expenses, movements, and handling. The main focus is

turned to efficiency and added value, or the end-user's perception of value. Efficiency must be increased, and bottlenecks removed. The measurement of performance focuses on total system efficiency and the equitable monetary reward distribution to those within the supply chain. The supply chain system must be responsive to customer requirements." (Hines, 2004 p.76)

Supply chains begins with raw materials that are processed in several steps into finished products. The finished products are delivered to customers by distribution networks. (Lepori, 2013) In supply chain management distribution networks have gained a lot of attention due to challenges in global demand and the introduction of network system thinking. Organizations with the goal to increase their competitive advantage by adding value and reducing costs started to implement global sourcing and manufacturing abroad. This changed the environment for distribution networks and much more efforts on how to manage global networks and global relationships were introduced. Another major change was that organizations more than before started to focus on core competencies to become more specialized and flexible, this resulted in a wave of outsourcing.

Companies hence realized the importance of sharing information with their suppliers, distributors and customers. Decision making in this more complex environment highly relied on the degree and quality of available information. (Millet, 2009) To still be able to manage businesses in a cohesive and efficient way most organizations turned to the benefits of IT and ERP (enterprise resource planning) systems. ERP systems can help manage and plan most commercial functions such as inventory, purchasing, manufacturing, finance, human resources, sales etc.

ERPs are highly complex systems though, and aligning it with the objectives of a company can be difficult. (Millet, 2009) The ERPs are composed of many modules that manage different functions, which creates a good overall system, however each module is rarely the most superior solution. To be able to create a solution that are more specialized, flexible and easier to fit the requirements of a certain company many best of breed solutions have been developed.

One company that has risen through the developments in distribution networks and IT is Consafe Logistics. Consafe Logistics develops best of breed solutions for warehouse management and supply chain execution. Their focus in a supply chain perspective can be seen in figure 1.

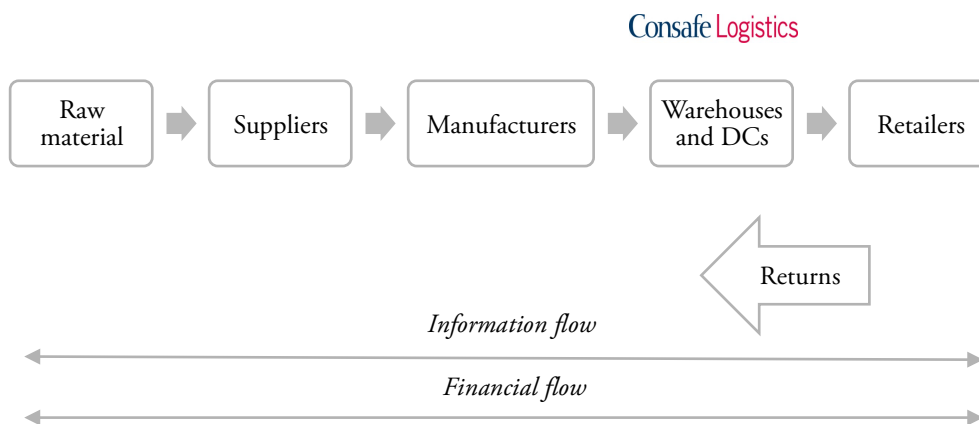


Figure 1 A simplified view on CL's part in supply chains

1.1.1 General information about Consafe Logistics

Consafe Logistics is part of The JCE Group, which has 10 000+ employees, CL represents one out of six business areas and accounts for roughly 320 employees and an annual turnover of ~ MSEK 400. Consafe Logistics is globally one of the leading suppliers of warehouse management systems (WMS) and their main market is EMEA where the company was ranked third in terms of turnover in 2012. Consafe Logistics has customers in more than 30 countries and headquarters in Lund, Sweden. Consafe Logistics also has subsidiaries in the Netherlands, UK, Poland, Denmark and Norway (Consafe Logistics, 2014).

Consafe Logistics started off by offering services to improve inventory management, which is still the core business, but they've broadened their business and are now specializing in supply chain execution. Consafe Logistics helps their clients with distribution issues both through consulting and by offering various IT-solutions. The company develops, implements and support solutions in three business areas: Warehouse & Distribution (W&D), Production Logistics and Enterprise Mobility. The product portfolio includes Warehouse Management Systems (WMS), Warehouse Control Systems

(WCS), Yard Management Systems (YMS), Manufacturing Executions Systems (MES), Work Force Management (WFM), Mobile Applications and more.

About 80 % of the turnover is generated from the W&D business area and Consafe Logistics' Astro WMS is the key product. It's scalable and a modular based WMS that works both in manual and automated warehouses and DCs. Consafe Logistics serves over 350 installations and their customers works in many various businesses from industry to retail.

1.1.2 Introduction to research issue

Consafe Logistics business strategy is to help customers with Supply Chain Execution. An important part of the strategy is to offer possibilities for process analysis and decision-making. The ability to collect and present data from the WMS is therefore a vital part. Currently, the WMS logs all data, but the presentation and visualization is limited to a certain list of metrics. In order to stay competitive and further increase customer satisfaction, the product portfolio was recently expanded with the introduction of a Supply Chain Dashboard. The dashboard, which is a module for Astro WMS, gives operators and Supply Chain professionals the opportunity to monitor warehouse processes in real-time. By visualizing business critical information and making it more assessable, the dashboard gives enhanced opportunities for decision-making.

Previously, there's been no standardization in how to define warehouse management metrics for processes at Consafe Logistics; the metrics in the current dashboard were developed in workshops between Consafe Logistics and some driving partners. As mentioned, Consafe Logistics customers acts globally in various businesses and this has led to difficulties in selling the dashboard, it can be quite expensive module due to certain needs of specifications and modifications from customers. Hence, Consafe Logistics realized the need for a standardization of the dashboard metrics. When the firm was introduced to the Supply Chain Operations Reference (SCOR) model, a cross-industry standardized framework at a Gartner conference it was considered to be a good fit. SCOR is a worldwide accepted and renowned (Zhou et al., 2011)(SCC, 2014) process reference model that is developed and endorsed by the non-

profit organization Supply Chain Council. It's a cross-industry standard diagnostic tool for supply chain management, and its set of metrics is defined on a general level that should fit all types of organizations, not for any specific business or purpose. (SCC, 2014)

Additionally, consultants at Consafe Logistics have expressed a concern that they do not have a clear set of metrics to focus on when discussing future WMS-implementations with prospective customers. Traditionally it has been a time consuming activity to figure out which areas to address and what data that should be gathered (Mikael Brorsson, 2014). If more relevant and standardized KPIs would be used, Consafe Logistics could be more efficient, give better support to customers and consequently generate greater customer satisfaction.

In conclusion, Consafe Logistics currently has a twofold issue regarding KPIs. In order to overcome these, the firm wants to implement a new standardized cross-industry set of metrics that derives from the SCOR model.

1. To be implemented in their dashboard offering
2. To be more efficient and increase selling capabilities when discussing new implementations

Consafe Logistics consequently wants to gain an in depth understanding about the SCOR model and how it could be applied in their organization to offer best customer satisfaction.

1.2 Purpose

The purpose of this study is to develop a performance measurement system for warehouse activities; the system should be based on the Supply Chain Operations Reference (SCOR) model.

1.3 Research questions and objectives

Consafe Logistics objective is to help customers attain essential business information and present it in a more visual way. This would not only create possibilities for enhanced decision-making, but also create better supply chain visibility and opportunities for benchmarking. The fact that Consafe Logistics works with global companies in various businesses puts certain demands on which set of metrics to use.

Consafe Logistics therefore wants to gain a deeper understanding about the SCOR model as a whole. The main objective of this study is to investigate how the SCOR metrics framework can be applied to the company's services within warehouse management. Furthermore, Consafe Logistics would like to gain a comprehensive picture of what metrics its customers currently measure in order to identify if KPIs from the SCOR metrics portfolio are applicable.

This study should therefore answer some essential questions:

1. What types of metrics do Consafe Logistics' customers use today regarding warehouse management?
2. To what extent are metrics from the SCOR model applicable for Consafe Logistics' customers in warehouse management services?
3. How should a possible performance measurement model for warehouse activities based on the SCOR model be designed and used?

Expected audience

In order to answer the research questions and fulfill the purpose of this study, an in depth research about the SCOR model, and a broad investigation of Consafe Logistics' customers' performance measurement processes in warehousing was conducted. This is something Consafe Logistics can benefit from both in the dashboard implementation and when consulting. In addition, the research will also have a large contribution to academia. Not much research has been made on the SCOR model in regards to warehouse management; the result of this study could therefore support others who want to implement the SCOR model.

1.4 Research focus and delimitations

In order to enable a trustworthy study that will really contribute to Consafe Logistics' warehouse services some delimitations and focus areas had to be set. The focus areas and the delimitations have been derived from discussions with supervisors from both the university and the case company.

Due to the limited time frame of this study it was decided that the implementation of the model into Consafe Logistics software offerings was to be left out of the scope. Focus should be on understanding the SCOR theory and gather reliable and significant empirical data to be able to develop a correct PMS and process model. Since the case company wanted the performance system to be based on the SCOR model no other performance frameworks was to be thoroughly studied or considered for the solution. Performance measurement systems also raise additional questions such as measurement frequency and analysis frequency, these areas will however not be investigated in this study.

Warehousing is an activity-driven function and the measurements focused on in this study are those that can be retrieved from the Astro WMS and therefore closely tied to warehouse operations. The sections that have been focused on are therefore the execution processes, Source, Make and Deliver. To ensure that all customers no matter industry or country can use the model, a pre-determined set of metrics won't be included in the solution, a process model and a description on how to assemble company specific metrics are the final outcome.

The research focus of this study has mainly been in three different areas, warehouse operations, the SCOR model and Consafe Logistics customer's performance measurement. To be able to develop a process model it was important to see whether customers follow general warehouse theory in terms of warehouse activities and processes. Then there had to be an extensive analysis to see if these could be translated to standard terms and concepts in SCOR. To answer if the SCOR metrics were valid for Consafe Logistics' customers, a great deal of the work has been on finding what types of metrics customers currently are focusing on within warehousing. Together with the process model this formed the basic structure of the new performance model.

1.5 Thesis outline

Following outline, visualized in Figure 2, shows the structure of the rapport.

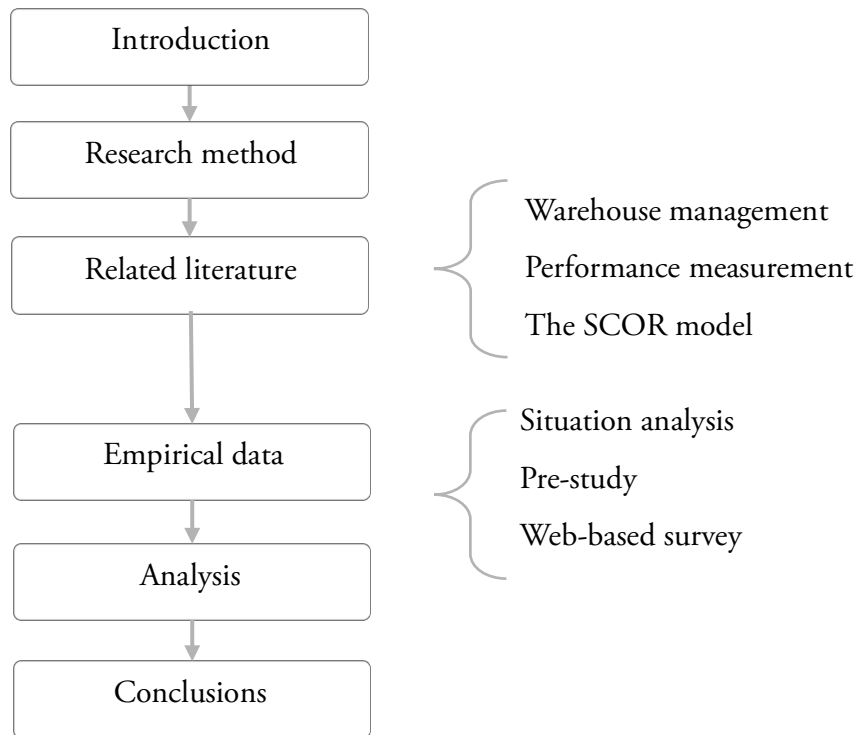


Figure 2 The outline of the thesis

1 Introduction

This chapter begins with a brief background to the research topic, which leads to an introduction of the case company, Consafe Logistics, and the research issue. The purpose and research questions will then be presented. Further, delimitations will be addressed and an insight in how the report is structured will conclude the chapter.

2 Research method

This chapter will describe how the study was carried out. It includes the course of work from beginning to the end, the selection of research approach, empirical data gathering methods and analysis. Finally, there's a section about reliability and validity.

3 Related literature

Three areas were chosen for research in this study, performance measurement, warehouse management and the SCOR model. The studies together provided the knowledge necessary to conduct the empirical data collection, and consequently develop the performance measurement system.

4 Empirical data

The empirical data gathered for this research is divided into three components 1, A situation analysis at the case company, Consafe Logistics. 2, An interview based pre-study achieved together with five companies. 3, A web-based survey sent to all Consafe Logistics current customers.

5 Analysis

The analysis mainly focused on finding the answers to the research questions, emphasis was therefore put on two things, the SCOR model and how well it fits in warehousing (both regarding processes and metrics) as well as the results from the web-based survey. The analysis of the survey enabled the opportunity to answer the first and partly the second research question. In the analysis of the third research question a model was designed and an example of how it can be applied is described. Benefits, weaknesses and prerequisites to using the new model will also briefly be discussed. Finally a summary and conclusions of the analysis will be presented in the end of this chapter.

6 Conclusions

In this chapter the constructed performance measurement system that was derived in the analysis is displayed. The other sections concern topics that reflect back on the entire study. The final sections include discussions regarding the result and if it can be linked back towards the purpose and the research issue. A discussion whether the result is generalizable as well as suggestions for further work and research are also included in this chapter.

2 RESEARCH METHOD

This chapter will describe how the study was carried out. It includes the course of work from beginning to the end, the selection of research approach, empirical data gathering methods and analysis. Finally, there's a section about reliability and validity. On the next page, an overview of the approach of this thesis is illustrated.

In Figure 3 a summarized overview of the course of work is presented. Each section, Situation analysis, Literature studies, Empirical research, Analysis and Conclusions are more thoroughly described starting on the next page.

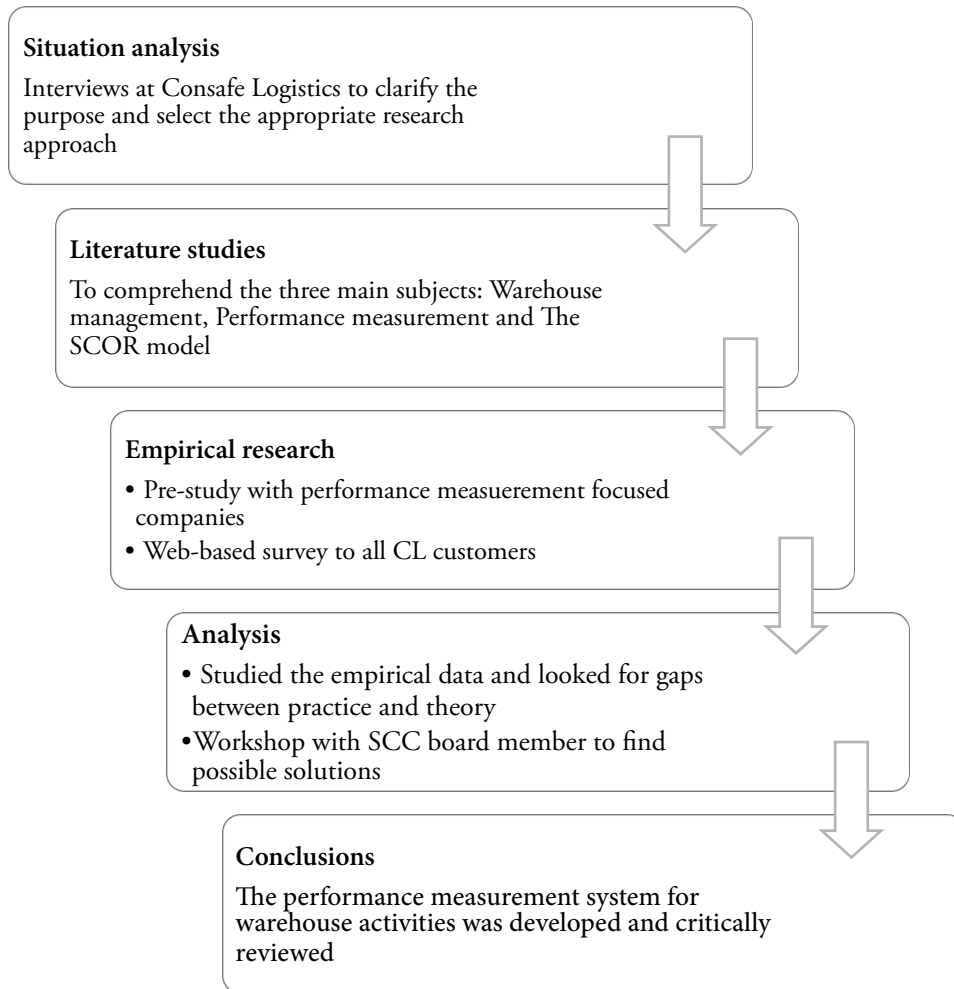


Figure 3 The research method

2.1 Situation analysis

The initial information given about this research was that Consafe Logistics wanted to modernize and standardize the way they worked with business intelligence (BI) and performance metrics. To be able to clarify the initially vague information and to be able to construct the research issue, the purpose and delimitations for this study, a situation analysis was performed.

Step one was a series of seven meetings with employees at Consafe Logistics. This type of concept meetings are important in the design phase of a research to get input from people with certain knowledge and/or interest for the research issue (Jacobsen, 2009).

The main objective for these interviews should be to generate ideas rather than data. However, to get valuable input and to keep the discussion on topic, some structure is necessary (Jacobsen, 2009). A semi-constructed interview guide was therefore developed. The semi-structured interview is based on some beforehand-decided questions, however it's an incomplete script thus there's a need for improvisation (Myers, 2006). The interview guide used, led to an open conversation rather than short answers to a list of certain questions, once and a while the conversation were directed back to the subject.

This input really helped clarify the purpose of the study, it also made clear in what areas theory needed to be studied to conduct a proper empirical data collection. To understand the product and the main industry in which Consafe Logistics operates, a literature review on warehousing was necessary. The purpose to create a SCOR based performance measurement system, demanded further understanding in performance measurements and the SCOR model.

When the purpose was clear, the research questions that should resolve the objectives needed to be developed. Therefore, an initial literature review on performance measurement within supply chain management was conducted. A method that suggests that when a company decides to upgrade its supply chain performance management it should be done in a three-step action plan (described in chapter 3.1.5 *Performance measurement method*). The method helped the authors to formulize the research questions and the objectives.

2.2 Research approach

After the purpose and research issues was stated an appropriate research approach should be selected. There are two main research approaches, the deductive approach and the inductive approach (other additional approaches are different combinations between these two). The deductive approach means that the research starts in theory and continues in empirics. The researcher obtains expectations of the reality based on theory, and then investigates if those expectations are supported in reality. The inductive approach means that the researcher follows a reverse method, which starts in empirics and continues with theory instead. Here, little or no initial expectations should impact how data is gathered; the goal is that no limitations should exist, which may have an impact on what data is collected. (Jacobsen, 2009)

Even though none of these approaches fit this study in full, the deductive research approach was the more appropriate method. The reason for this is because the research questions in this thesis were broad and there was a need for the ability to generalize, in such research the deductive approach is the most appropriate (Jacobsen, 2009). The deductive approach was also more suitable than the inductive, due to lacking knowledge within the area of investigation; the SCOR model. The inductive approach doesn't require any prior knowledge to the research topic, however this can be a risk if the researchers don't now what they're looking for (Jacobsen, 2009). In this case an empirical study couldn't have been conducted without a primary theory base.

2.3 Literature studies

To make sure enough knowledge was gained about warehouse management, performance measurements and the SCOR model, three literature studies were performed before designing the empirical research. Consafe Logistics requested a more in depth understanding about SCOR, which is why the most extensive literature review was on the SCOR model.

Articles, journals and books laid ground for chapter 3 Related literature. The information was mainly retrieved from three sources: LUBsearch, Gartner.com and Supply-chain.org. LUBsearch is a search system and access point to all of Lund University library resources. Gartner is a leading information technology research and advisory company. The company delivers objective research in

most IT and technology fields. Supply-chain.org, is SCC' s (the developer and endorser of the SCOR model) website.

2.4 Empirical information

In case studies there are two main methods for gathering empirical information: the qualitative method and the quantitative method. The quantitative method, often based on surveys with numerical outcome, is most commonly used when there's already a good perception about the phenomena and a broader analysis is preferred. The qualitative method are based on interviews and offers more in depth information due to that interviews allows more detailed and nuanced answers than a survey does. The qualitative method is most commonly used in exploratory research where the subject is new or sensitive to unexpected conditions (Jacobsen, 2009) (Metodkurs för Examensarbete 2014).

When using the deductive research approach, the method for gathering empirical data is usually quantitative (Jacobsen, 2009), (Kotzab et al., 2005). This is mainly because resources don't allow researchers to make a broad investigation that is also in depth (Jacobsen, 2009). This has led to the main critique that researchers could miss important information due to that they've created an inaccurate image of the reality based only on theory. What could happen is that the empirical study focuses on areas that are not essential in practice (Jacobsen, 2009). To make sure that the empirical research in this case didn't lack practical importance, qualitative interviews were held with different companies with knowledge in warehouse management and SCOR or performance measurement. This helped when the structure of the quantitative and qualitative web-based survey was constructed.

First a qualitative pre study was carried out, interviews were held with companies with knowledge in performance measurement SCOR and warehouse management. The main purpose off the pre-study was to use the benefits from a qualitative method to gain relevant information from practitioners, and in that way obtain a reliable research.

2.4.1 The pre-study

The pre-study consisted of interviews with five companies, three SCOR practitioners and two Consafe Logistics customers. Even though the theory on the SCOR model is extensive it was very important to get practical insights on how the SCOR model can be implemented and to get suggestions/recommendations for the selection of metrics to the new model. Via the members list on supply-chain.org companies located in near proximity were contacted. Alfa Laval, Ericsson and a manufacturing company who want to be anonymous were contacted and they all chose to participate in the study. Ericsson can be considered experts with a long commitment towards SCOR while Alfa Laval and the manufacturing company are fairly new adapters. To get insights on how Consafe Logistics customers currently work with performance measurements and to find possible differences or barriers towards the SCOR model two additional companies with knowledge in warehousing and performance measurement were interviewed.

The selection of companies was made on different criteria, proximity, performance measurement knowledge and SCOR engagement being the most important. The purpose of the pre-study was to provide an opportunity to conduct a research with both theoretical and practical input. One can argue if the selection of companies is representable for Consafe Logistics' customer base as a whole, all five companies are large international companies with process models and frameworks in place. For the pre-study however there was a point in choosing this type of companies, to interview companies with less developed performance measurement systems would not have given the desired results. To be able to construct the survey there was a need for a better understanding in performance measurement and the SCOR model. Experience in performance measurement therefore played its part. The survey was meant to cover the latest thinking in performance measurements something larger companies are possibly more capable of sharing. That the survey later was sent to all customers ensured a more reliable research.

2.4.2 The web-based survey

Three ways of Internet questionnaires have been considered when the web-based survey was developed, an email questionnaire, where the questions are a part of the email, an attachment, where the questionnaire is found as an enclosure and a web-based questionnaire, where e.g. the questionnaire is designed as a web page (Denscombe, 2007). In this thesis the latter has been used. The reason why it was used is because it can use ready-made email lists from a company (Denscombe, 2007), which was available from Consafe Logistics and since the authors used the marketing tool Consafe Logistics normally use when conducting marketing projects.

The information attained from the pre-study was analyzed and used when designing the web-based survey. Questions that could validate or reject conclusion from the situation analysis were included in the survey as well. The survey was constructed in Easyresearch from Questback, a web-based service for questionnaires and feedback collection in all areas. To be able to understand the service and its potential, Catarina Malmsten and Camilla Frisk from Consafe Logistics' Operational Marketing department gave support, as well as provided the project with access to the company's ready-made email list of their WMS customers.

The survey was sent to 447 people, the recipients were warehouse managers or logistic managers on companies with a WMS implementation from Consafe Logistics. Out of these, 56 weren't longer reachable (outdated emails), which come down to 391 actual recipients. The response rate ended up in 68 answers (17.4%).

Web-based survey support

According to Malmsten, the structure and the understanding of the survey questions is of great importance. The survey was therefore examined and tested by two warehouse experts at Consafe Logistics during a consultation. This assured that the authors covered the metrics Consafe Logistics wanted to get an answer to and that customers could understand the questions.

To get an input on the academic aspects, such as number of alternative response options etc., Olhager was supporting the design process from the beginning as well. He was also one of the candidates that tested the questionnaire, making sure it was understandable and that no central metrics were missing in order to answer the research questions.

The metrics was stated by definition rather than name, this enabled recipients to understand the actual measurement and not be confused by having different names in their organization. To create a good foundation for analysis the design of the survey (see Appendix 1) was constructed according to main warehouse activities according to the theory in chapter 3.1 *Warehouse management*, which processes also were found in the SCOR theory. The questions related to receive and put-away are Source respective Deliver processes in SCOR. Storage and replenishment are defined in SCOR as Deliver respective Source processes. Pick is defined in SCOR as a Deliver process. Pack, ship and transport are also defined in SCOR as Deliver processes and returns are defined in SCOR as a Return process. (SCC, 2012) Cross-dock was however not included in the survey, since the professionals at Consafe Logistics believed they will be covered by e.g. receiving or put-away. Consequently the survey was based on both theoretical and practical knowledge and should give reliable and generalizable answers to enable the development of a PMS model based on SCOR.

During the sessions with both the experts at Consafe Logistics and with Olhager, it was decided that both closed questions and open-ended questions would be the most appropriate way to conduct the survey research. Closed questions are considered to be quantitative and open-ended questions are considered to be qualitative in questionnaires (Denscombe, 2007). By using open-ended questions, the respondents are given enough space to express their own point of view (Denscombe, 2007). Since the survey was built on both open-ended questions and closed questions the nature of the web-based survey was both quantitative and qualitative.

Open-ended questions were especially important according to Olhager in order to not miss what important metrics the customers were using. Thereby, it was determined that the first question, Question 1 “In your warehouse, what are

the most important metrics for warehouse performance measurement?” should be an open-ended question as well as mandatory to enable a good analysis. No other of the open-ended questions was mandatory, which can be seen in Appendix 1, Chart 1. Closed metric questions were essentially used to capture measurements that were stated by the experts at Consafe Logistics and were therefore also mandatory. Since they expressed their will to include such questions, all metrics included in the closed questions were not based on SCOR metrics. 49% of the metrics included for the closed metric questions were identified using SCOR metrics in the workshop and 51% were expressed by Consafe Logistics to be important.

2.5 Analysis methods

Multiple analysis methods have been developed for qualitative and quantitative research, which can be read about more thoroughly in Denscombe's *The Good Research Guide* (2007). Some examples are e.g. statistical tests such as factor analysis or cluster analysis, or another more straightforward method called content analysis for quantitative methods. In regards to a qualitative method, the raw data should be coded, and thereby categories should be developed in order to be able to compare the categories. One should also strive to establish fewer more theoretical categories that enclose the original categories. (Denscombe, 2007)

In this project content analysis was found to be the most appropriate method to use in regards to the questionnaire, mainly due to the nature of the survey (quantitative and qualitative), but also given the amount of text that were analyzed regarding the first open-ended question, question 1.

Content analysis

It's up to the researcher to decide if content analysis will be used to quantify the qualitative data (Denscombe, 2007).

More importantly though, is that the method is used to analyze text, e.g. in the form of writing or sounds and works as a way to quantify the meaning of the text. Its procedure is quite easy to follow. (Denscombe, 2007)

1. Select a suitable sample of the text
2. Break it down so that smaller factors can be reviewed
3. Develop categories which later will be analyzed
4. Code the factors in line with the developed categories
5. Count how many times the factors appear
6. Analyze the text with consideration to the quantity

Content analysis is a good analysis method since it can easily be repeatable by other researchers, which is a way to ensure that this thesis results would be the same if it would be conducted again. However it has its drawbacks. The main drawback is that it has a tendency to out-lift factors from the context as a whole. It's also said to work best when the text is simple. (Denscombe, 2007) During the pre-study session with Olhager, it was also pointed out that there was no need for heavily statistical analysis of the quantitative closed metric questions in the survey. The reason is because quantitative data can still be used effectively, even though no complex statistical analysis is performed (Denscombe, 2007)(Olhager, 2014) and since there were only 35 metrics included in the closed questions compared to about 200 of the first open-ended question. Thereby, the authors were able to answer the research questions anyhow.

Below follows how content analysis was carried out in this thesis.

1. Select a suitable sample of the text - filter the metrics by using excel, e.g. "Hi" and "ads" are removed from the sample
2. Break it down so that smaller factors can be reviewed – develop sub-categories such as "receiving metrics" and "picking metrics"
3. Develop categories which later will be analyzed – create categories such as "inbound"
4. Code the factors in line with the developed categories – sort the sub-categories into the categories, e.g. "receiving" can be put into inbound
5. Count how many times the factors appear – count by using excel how many times the categories appear
6. Analyze the text with consideration to the quantity – start the analysis

In Appendix 1, Table 2 or in section 5.1 *The first research question*, the results are shown. Once the analysis of research questions 1 was complete, and the conclusion showed what metric-categories customers currently value, the next task became to see if they could be translated to SCOR.

As all metrics in the first open-ended question were categorized into well-known warehouse activities (see e.g. Appendix 1, Table 2), the procedure to find correlated warehouse metrics was fairly straightforward, but time-consuming. For every single metric, the customers expressed as the most important measurement, a translation was searched for in SCOR version 11 and 9, as well as supply-chain.org. Once the metrics have been found, a summary of how many metrics that could be translated to SCOR was established. As all SCOR metrics are also expressed with attribute (see section 3.3.4 *SCOR performance* for further reading), the summary was made according to SCOR metrics attributes. This summary is shown in Section 5.2 *The Second research question*. It showed that 61% could directly be translated to SCOR metrics.

Since there were still 39% of the customer's metrics that couldn't be translated, further analysis was needed to find an equivalent towards SCOR if a PMS model was going to be built. Therefore focus was directed instead towards the other part of the SCOR model, which also was proposed by Magnusson in the workshop, namely SCOR processes. Consequently the authors needed to see if the customers' metrics could be translated to SCOR processes instead.

As 61% could be translated to SCOR metrics, their linkage to SCOR process could automatically be found (see chapter 3.3.4 *SCOR performance* for further reading). In regards to the 39% however that couldn't be translated to equivalent SCOR metrics, a deeper analysis needed to be conducted. Since no processes could be pre-determined in regards to the first question in the web-based survey, and since all other questions were based around SCOR warehouse processes, most concentration was directed once again towards the first question. And as all customer metrics were already categorized according to well-known warehouse theory, the authors could look for corresponding SCOR processes in version 11 and 9 of SCOR again. An example of a customer metrics that couldn't be translated to SCOR metrics was, "Amount

of wrong picks”. However, there is no doubt that the metric can be linked to the process “Pick Product”, which is a level 3 deliver process in SCOR. This was repeated for all those metrics, the summary is illustrated in chapter 5.2 in the section *Processes*.

2.5.1 Workshop with SCC board member

Through Olhager’s contacts and previous networking by the authors, an opportunity to interview Lars Magnusson board member of the SCC and Manager for supply demand at Ericsson opened up. Magnusson was coming to Lund University to lecture in Supply Chain Management and SCOR, in connection to this a workshop for possible solutions was arranged. The workshop consisted of discussions, brainstorming and taking share of Magnusson’s previous experience in SCOR in regards to warehouse management.

The main ideas for the process model design originated from this meeting. To be able to share thoughts and ideas with an expert on the SCOR model helped develop the process model, which helped in reaching the objective of this study.

2.5.2 Applying the new warehouse performance model

To investigate if the new model offered enough detail and if it could support reaching a set of metrics proposed by the SCOR model, an example was carried out. The authors worked with an activity profile that was previously completed by Consafe Logistics. The 6-step model from SCOR theory was also implemented and even if much delimitation has been made it explains well how the new model could be used.

2.6 Conclusions

In the chapter conclusions, the constructed performance measurement system that was derived from the analysis is displayed. The other sections concern topics that reflect back on the entire study. The final sections include discussions regarding if the result can be linked back towards the purpose and research issue. If the result is generalizable and suggestions for further work and research. This discussion is based solely on the author’s own opinions.

2.7 Validity and reliability

There are two types of validity and one type of reliability that denotes well-conducted researches (Jacobsen, 2009 p 417). These make sure that it actually measures what being expected (i.e. internal validity), it can be generalized and transformed to other areas (i.e. external validity) and that it is accurate and trustworthy (i.e. reliable).

Internal Validity

One question that can be asked is if the indicators that's being used, actually measures what's of interest. Such critical considerations should be used during the entire process. (Jacobsen, 2009)

External Validity

A central element in both quantitative and qualitative approaches is that the investigations cover a sample of a population. However, in a quantitative approach, if the selection of the sample is performed properly, a generalization of the sample can be made to the whole population with a degree of uncertainty. The degree of uncertainty means that a level of vagueness must be considered when a generalization is made from a sample to a whole population. (Jacobsen, 2009) A low response rate would for example imply a higher degree of uncertainty in terms of a generalization.

Reliable Results

Another question, which is considered a must, is if the way the research is performed has an influence of the outcome of the results, in other words, if the research approach has an impact of the results. (Jacobsen, 2009)

How the study was performed

It is apparent that the quantitative and qualitative research methods both have their advantages and limitations. And since qualitative research increase internal validity and quantitative improve external validity (Kotzab et al., 2005), a combined approach was used in this study, but with more focus on a qualitative approach.

In the qualitative method, five companies were chosen for more in depth research via interviews. Two of them are current customers of Consafe Logistics, the other three are companies that are currently using the SCOR

model. All firms have knowledge about performance measurement and are operating one or several warehouses. All five companies have been chosen due to their interest in this study and performance measurement in general. However, the results cannot be generalized for the same reason, since qualitative methods do not give indications about general nor typical aspects, but rather about characteristics that are special and unique (Jacobsen, 2009). That is why a mixed quantitative and qualitative web-based survey was selected to follow up on the qualitative interviews.

The web-based survey was sent to all of Consafe Logistics customers. In this way was possible to see if there were an indication of connection between the initial five companies and a wider range of customers, which was represented by a sample of the customers. The analysis focused on finding gaps between what's currently being measured by customers, thus concentration was essentially directed on the first, broadest and mandatory question in the survey, which also obtained most responses. More specifically, the focus was on what types of metrics are being used by customers today and how can they be translated to a standardization based on the SCOR model.

Indication of validity and reliability

The pre-study made it possible to outline what questions were of interest to ask in the web-based survey, i.e. for the authors to ensure that the questions that follows from the result of the interviews, actually would measure what's of interest (i.e. internal validity). A session with the authors' supervisor at Consafe Logistics and a colleague was also conducted to ensure internal validity, and the web-based survey led to the basis for analysis of research questions 1 and partly research question 2.

Furthermore, the sample of companies in the interviews, which are operating in warehousing, performance management and some using the SCOR model, as well as the sample of customers and their metrics from the survey that could be translated into an equivalent to SCOR, are considered to be representative for the generalization of the results of this research (i.e. external validity). Thereby the results could be applied to Consafe Logistics' warehousing services.

In terms of reliability, the qualitative interviews were designed after the same template of questions related to performance measurement, but also SCOR and warehousing. In addition, supervision from Jan Olhager, Professor in Supply Chain Strategy, as well as discussions and a workshop with Lars Magnusson, member of the board of directors at SCC, strengthens the reliability of this thesis due to their knowledge in research writing and knowledge of how to use the SCOR model.

To summarize, the pre study made sure that a reliable investigation could be made (since it confirmed that theory found in literature was the case also in reality) and the web-based survey ensured that the results could be generalized to a broader customer base, even though the response rate (17.4%) needs to be questioned. Guidance from the authors' supervisors at Lund University and at Consafe Logistics, as well as supervision from the board of directors at SCC also supports the trustworthiness of this report. The study thereby measured what was of interest (internal validity), and since the web-based survey was re-sent two times to the customers no further generalization could be made in the way this thesis was carried out (external validity).

Source criticism

Even though all sources in this thesis have been selected with care and interest to fulfill the purpose, there is always a need to be critical. Source criticism means that the writers take a critical perspective of the sources that have been selected, as well as how the collection of data has been conducted. By doing so, the authors should ask themselves if the result would have been different if alternative ways to conduct the research had been selected. (Björklund & Paulsson, 2003)

The literature was selected from well established and reviewed sources, and focus has been directed towards finding influential literature. For the empirical data the authors have found the people that have taken part of this research reliable and knowledgably. The results of the study may have become different if other sources would have been used. To make this investigation as reliable as possible the authors have taken this into consideration and possible actions to reduce that risk have been taken, for example by using a combined quantitative and qualitative approach, even though more focus has been on the qualitative.

3 RELATED LITERATURE

Three areas were chosen for research in this study, performance measurement, warehouse management and the SCOR model. The studies together provided the knowledge necessary to conduct the empirical data collection, and consequently develop the performance measurement system.

Performance measurement, will give the reader a brief insight to the importance of performance management and performance measurement. This study was conducted to find a method that would help when developing a performance measurement system.

Warehouse management, explains the meaning of warehousing operations, warehouse management and warehouse management systems (WMS). It summarizes general warehouse processes, warehouse types, warehouse trade-offs, trends and challenges. The purpose was to provide an understanding about warehousing, CL's services and products as well as the industry as a whole for which the scope of this thesis' is carried out. Furthermore, the chapter gives an understanding of the classification of metrics in warehousing, thereby it also works as a basis for the survey as well as the analysis.

The SCOR model will provide an introduction to the SCOR model and SCOR methodology. The purpose is to include enough information about the SCOR model so that the developed performance measurement system can be understood.

The Venn diagram in Figure 4 shows an idea of how the theory in this study is connected.

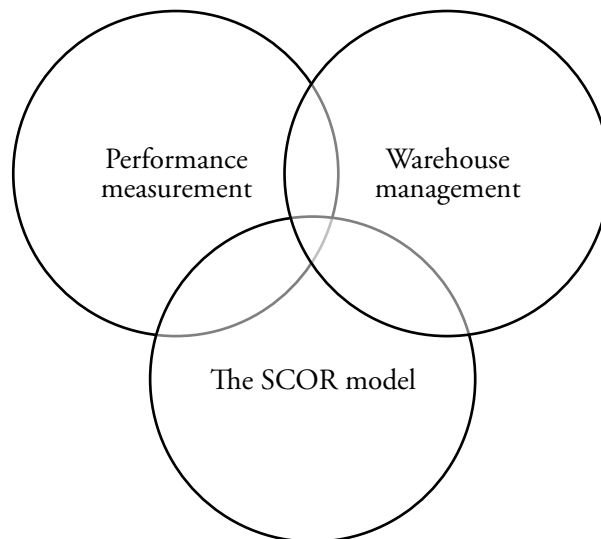


Figure 4 Literature studies connected

3.1 Performance measurement

When exploring literature on performance management and performance measurement it's clear that this topic has been and still is significant both to researchers and practitioners. Tens of thousands of articles, book chapters and conference journals can be found. This research study however will only provide a brief introduction to performance management, measurement and metrics based on the most recognized literature.

To get a brief understanding about any business term a definition is often a good start. Performance management has been defined as a “process by which the company manages its performance in line with its corporate and functional strategies and objectives” (Bititci, et al., 1997).

More practically performance management can be seen as the process of creating and executing business plans effective and efficient.

This process often starts with the creation of budgets and operational plans that are tied to strategic goals, these initiatives can then be allocated resources by managers based on financial assessments. The next step is to execute these plans and focus on identifying, measuring and developing performance. To develop and inform corporate strategies throughout the organization is therefore an important part of performance management, however the most relevant part to this research is performance measurement.

Performance measurement has had a tremendous impact in management over the last decades according to this research there are three main reasons why performance measurement is essential.

1. Today's businesses are very complex, which also makes them hard to manage. Performance measurement's purpose is to simplify the reality so that rational decisions can be made. That the reality is transformed to simplified numerical concepts that can be communicated and acted upon is the key to successful management (Lebas, 1995).
2. Performance measures play an important role in success by giving the opportunity to evaluate performance and benchmark the results against similar organizations (Camp, 1989) (Stewart, 1995).

3. Performance measurement plays the role of feedback in one's organization, it facilitates the assessment whether plans were accurate or not and it shows how well the execution was carried out. These processes are of critical importance to effective and efficient performance management (Bititci et al., 1997) (Bongsug, 2009).

The key in all of these statements is that implementing performance measurement in an organization will not improve performance by itself. It will however facilitate decision-making and the control over processes. The business information that is attained through performance measurement is the real value of performance measurement.

3.1.1 Performance measurement systems and frameworks

The ideas behind why performance measurement is necessary have stayed the same over time, however the way it's been accomplished has varied. The systems for achieving a well-functioning performance measuring process have been under continuing change. At first organizations often concentrated only on financial measures, which left operations unsuccessful, (Kaplan and Norton, 1996) in later years especially after the implementation of the more holistic supply chain thinking internal processes, customers, and innovations started to get more attention.

The structure of the systems has also differed a lot. With increased complexity more structure has become important to get a grip over what's really important. Measures have been divided into classifications both horizontally so that each department easy can find metrics valuable to their processes and vertically into different levels of management strategic, tactical, and operational (Patel, Gunasekaran, and Tirtiroglu, 2001).

The different performance measurement systems (PMS) that have been developed to help manage performance and provide feedback from the processes and the activities performed are from an operational point of view all a set of metrics used to quantify the efficiency and effectiveness of actions (Neely et al., 1995).

3.1.2 Performance measures and metrics

This subsequently leads us to performance metrics, metrics are used to define the measure in terms of scope and content. There are often mix-ups between different types of metrics to clarify Gartner have put together a compilation of commonly used metrics and their definitions, shown in Table 1.

Table 1 Different metric types and their definition (adopted from Gartner, 2014)

Metric	Definition
Performance Indicator	What you need to do (predictive measure)
Result Indicator	What you have done (historical measure)
Key Performance Indicator	(KPI) What you need to improve <i>significantly</i>
Key Result Indicator (KRI)	What significant things have been accomplished
Critical Success Factor (CSF)	What must be done in order to drive strategic business outcomes

3.1.3 Challenges in performance measurement

Even though performance measurement is a stated factor for successful management many companies are not engaged in it, and there are issues that speaks against it.

1. Measuring is often put in negative terms because people think of surveillance and pressure to perform.
2. To develop a measurement system, or a set of KPIs can be very challenging and time craving.
3. Even if a measurement system is in place it has to be continuously updated to stay relevant and it's easy that the system keeps expanding and the meaning of having a few powerful KPIs are lost.

“It's easy to forget that performance measurement and monitoring can be better addressed using trivial few which are not really trivial in reality but instead are those few areas most critical to success.” (Thakkar, 2009)

3.1.4 Performance measurement trends

The development of information technology has changed business environment almost entirely. And IT has of course been very influential in performance measurements. Almost all processes today are in some way in touch with IT so it has become much easier to measure. Three main trends in performance management have been found in this research.

Real-time

The current highly competitive markets have created the demand for both businesses and products to be able to change fast and dynamically. The company that meets consumers' demands fastest is the one that survives. To be able to be flexible and develop winning strategies for the future it's important for managers to have meaningful performance information to avoid becoming lost in a sea of data (Elrod, 2013).

Mobility

The ability to change fast and dynamically also means that decisions must be able to be made wherever you are. Mobility is therefore a large trend within performance management. Even if the logistics manager is away from site he wants to be able to manage the warehouse like normal. And with modern technology this is becoming more and more standard. 24-7 Internet connectivity, cloud solutions, smartphone support these are all much more common in warehouses today than ten years ago.

Visibility

To create a system so that critical business information can be attained, analyzed and acted upon has become almost as important as performance measurement itself. The increased willingness to measure together with increasing number of processes measured and the increased possibilities to automated measuring thanks to IT and ERPs, these have created massive opportunities to support decisions. However there is also a great risk to get lost in the large amount of data that is gathered in today's businesses. A critical success factor is therefore to make important metrics more visible and, if possible, display them in a dashboard that provides the relevant metrics. (Searle, Dixon, 2013)

3.1.5 Performance measurement method

The method that was found to be the best match for a company who decides to upgrade its supply chain performance measurement is described in a research paper from Gartner. Consafe Logistics is currently using Gartner as a source of industry information and news. The fact that they are familiar with many of the ideas and concepts was a big plus.

The method that Gartner suggest is a three-step action plan.

1. First, identify where you currently are.
2. Next, define the desired metrics; what should the future state look like?
3. Finally, develop a migration plan to move from the "as is" to the "to be."

(Gartner, 2012)

For the future state, three levels of aligned metrics are recommended: the executive level, a midlevel for the end-to-end supply chain and a third level with deeper functional metrics (Gartner 2012). This model is however directed towards companies that work with global supply chain management from an end-to-end point of view. Something to have in mind is that most of the information can't be acquired from a WMS alone and consequently this model will not be used fully. Warehouse management is strongly focusing on operational measurements (metrics on executive level are often more financial), which is why focus will be on deeper functional metrics.

Translated to this specific study the steps will be:

1. What metrics are Consafe Logistics customers tracking today?
2. Define desired metrics according to the SCOR model (future state) and find gaps.
3. Develop an implementation plan for the new performance measurement system.

3.2 Warehouse management

Warehouse management has been defined as the combination of planning, decision-making and controlling inbound, storage and outbound flows (Faber, 2013). While this thesis essentially focuses on the control and the decision-making aspects of warehousing, one can find more relevant research about planning in N. Faber's dissertation.

Warehouses have always been paid a great deal of attention from managers due to the large potential impact it can have in creating customer value. Like most areas the key objectives for managing warehouses have changed over time to create additional competitiveness. The first objectives within warehousing related to maximizing the utilization of resources within the warehouse. The more expanded concept inventory control aimed to maximize profits while providing good customer service (Tompkins & Smith, 1998). The objective of present warehouse management is to efficiently and effectively organize the processes in a warehouse (Faber, 2013), i.e. it encompasses both the objectives of inventory control and warehousing.

Several sources imply that keeping good control over a corporation's warehouse(s) is of great importance. As an example, the competitive power of an entire company as well as the complete supply chain may be derived from outstanding performance within the warehouse or distribution center (Van Den Berg, 2012). In a broader context, a company's warehouse operations can influence the firm's corporate performance in manners such as logistics costs, customer service and business alignment (Van Den Berg, 2012).

Warehousing is however a correlation between logistics cost and good customer service; the higher customer service a company aims for, the greater logistics costs one can expect, which is one of the greatest trade-offs companies face in warehouse management (Van Den Berg, 2012). Similar reasoning is presented by Gwynee Richards (2011) in his illustration of warehouse management trade-offs, which Figure 5 illustrates. Hence, the command of these elements is fundamental to warehouse management.

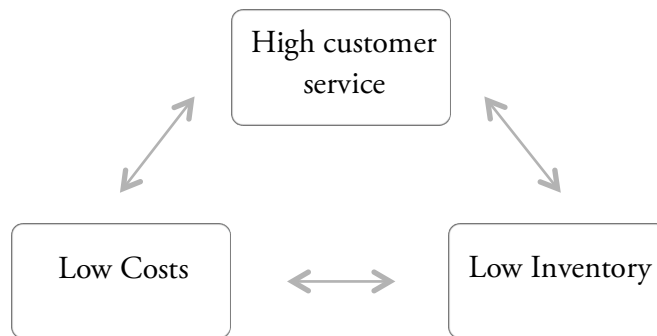


Figure 5 Trade-offs in warehouse management, adopted from Gwynne Richard (2011)

3.2.1 Warehouse activities

In order for the reader to get an insight of this thesis area of research, following will describe basics behind warehouse activities. The theory in this section follows general warehouse philosophy and is similar to several renowned publications in the field of warehousing, both old and new.

Bartholdi & Hackman (2011) illustrates the normal physical activities and flows in a warehouse similar to Figure 6. The inbound processes are represented by receiving and put-away whilst the outbound processes includes picking, packing and shipping.

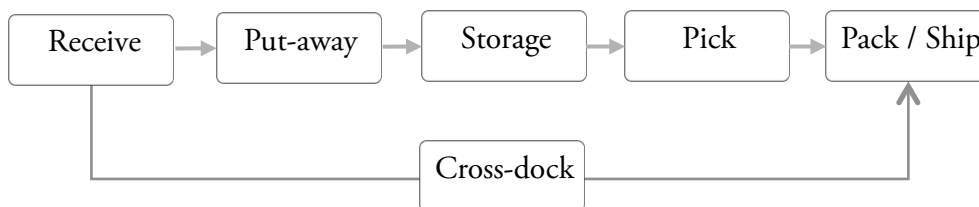


Figure 6 Warehouse activities, adopted from Bartholdi & Hackman (2011)

In the following section, brief descriptions of Bartholdi & Hackman's (2011) different activities in the inbound and outbound processes are presented, as well as other descriptions that are relevant to the topic.

Receive

Receiving is the first activity that is managed in a warehouse. The activity may start with a notification of incoming goods, which allows the workers to arrange coordinated unloading of the incoming goods. Normally the goods is also scanned and registered in the company's WMS.

Receiving represents about 10 % of the cost in a normal warehouse.

Put-away

Prior to the put-away of a stock keeping unit (SKU) is being made, it's important that a (convenient) storage location is selected for storage. The reason for this is because the storage location many time reflects how quickly and how cost-efficient it later on will be retrieved for a customer. To do this, the warehouse staff needs to be able to control the inventory, i.e. the storage locations. Workers and managers need support to able to quickly access information about available storage locations, things to consider can be, how much weight a storage location tolerate, how spacious they are, how easily they are accessed etc. The put-away can then be realized with the help of various equipment such as forklifts, roll trolleys or conveyers.

Put-away usually corresponds to about 15 % of warehousing operating payments.

Storage

There are two main storage types, dedicated storage and shared storage. In general, a unique address is assigned to every single location in a warehouse, regardless if it's dedicated or shared location. A dedicated location is a storage, which is reserved for a specific and allocated SKU. In this manner, high frequent SKUs are assigned to more convenient locations, which streamlines order picking. However, a consequent of dedicated storage is often that volume utilization becomes insufficient.

The other type of storage, shared storage, can on the other hand be used to improve space utilization. Here, SKUs can be assigned to several locations. Once such a location becomes empty, another SKU can be assigned to this

specific location. Consequently, the utilization of the inventory will be higher, the tradeoff is of course that a SKU can be located in many different locations and can thus be harder to find without good systems in place.

Pick

Normally, order-picking (retrieving a SKU from storage location) represents about 55 % of total warehouse operating costs. But it can also be further broken down to traveling, searching, extracting and paperwork and other activities. This is shown in Figure 7.

As a mean to get the right information to the order pickers, pick-lines are used, which contain instructions on what to pick, in what quantity and in what units of measure. Each pick-line corresponds to a specific location in the warehouse. It should further be notable that a pick-line may consist of several picks from the same location. Of course picking have been of large interest for automating due to high operating cost and manual handling.

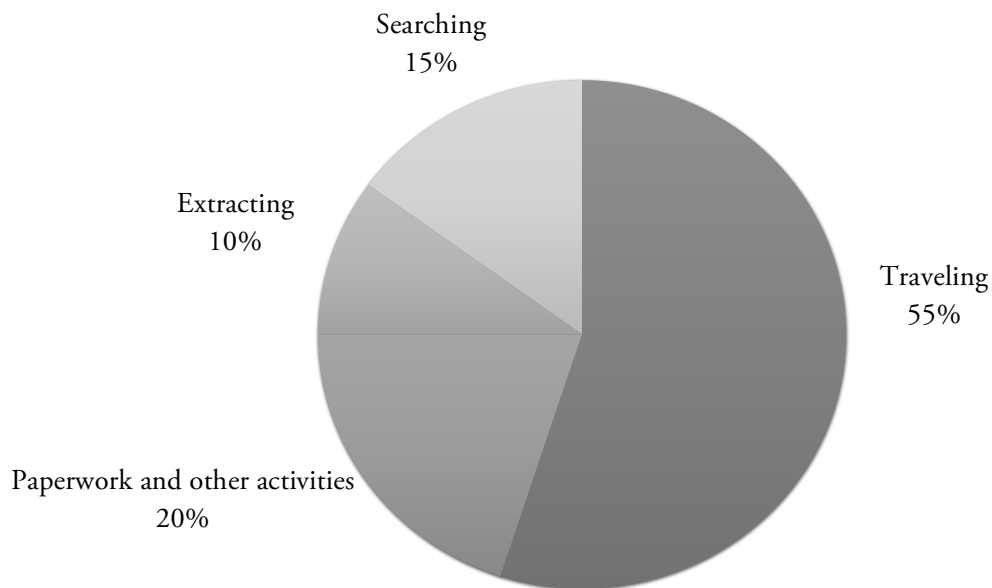


Figure 7 Picking costs, adopted from Bartholdi & Hackman

Pack/Ship

Packing is also a quite labor-intensive activity because of the magnitude of orders (and SKUs) that are handled, often inspections take place at this stage as well. The inspections are performed to control that the orders are complete and accurate, order accuracy is a crucial measure and important to create good service to customers. Inaccurate orders can generate both expensive returns and poor reputation.

In general, the numbers of units that are handled in the shipping dock are lower compared to that of picking. The reason for this is because customers' ask for consolidated shipments, which means that orders are packed together on a single carrier (e.g. pallet or case), which enables economics of scale benefits due to lowered shipping and handling expenses. However, there are customers, e.g. e-commerce actors such as Amazon, who are more likely to ship goods separately, even though one customer buys two books just a quarter of an hour apart from each other. In this case, rapid response is more important, and shipments can be sent separately because it's not a concern for customers.

Cross-dock

Cross docking is referred to the activity when goods are not stored in the warehouse. It is instead directly transferred, after receipt in receiving, to the shipping dock where an aggregation with other goods will be coordinated into a truck (Van Den Berg, 2012).

Returns

The return flow is the reversed movement in warehousing, and as e-commerce is growing (Kripashankar et al., 2013), returns will likely become a larger function in most warehouses. In general, the amount of returns in the e-commerce industry is about 25-30 % states Bartholdi & Hackman (2011).

3.2.2 Warehouse types

There are different types of warehouses depending on what purpose they serve. Examples of warehouses and DCs defined by Bartholdi & Hackman (2011) are:

A retail distribution center

Normally serves the supply to retail stores, such as Walmart and IKEA.

A Service part distribution center

These DCs store hundreds or even thousands of different parts, many which normally also are expensive and slow moving. Subsequently, such DCs are among the hardest to control and manage. An example of a company that holds spare parts is Ahlsell Sverige AB.

An e-commerce or catalog fulfillment distribution center

DCs like this commonly receive small orders from individual customers, which orders via Internet, phone or fax. A normal order is commonly within the size of 1-3 items.

A 3PL warehouse

Such a warehouses usually handles the supply of different companies, which have decided to outsource this competence due to the lack of economics of scale from running their own warehouse operations.

A perishables warehouse

These types of warehouses normally handle food, flowers or other products that need refrigeration due to their short shelf life.

3.2.3 Warehouse performance measurement

Assessing warehouse performance has been largely ignored in research literature (Johnson & McGinnis, 2010). Performance measurement and metrics have also been considered to be a complex matter, and operating the measurements is often inadequately understood followed by weakly formulated definitions of what will be measured (Melnyk, Stewart, & Swink, 2004). However, when it comes to the control of a warehouse, metrics make it possible for the workforce to better evaluate and govern their area of responsibility (Melnyk et.al, 2004) and thereby solve problems before it's too late (Ilies, Turde, & Crisan, 2009). Performance measurement is also desirable to generate the greatest paybacks (Johnson & McGinnis, 2010).

To simplify, warehouse performance measurements are made to ensure: Good customer service that a philosophy of continuous improvement exists among the staff and that issues are discovered before they harm the operations (Gwynne Richards, p 230). One way to deal with these objectives is to work with one of the most common warehouse performance metrics of today called "a perfect order"; SCOR refers to this as "Perfect Order Fulfillment". Blanchard Dave (2008) examines the perfect order, which comprises four main factors, namely:

1. Delivered on time (orders that arrive upon agreed time between the stakeholders at the correct location);
2. Shipped complete (orders which are called off with all units and lines, i.e. in full);
3. Shipped damage free (shipped in correct condition);
4. Correct documentation (orders received by customer of which are accurate in terms of required documentation including invoicing)

By focusing on perfect order performance, one can foresee operational efficiencies, increased sales and market share and conclusively growth in the bottom line (Casey, 2011). One should however pay attention to, that achieving the perfect order isn't easy. If every single factor achieves a score of 95 %, the overall percentage is only 81.4 % (Blanchard, 2008).

3.2.4 Challenges in warehouse management

With the trade-offs mentioned already and the imminent pressure on companies to reduce costs in all functions its obvious that there are extensive challenges in warehouse management. Gwynne Richards have created a list on what he believes to be the main challenges within warehousing, the ones mentioned below are perceived to be the most relevant to Consafe Logistics' business, and to the scope of this thesis.

1. Pressure to balance cost and customer service. Here, warehouse managers have to face the struggle with lowering operating costs and at the same time try to improve service towards customers.
2. Achieving the perfect order, the manager has to fight each and every aspect (presented on previous page), which can lead to that an order would be imperfect.
3. Data and information transfer. The mastery of data is one of the major dares in warehouse management, and the warehouse manager is the one that is responsible for processing it successfully. This also means that continuous updates of the data need to be performed and that the data needs to be transferred to correct location in order to use the data effectively and thereby enable the control of the warehouse.

3.2.5 Warehouse Management Systems (WMS)

Even though the WMS market is becoming mature, it does still play a significant part of the ever-changing shipping and distribution environment (McCrea, 2014), but what is a WMS actually?

A WMS is a software system that enables one to control different activities in a warehouse or a distribution center. It regulates the tasks that need to be accomplished, by sending commands to the staff's hardware devices or the automated material control systems. (Van Den Berg, 2012). A WMS provides real time communication by conveying activities for staff and machines to perform.

There are very many different functions in a WMS, ranging from receiving and quality assurance to packing and shipping. In some, there are more high-end functions, which cover for example forklift travel optimization, support for

forward pick areas (FPA) and automated replenishments. The most important capabilities of a WMS are apart from controlling the warehouse, of course to handle all main activities from the receiving to the shipping. (Van den Berg, 2012)

WMS Receive and ship

A WMS's most central capabilities are to register receipt of inventory into the warehouse and register its shipments out of the warehouse. The key link here is that such capabilities are required for the creation and documentation of financial transactions both upstream to suppliers and downstream to the recipient. (Bartholdi & Hackman, 1.2 Types of warehouses, 2011)

WMS Stock Locating System

The succeeding functionality of a WMS is to manage the inventory of storage locations. With such a feature, a software system can achieve more than just handle transactions of financial nature, it can also support warehouse operations such as give directions on warehouse activities from and to storing locations, respectively. (Bartholdi & Hackman, 1.2 Types of warehouses, 2011)

3.2.6 Warehouse management trends

Even though the fundamental processes of warehousing: receive, put-away, pick, pack and ship, remains the same, it's what happens outside the walls of warehouses that drive how these processes will be executed (Terry, 2013). In addition, Ulf Jansson (2014), CEO at Consafe Logistics, also addressed this statement, saying that customers expect providers of warehouse management software to be more oriented towards end-to-end solutions and therefore best-of-breeds suppliers in warehousing need to put emphasis on the bigger picture. This essentially means that a WMS vendor must stay innovative in today's dynamic business environment (McCrea, 2014). Following trends have been identified in this research.

Visibility

Collecting more data on inventory management, and across the entire network of the supply chain, making it available in real-time is a strong trend within warehousing. This also includes being able to use data warehouses and analyze big data in a better way. Strong communications, deeper integration and increased collection points, are some of the prerequisites. (Terry, 2013)

Integration of warehouse control systems (WCS) with WMS

WCS is the software that traditionally is used to control automated materials handling equipment (McCrea, 2014).

Consumerization

The use of consumer devices and operating systems is being recognized in warehouses today. Younger IT tech firms are seeking to utilize consumer phones and tablets in the warehouse (Terry, 2013), which also is the case for Consafe's customers (Brorsson, 2014).

Software as a Service (SaaS) & Cloud

Cloud computing has a substantial impact on the supply market (Schramm, Wright, Seng, & Jones, 2010), and several WMS developers offers it, but it seems to be few warehouse managers however who are willing to take the risk of data insecurity and downed Internet to get the cost and software benefits with cloud (Terry, 2013).

Another trend worth mentioning is:

Omni-channel trend

Improved support for omni-channel distribution is gathering attention 2014 (McCrea, 2014). Here, warehouses have to handle both goods for stores, and picking for e-commerce fulfillment, which requires altered processes, and a greater deal of returns. Some retailers also consider some-day delivery, i.e. the Amazon effect (Terry, 2013). The question of "when" some-day delivery will be big still remains (SupplyChainBrain, 2014).

3.3 The SCOR model

There are many challenges in business today, competing in a global market and to manage network organizations have already been mentioned. To reduce costs to be able to increase revenue is of course another great challenge. Supply chain costs generally accounts for between 60% and 90% of all company costs (Hoovers, 2006), reducing supply chain costs is therefore of major importance.

According to the SCC it's truly hard to manage a supply chain because there are so many subjects that have influence. Issues like stock market volatility, oil prices, labor costs, political instability, reducing inventory/asset management, sustainability, risk management, must all be considered to be able to achieve an effective and efficient supply chain. Good management will however provide superior and consistent customer service while lowering costs, which will lead to increased profit and margin.

The main concern in supply chain management is usually that it's hard to see the end-to-end perspective spanning from the supplier's supplier to the customer's customer. The SCOR model was developed to describe all activities that are associated with satisfying a customers demand, by describing supply chains using process building blocks all different types of supply chains can be described, from simple to complex, from single country SC's to global ones and across different industries. The result is that all disparate supply chains can be described using the SCOR model. This enables users to have more clear objectives and compare the performance of supply chain operations within their organization and against other. Using the SCOR model can thus help diagnose, address and communicate supply chain management practices, this together offers a strong basis for supply chain improvement. (SCC 2014)

The SCC was founded by 69 organizations in 1996 and practitioners from these members developed the SCOR model. The framework is defined as a process reference model that provides "a standard language for supply chain operations and a blueprint of the key activities needed to manage effective and efficient supply chains" (SCC, 2014). It is basically a diagnostic management tool with a strong focus on performance measurement, especially developed for measuring and understating supply chain conditions and it offers a foundation for improvement (SCC, 2014).

3.3.1 The SCOR model elements

SCOR is still very different from other scorecards and performance measurement frameworks. SCOR consider all processes in SCM and delivers a complete solution from cost control to supplier/partner relationship management. The process reference model also incorporates business-reengineering elements other than the process measurement system, well-known concepts such as benchmarking, best practices and planning strategies are integrated into a cross-functional model. The SCOR model was developed with knowledge combined from both practitioners and recognized literature and the SCC keeps it updated. The model is always changing and evolving with present supply chain challenges, the current version is SCOR 11.0 and came out in December 2012. The SCOR model is built on four ground pillars that are described in Table 2.

Table 2 The SCOR elements

Performance	Processes	Practices	People
Standards for metrics in five categories: Reliability Responsiveness Agility Cost Asset management efficiency	Standard processes to describe what activities are performed where and how: Plan, Make, Source, Deliver, Return and Enable.	Standardize processes that impact supply chain performance using Emerging, Best, Standard and Declining practices.	Manage critical supply chain resources and develop and retain your employees. Consider skills required to perform the work effectively.

With this comprehensive model SCOR can help managers analyze their supply chain and give them the ability to: recognize opportunities for improvement, implement changes, improve operational processes, track results and sustain goals (SCC, 2014). That the SCOR model provides a framework that link processes, metrics and best practices into a unified structure is what makes it stand out, it can help to capture the “as is” state and a “to be” state can be derived from there and that’s really what this study aims for in warehouse operations.

Lately SCC has also developed models to fit other functions than supply chain such as DCOR (Design Chain Operations Reference) for product design and CCOR (Customer Chain Operations Reference) for sales and support functions.

The purpose to develop a performance measurement system for warehousing required focus on two main parts of SCOR: the development of a process model and to find an aligned set of metrics. The literature study will therefore focus on the Performance and Processes sections. For further comprehension on interesting areas such as SCORmark the SCOR models benchmarking support or Practices and People mentioned above a membership for full access to the SCC and SCOR is recommended.

3.3.2 SCOR Processes

As mentioned briefly before the SCOR process model should describe every activity associated with satisfying customer demand. The model consists of Level 1, Level 2 and Level 3 processes to be able to describe a supply chain in different levels of detail. In each level 1 process, three or more distinguishing level 2 process classifications subsist (SCC, 2012). Furthermore, the processes are organized in ways called aggregation and decomposition (SCC, 2010). This means that SCOR has got a hierarchical structure where one can aggregate from level 3, to level 2 ending up in level 1, and decompose the other way around to get the preferred level of the organization described. If even more detail than level 3 is preferred the model can support companies to decompose further into industry specific levels 4 and 5, but these aren't in the scope of SCOR and therefore do not offer an aligned set of metrics. (SCC, 2010) Furthermore, the numbers that are used to code processes in SCOR, does not reflect what type of process level it has. An example is S1.2 Receive Product, which is a level 3 process (SCC, 2012).

Level 1 Management Processes

SCOR is structured around six level 1 processes, called: Plan, Source, Make, Deliver, Return and Enable (SCC, 2012). All have been acknowledged as characteristic processes, which need to be executed in order to fulfill customer orders (SCC, 2012). In Figure 8, an illustration shows how SCOR processes can be related to e.g. warehouse operations.

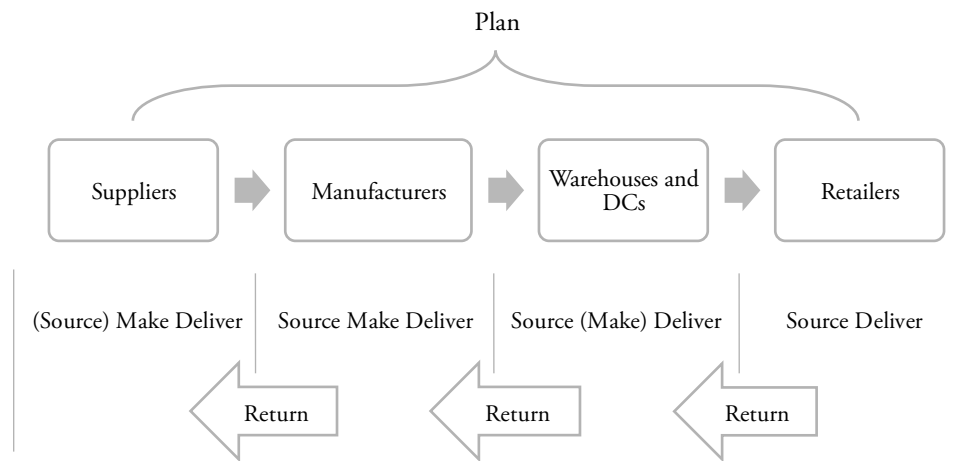


Figure 8 SCOR processes in a supply chain

As can be seen, Source, Make, Deliver and Return are connected to warehousing and Plan covers all the organizations. Enable is not illustrated in the Figure. Level 1 processes are also called management processes or top level and are further described below according to version 11 of SCOR.

Plan

These processes refer to the development of plans to function the supply chain. Here, e.g. gathering of information on accessible resources and congregation of information on requirements is being made so as to conclude what breaches and capabilities that exist in demand or in resources. The conclusion later helps detecting ways to correct these breaches or maximizing the capabilities.

Source

The processes of Source exemplify for example the issuance of procurement orders, including receiving, validation, and storage as well as the authorization of invoices from the supplier.

Make

Make denotes the processes related to the establishment of content or transformation of materials for services. Make represents all types of conversions, which is why the terms manufacturing or production isn't used. In addition, repairing, recycling, renovation and even remanufacturing are also included in Make although it could be part of a Return process.

Deliver

Here, Deliver represents the processes connected to creation, maintenance and fulfillment of customer orders such as validation, receipt, establishment of customer orders, scheduling deliveries, picking, packing, and finally shipping and invoicing customers.

Return

The reverse flow of material is what it's referred to in this sense. Here, identification of the need of returns, the arrangement of decision-making or the scheduling of activities as well as the shipment and receipt of the returned goods are included. Other activities such as recycling and remanufacturing are not described here, but in the make processes as described above.

Enable

Enable designates the processes that are related to the managing of a supply chain. These processes cover management of business policies, performance management, data management, resource management, contract management, supply chain network management, compliance management and risk management.

Level 2 Defining Processes

Level 2 processes, denoted as the configuration level, define the strategy of an operation (SCC, 2012). Level 2 process diagrams can help in most projects to find a potential issue or redundancy in the supply chain (SCC, 2012) (SCC, 2008). Examples of level 2 processes are "Source Make-to-order Product", "Deliver Stocked Product" and "Return Maintenance, Repair and Overhaul (MRO) product" (SCC, 2014).

Level 3 Operational Processes

In level 3, the formation of individual processes is defined, i.e. it sets out the execution of level 2 processes and is focused on more detailed actions (SCC, 2012). Furthermore, level 3 processes specify a firm's capability to be competitive in its designated markets and it's on these level corporations "fine tune" their operations strategy (SCC, 2008, p. 7). If a company operates a warehouse, it's on level 3 one find the connection to the warehouse's certain activities, such as picking (Magnusson, 2014). Another example of a level 3 process is "receive, enter and validate a customer order", which most, if not all companies need to perform (SCC, 2012).

The focus of level 3 processes is to ensure that correct skills of staff, inputs and outputs, process performance, technology skills and/or practices are captured (SCC, 2012), which enables a company to run their warehouse operations as defined by the organization's strategy. Furthermore, process diagrams on level 3 can help sort out decision points, process disconnections and triggers that are needed to structure an organization's operations (SCC, 2012).

Level 4 and 5 Processes (not in scope)

Level 4 and 5 processes are industry, product, location or technology specific and not included in the scope of SCOR. The SCOR model cannot support all different processes that are used on this level due to the modifications every company faces. Level 4 and 5 process descriptions are therefore up to every company to perform (SCC, 2010). For examples and further reading of level 4 and level 5 processes, see section 3.3.5 Applying the SCOR Model.

On the following pages, illustrations shows how SCOR processes are built up and connected.

Process illustration

As mentioned before, SCOR is a hierarchical process model, which is illustrated in Figure 9.

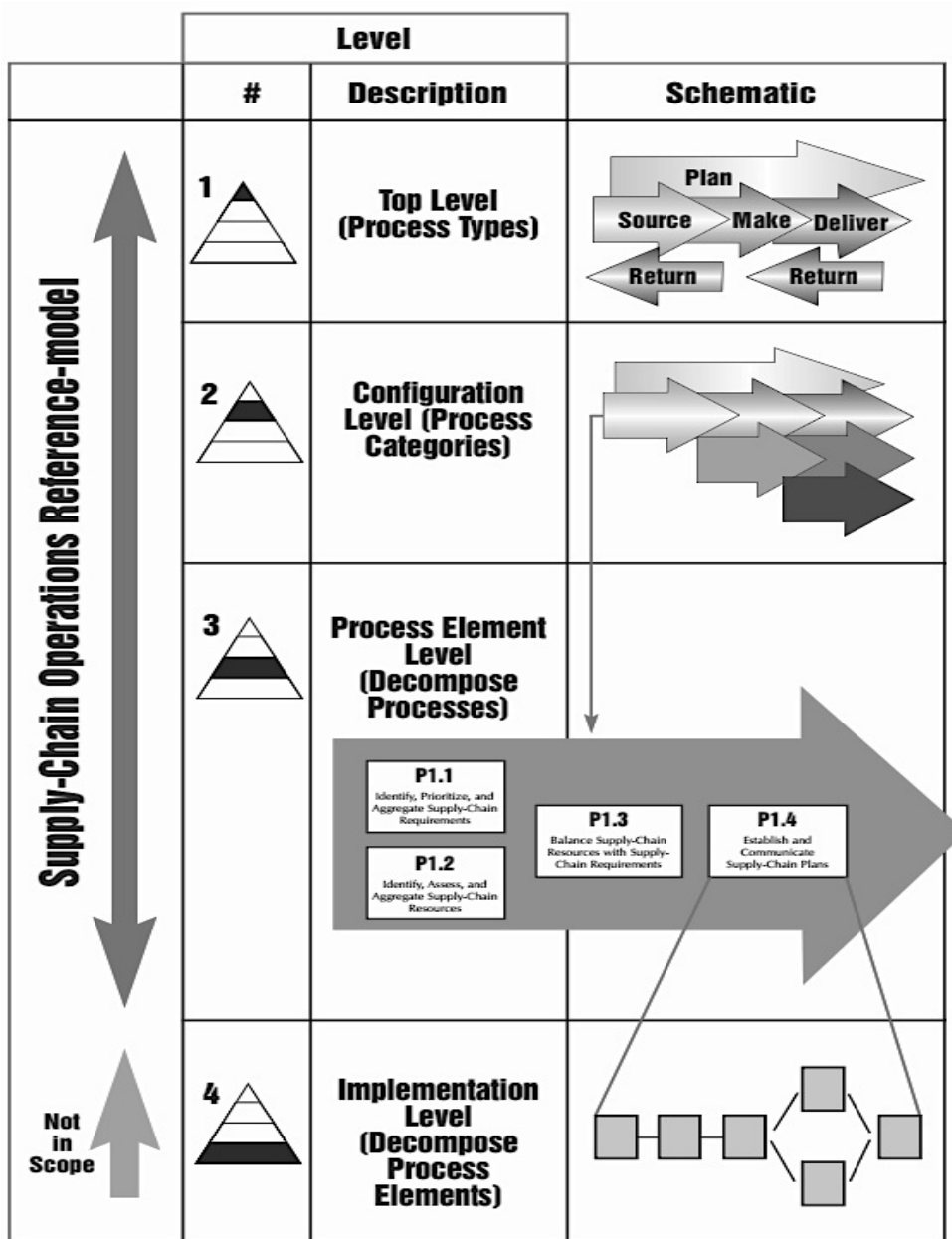


Figure 9 Process illustration (SCC, 2008)

In Figure 9 above, it's shown how level 1 to 3 processes are built up within the scope of SCOR while level 4 isn't. However, in order for the reader to get even a better understanding about SCOR processes, an example of how processes are connected is shown in Figure 10. The example shows how a level 1 process (Deliver) is decomposed into a level 2 process (Deliver Stocked Product) and finishing with connected level 3 processes. When using either SCOR version 11 or their web page, it's easy to follow the processes in this hierarchical way.

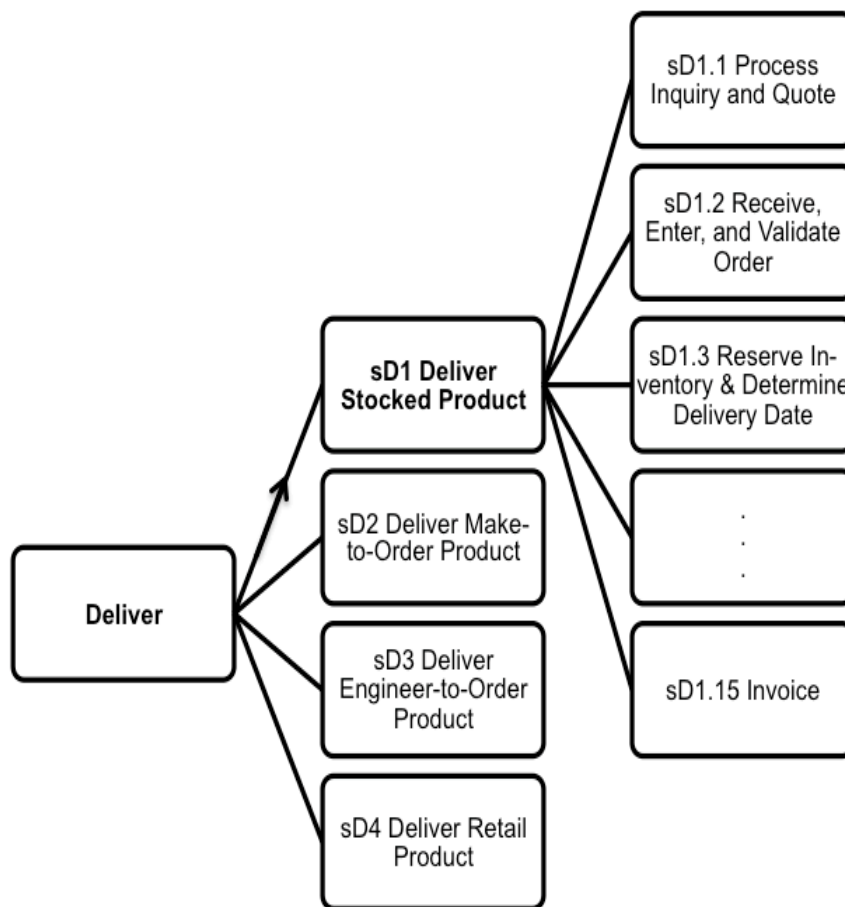


Figure 10 Example of Deliver processes, 1, 2 and 3 (SCC, 2012)

3.3.3 SCOR performance

The performance section of SCOR describes standard metrics that measure the previously described processes. Two essentials exist: Performance attributes and their associated metrics (SCC, 2012).

Attributes

The attributes set out a combination of metrics used which measure a certain strategy's performance. They cannot be measured themselves but work as direction whether the right strategy is being used. (SCC, 2012) There are five different attributes in SCOR that are presented below according to version 11.

Reliability (RL)

Reliability tackles the capability to accomplish responsibilities as required. Focus is on the predictability of the outcome of a process. Reliability is a customer-focused attribute.

Responsiveness (RE)

This attribute addresses the speed at which tasks are accomplished. Reliability is a customer-focused attribute.

Agility (AG)

Agile or flexibility refers to the speed of which the business is able to change to non-forecastable decreases or increases in demand as well as if suppliers or partners are going out of business, natural disasters, terrorism, economy matters, labor issues or equal occur. Reliability is a customer-focused attribute.

Cost (CO)

The cost to operate a process is addressed by the cost attribute. Labor cost and material cost as well as costs in transportation are all examples. Cost is an internal-focused attribute.

Asset management efficiency (AM)

This attribute describes the ability to utilize the business' assets efficiently. Strategies included are e.g. to reduce inventory. Asset management efficiency is an internal-focused attribute.

Metrics

In SCOR, a metric is “a standard for measurement of the performance of a supply chain or process” (SCC, 2012, p. 1.0.2). Metrics are lined up in a hierarchical structure, consisting of three levels.

Level 1 metrics

Level 1 metrics, often called strategic KPIs in SCOR, are diagnostics metrics for the overall wealth of a supply chain and shows how an organization is performing in fulfilling its desired positioning in its chosen competitive market area (SCC, 2012). Level 1 metrics are coded as shown in Table 3, e.g. RS.1.1 – Perfect Order Fulfillment, where RS means responsiveness. In general the relationship between metrics and attributes is strong in SCOR, which can be seen in the table.

Table 3 Metrics and attribute relationship in SCOR (SCC, 2012)

Performance Attribute	Level 1 Strategic Metric
Reliability (RE)	Perfect Order Fulfillment (RL.1.1)
Responsiveness (RS)	Order Fulfillment Cycle Time (RS.1.1)
Agility (AG)	Supply Chain Flexibility (AG.1.1) Supply Chain Adaptability (AG.1.2)
Cost (CO)	Total Cost to Serve (CO.1.1)
Asset Management Efficiency (AM)	Cash-to-Cash cycle time (AM.1.1) Return on Supply Chain Fixed Assets (AM.1.2) Return on Working Capital (AM.1.3)

Level 2 & 3 metrics

Level 2 metrics serve as a diagnostics for the level-1 KPIs. Thereby, if the performance of Level 2 metrics is measured, it will be possible to find out if breaches exist or if any improvements of Level 1 metrics can be conducted. (SCC, 2012)

Furthermore, Level 3 metrics serve similarly as diagnostics for Level 2 metrics, and attribute and number also code both Level 2 and Level 3 metrics. An example is CO.3.102 – Cost to Pick Product (SCC, 2008). In the next section, an example illustrates reliability metrics from Level 1 to 3.

Example of metrics level 1 to 3

A perfect order, or as defined in SCOR, Perfect Order Fulfillment is a metric that was described in section 3.1 Warehouse Management. In Figure 11, an illustration of this metric is presented, which enables the reader to follow the decomposition from level 1 to 3.

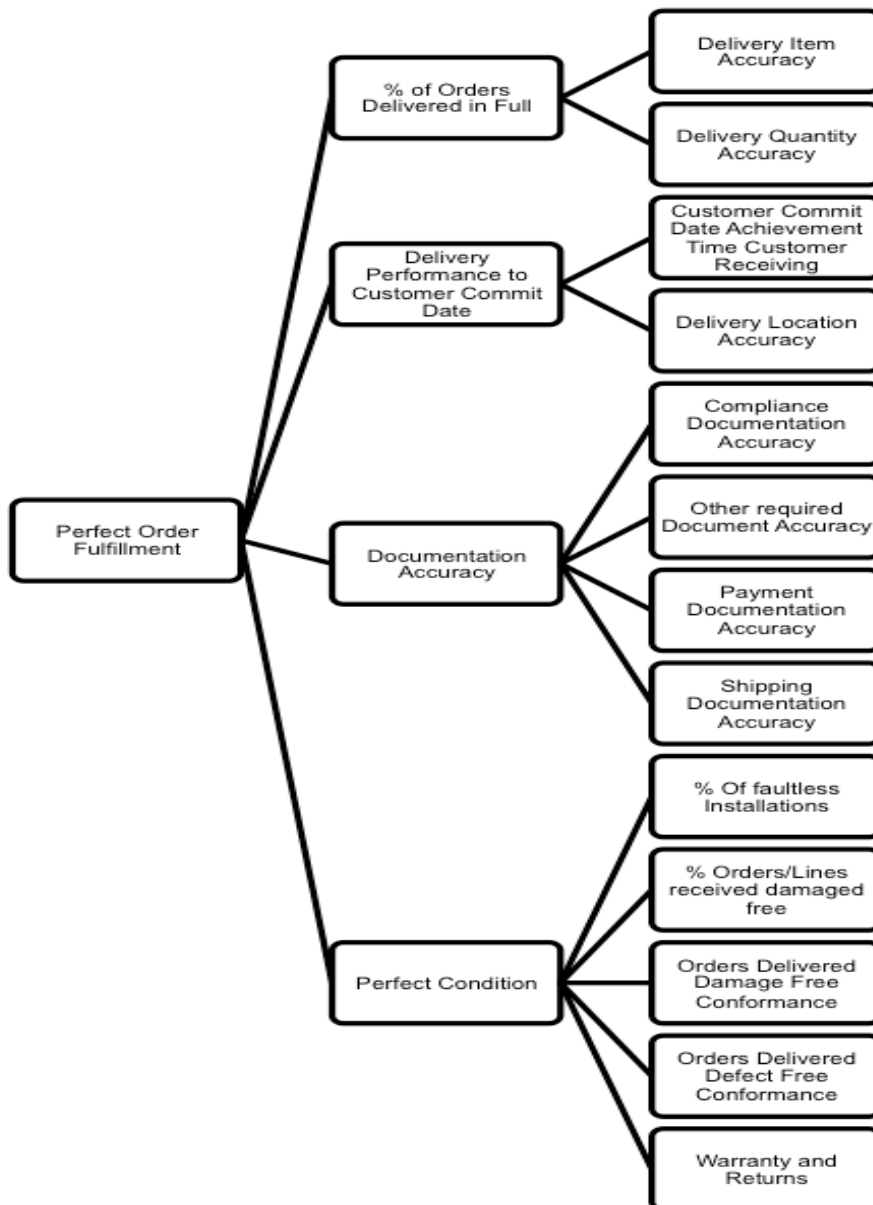


Figure 11 Metrics from level 1, 2 and 3 (Adopted from SCOR version 9)

Link to processes

Level 1 metrics often cross multiple SCOR processes in a supply chain (SCC, 2010), but they don't necessarily have to be connected to a SCOR level 1 process though (SCC, 2008). When analyzing performance of metrics from level 1 to 3, i.e. conducting decomposition, it helps to identify what processes that need further investigation in order to improve performance (SCC, 2010). And as SCOR lists the processes that influence the performance of metrics, a manager can for example examine level 2 metrics to decide what level 3 processes and metrics to investigate further, in order to achieve supply chain superiority (SCC, 2010).

3.3.4 Applying the SCOR model

This far the processes in the scope of SCOR have been general. However, the implementation of supply chain management practices within the company occurs at Level 4 (see Figure 12). A good thing about SCOR is the hierarchical decomposition, where each levels' processes can be further described with more detail in a lower level. By doing this it's easier to find what metrics and processes that are important for each role. A supply chain manager might focus on level one metrics, a warehouse manager on level 3 delivery metrics and a warehouse employee on the level 4 process descriptions. An example of a process description hierarchy from level 4 and 5 is described below.



Figure 12 Level 4 example delivery tasks

Level 5, Example check credit activities

- D 5.1 Access credit screen
- D 5.2 Check credit availability
- D 5.3 Contact accounting
- D 5.4 Communicate results to customer

The structure of SCOR is quite easy to communicate in this way, but to establish these process models can be hard for companies that are not used to work with process models.

Therefore SCC has come up with 6 steps to follow.

1. Obtain generic descriptions (this is what people describe)
2. Map these generic descriptions to SCOR process IDs (normalize)
3. Create swimming lanes to reflect organizational boundaries
4. Create workflow with these SCOR processes
5. Add description to workflows to reflect inputs/outputs of the processes
6. Optionally add other relevant information

The reason why SCOR is offering so many different models and standard procedures is to achieve configurability and standardization. Two supply chains never look the same however the models should still be working for all different possibilities. The models are important for many different reasons such as: strategy development, process optimization, management alignment and benchmarking. A process model can also help to highlight information such as people and system interaction issues. (SCC, 2008)

4 EMPIRICAL DATA

The empirical data gathered for this research is divided into three components. 1, A situation analysis at the case company, Consafe Logistics. 2, An interview based pre-study achieved together with five companies. 3, A web-based survey sent to all Consafe Logistics current customers.

The situation analysis consisted of a series of semi-structured interviews with seven of Consafe Logistics' employees. The primary goal was to understand Consafe Logistics and its business. Secondary, it should help to outline the objectives and delimitations of this research. This by finding out how different sections within Consafe Logistics acts and interacts when it comes to process modeling, performance measurement, metrics etc.

The pre-study was conducted together with five companies based in Sweden. In three of the interviews focus was on the SCOR model to learn as much as possible from practitioners valuable experiences. The aim with the other two was to get insight into Consafe Logistics customer's processes, performance measurement and warehouse management more generally. The interviews offered nuanced open answers and essential information was incorporated in the survey.

The web-based survey was conducted to be able to answer the first and partly the second research question. The survey was based on all previous attained information both empirical and theoretical. The recipients were warehouse managers from all sites with a WMS from Consafe Logistics. See Appendix 1 or section 2.4.2 *The web-based survey* for further reading regarding the web-based survey.

Figure 13 illustrated below shows in what order the empirical data was collected, this chapter will be structured in the same way.

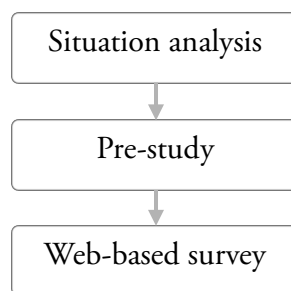


Figure 13 The empirical data components

4.1 Situation analysis

As mentioned before, performance measurements has been unstandardized and often a tedious work for pre-sales to define. To be able to understand other functions opportunities and limitations we interviewed the following people, shown in Table 4.

Table 4 Interviews with Consafe Logistics' employees

Name	Title	Section
Mikael Öhwall	CTO	R&D
Fredrik Sjödin	Project Manager	Projects
Henrik Fröjd	Project Manager	Customers
Thord Sjölin	Project Manager	Customers
Mikael Holmqvist	Market Director	Market
Stefan Oldenburg	VP, Sales	Sales
Helene Hult	System Developer	Projects

Presented below are the main conclusions:

Large interest for performance measurements

Öhwall tells us that there is a large interest for performance measurements. Especially when discussing new implementations customers are very aware and they see many potential measurements that can be KPIs. “The customer wants an overview of all their processes and to get an end-to-end perspective they are enthusiastic for performance measurement, the WMS can’t just be a black box controlling their processes”. But somewhere in the execution the initiative is lost. Öhwall describes a reality where the data from their WMS are used very infrequently and deficient and that Consafe can get better at communicate the potential for automating the construction of KPIs. This is something that Gullage, 2007 also states is a factor for success.

All data available from Astro WMS

All transactional data are logged to a data warehouse for a period of time, and Consafe Logistics is good at communicating the possibilities of accessing the data. Sometimes though this can develop a false sense of having the right business intelligence tools. It’s important to understand that logging all data is not the same as measuring and analyzing the data.

A standardized set of metrics that can be easily communicated could be a step further in their consulting regarding performance measurements within warehousing. Another important thing that came up is the need for transparency and ease to present KPIs that should be aligned to strategy. The warehouse processes and performance measurement shouldn't be an external part of the organization; it should be aligned to the organizations' overall strategies and goals (Elrod, PE Murray, & Bande, 2013), which also - Holmberg (2000) mentioned to be a typical measurement problem.

Mainly standardized processes at all sites

One off the main findings is that even though the physical layout of the warehouse differs from customer to customer the processes and activities in a warehouse are very often standardized. Consafe Logistics builds their business on being experts in warehouse operations and their process knowledge, so customers almost always adopts their flow and processes schemes. (Sjödin, 2014)

Troublesome ROI calculations

One issue in warehouse performance measurement and the implementation of WMS is the calculation of the return on investment (ROI). This is of course a big problem for companies trying to get approval for such an investment. This could also be a good reference for Consafe Logistics in marketing purpose.

Inconsequent and deficient measurements at customers

One statement that all the interviewees endorsed was that the measurement maturity level at their clients is generally low. "A few customers are good at setting goals, measuring and presenting performance, but most are very inconsequent and deficient in their performance measurement efforts" (Öhwall, 2014).

Warehouse managers "the person to talk to"

One important question for the continued research was, who should be the recipient of the survey to get the most reliable answers? When discussing this issue with Consafe employees some different possible recipients were discussed however when talking to former warehouse manager Thord Sjölin it was found that a warehouse manager should be able to answer the questions and give additional valuable inputs.

4.2 Qualitative pre-study

To be able to answer the research questions in this study a broad investigation was necessary. To minimize the risk that the research was missing practical importance a combination of two different types of data collection was used. The pre-study's purpose was to incorporate practitioners view on performance measurement and the SCOR model.

4.2.1 Alfa Laval

As a part of this research's pre-study some companies that have already implemented the SCOR model were interviewed. The first such interview was with Martin Axelsson at Alfa Laval.

Table 5 Company summary - Alfa Laval

Company	Alfa Laval
Type of products	Spare parts
Type of warehouse	Manual with industrial paternosters
Type of WMS	Movex module
Number of sites	5
Picks per week	1200-8000
SCOR model implemented	Yes

Alfa Laval started to look into the SCOR model in 2006, the background was that Alfa Laval was looking to become more globally standardized. In a large organizational change, different efforts to achieve this were developed. The main focus was to implement the same enterprise resource planning (ERP) system to all subsidiaries, another objective was to standardize all operating procedures globally. The SCOR model came up as a possible framework for aligning the operating processes, as Axelsson put it, "we wanted a internationally recognized process framework so we didn't have to invent the wheel again". Today all processes are documented according to the SCOR model.

The main conclusions are presented below:

Possibilities to communicate corporate strategies

When it comes to performance measurements Alfa Laval states that one main benefit in the SCOR model is that it can be communicated between different functions. The level based framework will enhance the possibilities for communications between functions and also the communication towards management.

Especially plan one of the SCOR models main processes will have enhanced possibilities within Alfa Laval's new initiative. The system will identify requirements and help establish the daily scheme. There is also support for what to do if the plan isn't accurate such as transferring equipment and labor between functions.

Easy presentations of KPIs

Alfa Laval has chosen a ERP based module to manage their warehouse, Axelsson explains this decision by telling that the basic WMS functions in their ERP are good enough and best of breed solutions like fork-lift optimization and other functions are not necessary. Currently Alfa Laval is using printed spreadsheets in the warehouse's different stations to visualize performance goals, something that's working well, however it's not optimal says Axelsson.

In SCOR the processes are linked to certain metrics and Alfa Laval has also chosen to link the processes to certain roles within the warehouse in this way there's a standardized description to each role. Axelsson further explains that all processes will not have metrics linked to them this to keep the KPIs to a manageable amount. The important part of the new solution is that different functions will have a "homepage" where the most important few KPIs are easily accessible in a performance indicator. The new solution will also include a work list that will support different actions depending on current situation.

Finance metrics not available in SCOR

The SCOR model can be perceived to have one major disadvantage and that's that it don't include any financial metrics (Axelsson, 2014). Though this is not entirely true SCOR are measuring many financial metrics including profit margins, inventory turns, asset turnover, and working capital (SCC, 2014). However it's true that SCOR are focusing on supply chain and distribution

networks efficiency and effectiveness, the measurements are therefore focusing on execution measurements rather than financial measurement.

Possibilities to end-to-end measurements

In SCM the purpose has always been to gain an end-to-end perspective and to find ways to increase common value. Still information sharing have had a slow implementation pace, many companies sees the disclosure of information as a risk. Axelsson thinks that the SCOR model can be really helpful

Alfa Laval's vital few

- Safety – Injury or damage but also incidents called misses that are close to result in the above.
- Quality – Claims, prime performance on products
- Delivery – Error-free deliveries, on-time deliveries
- Cost

4.2.2 Ericsson

Ericsson was very early with their recognition of the SCOR model, they became members in 1997 when the SCC had only existed for a year. Their initiative however really spun off in 2002, the financial crises had hit hard and it wasn't going well for Ericsson (Magnusson, 2014). In an effort trying to reverse the trend Ericsson looked into many external organizations focusing on models and frameworks for organizational change. It resulted in about 50 analyses where a handful was chosen for a more extensive investigation. Magnusson informs that SCC was one of the initiatives Ericsson believed could really help them. A pre-study was initiated and after a couple of years their efforts towards SC excellence, especially within process modeling and performance measurements were in line with the SCC's ideas.

Ericsson first started to implement the SCOR model on their own but later realized that SAP's business warehouse that they were currently using had already implemented SCOR so the transition weren't that extensive after all.

The main conclusions are presented below:

Important to understand the “as is” and “to be” state

In a large organization like Ericsson it is never easy to change. Magnusson emphasizes the need for knowing and communicating the “as is” and “to be” states. To create opportunities for change through communication, top management need to be able to explain why the change is required and how the change is planned. Ericsson still met some resistance and over a two-year time they measured and presented KPIs from both the old performance system and the SCOR model.

System religious

An ever on-going discussion in performance management is that its always more fun to start up a project than to really see it come through. And Magnusson agrees that often a project works great when the project is still active, but later a gap between how the project’s developers saw things and how the actual operating procedures are acted out differs and the measurements are not longer align to the current business. Therefore one must always be critical against performance measurements, to measure something just because your managers tell you to can be a massive waste of time says Magnusson.

Importance of establishing SCOR process models

According to Magnusson a good SCOR performance measurement system must be aligned to the processes and if a blueprint or block schedule can be constructed, metrics can much easier be decided because SCOR, metrics are linked to certain processes.

“Using these process building blocks, SCOR can be used to describe supply chains that are very simple or very complex using a common set of definitions across disparate industries. Public and private organizations and companies around the world today use the model as a foundation for global and site-specific supply chain improvement projects.” (SCC, 2014)

To improve decision-making and to gain access to vital information, Ericsson implemented both a macro and a micro view. In the macro view each unit in a SC aggregates to an end-to-end perspective and a holistic view can be acquired fairly fast. If more detail is preferred one can look into the micro perspective where all processes within each unit also is structured from the SCOR model. And this is where the SCOR model really have their strength, the metrics are

not only linked within each unit but every unit is also linked to each other, which offers the possibility to see the entire SC's performance.

The warehouses within Ericsson all have this micro view and their own SCOR model put in place. The warehouse's functions are divided into the different execution processes; Source, Make and Deliver and more detailed information such as order-structures and storage-structures can be found via SCOR linked metrics. Another pleasant fact in warehousing is if using a WMS there's so called natural data entry points. Every time a value added service are acted out this will be documented by the WMS. This information can therefore also be presented in operational dashboards. Ericsson is using this opportunity to visualize performance to show if everything is going as planned. "It measures the pulse of our operations and gives opportunity to decision making both when things are going well and when problems occurs" (Magnusson, 2014).

Real time and online

In a more globalized world it's no longer enough to be able to manage and control ones business on site, opportunities to manage the business globally and in real-time is a prerequisite to be agile, shorten lead-times and to create customer satisfaction. (Magnusson, 2014)

Inspiration for improved performance management, not strict rules

The SCOR model should never be read from book to book nor should everything in it be implemented, it should rather be seen as an inspiration when working on improving SCM. Magnusson is firm when it comes to this, it's important to understand that each supply chain is different. One tip from Magnusson when working on a project to improve parts of the SC is to use the document and read what best practices can be implement and how to structure the performance management and then chose the ones that fit the current supply chain and processes.

Ericsson's vital few

- Lead-time/Cycle time – Macro and micro level end-to-end lead-time
- Capital
- Cost to service

4.2.3 The manufacturing company

The manufacturing company (who wants to be anonymous) acts in the furniture industry and essentially manufactures wooden fixtures. The interviewees said that SCOR has been an inspiration for a couple of years and the firm uses it to structure their top level processes (level 1 processes), the company is still quite immature in their process-thinking, but SCOR's Plan, Source, Make and Deliver processes was well known in the organization. "The reason why we started to use the SCOR models is because we wanted a standardized model for our processes, and we also wanted to be able to benchmark". However, since the company only handles full pallet picks (one order line equals one pallet), they haven't implemented very many of the SCOR model's metrics.

A simplified version of the company's supply chain consists of; a raw material warehouse that distributes to the production facilities, thereafter a finished goods warehouse and finally distribution to retailer. The corporation has got a lot of expensive manufacturing equipment and therefore tries to utilize the machines as much as possible. In other words, it's the warehouses that should handle the deviations. The company uses a M3 ERP and WMS plus a data warehouse to collect information from. QlikView is currently used as an access software e.g. it's used to extract data, which is used in a supply chain manager dashboard (no operational dashboard is used). QlikView is also used to perform analysis and establish reports. Excel is also used for this purpose throughout the corporation, but that's something the company want to fade out due to the amount of manual handling (mistakes can more easily be made).

The main conclusions are presented below:

Too little detail in SCOR

The interviewees states that SCOR have advantages such as to be able benchmark, but they also mention that it's hard to prioritize and find the time necessary to get the full grip of SCOR. People currently have other more important projects and things to do. Another drawback according to the company is that SCOR doesn't always have the level of detail that is desirable. "But on the other hand, a general model cannot have too much focus on detail", they says.

What's measured gets done

“What's measured gets done” is a common phrase by practitioners, and mentioned again by the candidates in this interview. Once there is a metric to look at, people have less subjective opinions about the reality. “If an organization start to measure the efficiency of a process that will probably increase performance by 20-30 % without any actual changes to the process”. In this company's opinion, if a corporation wants a higher level, 50 – 85 %, attention must be paid to the metric and the process, and probably some business process re-engineering (BPR) action like best practice must be implemented. It's however hard to go beyond 85 % without starting to reinvent and more regularly regulate the process and its metric, the interviewees claim.

Cohesive analysis

The firm access all their data through one source (M3), but it's very important to access the correct data, the interviewees state. The company has separate functions for IT and process owners but they try to work together as much as possible so that analysis can be cohesive. One issue that is noticed by the company is that it's really hard to define a process in a system so that it correctly mirrors what's gets done in reality. If the information isn't communicated between the IT personnel and the process owners effectively, the KPI will measure the wrong thing. Therefore, only the process owner is allowed to change the process, this leads to more accurate statistics according to the company.

Importance of structured ways of working

To further increase the accuracy of the firm's source of information, the company has a documentation structure for all their processes, and thereby also their metrics. The structure contains four levels: 1, Business steering principles, 2, Process descriptions (how you should work, system independent), 3, Working instructions (how you should work in a specific system), i.e. instructions for how a truck is received, how pallets are scanned and how they should be prepared for put-away. 4, Configuration. However “it's first when we look at the metrics that we actually see how people work”, one of the candidates claims.

Use SCOR when new projects are implemented

The interviewees have sometimes experienced fear to change, and there have several times been light resistance to change already established processes and metrics. Especially when the company has tried to change performance management methods that's been around for a long time. "People are afraid to change processes". The answer to the questions if such behavior is due to that people are comfortable, the interviewees answered that "you shouldn't change the structure and the names for the sake of it". They mean a company should rather do it during a larger project where a change management team is already involved.

The interviewees have also experienced that people seldom know what to measure when a performance management project is initiated. So, during new implementations it nice to be able to create a standardized structure derived from the SCOR model. "By working like this, the old things gets phased out eventually", adds one of the candidates.

The manufacturing company's vital few (presented in a dashboard)

Supply chain focus:

- Availability:
Master plan adherence, Service level(s), Delivery security/reliability, Cancellations, Lead-time, Supplier delivery performance
- Cost:
Stock days, Inventory accuracy, Filling rate, Cost of poor quality
- Quality
- Good conditions:
(Sales/Growth has started to be focus of the supply chain too)

For every supply chain metric, the company has different classifications, e.g. current, goal and trend. Worth to mention is that none of above metrics are from SCOR.

4.2.4 Interviews with two current customers

As the research purpose and issue were established, the authors in coherence with the supervisor of this report realized the importance of conducting interviews with companies with deep knowledge in the area of warehouse management and warehouse performance. As a result, two of Consafe Logistics customers were contacted.

The interviewed companies (who rather stays anonymous) are two different actors with extensive warehouse management operations, one with a great market cap of the Swedish' food industry, as well as a big furniture player. Both companies' warehouse processes are similar to Bartholdi & Hackman's "standardized" warehouse processes, shown in section 3.1.1 in this report, which also later on was used as a basis for the web-based survey. Table 6 and Table 7, give a brief overview of the customers interviewed.

Table 6 Company summary - The food company

Industry	Swedish Food Industry
Type of products	Food & Beverage
Type of warehouse	Manual (50 %) & Automated (50 %)
Type of WMS	Sattstore WMS
Number of sites	7
Picks per week	-
Implemented SCOR model	No

The short shelf life of many of the products in this industry leads to promotions, which in turn triggers a bullwhip effect throughout the supply chain, the interviewee states, and therefore, it makes things harder for the companies' distribution centers to run efficiently. Economic situations have also shown to have its impact on their business. With that in mind, together with a great amount of different SKUS, standardized warehouse processes and hundreds of employees administrating their biggest sites, management has decided that Cost per SKU is the organization's top KPI.

Consequently, performance measurement is important for the company's warehouse operations, but at the same time it's easy that too much measuring leads to inefficient use of metrics the interviewee claims. "It's easy to measure everything, but this doesn't mean that you will improve anything", he says and admits that they measure up to 15 different metrics, but probably only three or four are relevant.

The site in Skane was upgraded with automation in not too many years ago, which has had a great impact on the way they are managing their make-to-order flow. The manual labor in the warehouse is still based on knowledge and experience, while in automation, the interaction between human and the machine has a greater impact on their daily flow, he says. Therefore, another important KPI is machine availability.

The main conclusions are presented below:

Operational visualization of KPIs/metrics

Dashboards from the operator interface SattStore WMS are used at their different sites inside the warehouses. The staff has continuous excess to operational metrics that are monitored on big TV-screens on the different departments on the sites. Speedometers like a typical dashboard e.g. visualize picking performance. The company uses much visualization in their warehouse. It's important for the company to monitor the operational activity in this way, says the respondent, and states that the firm conducts flow optimization based on the performance of the visualization from the dashboard. The overview is however something Sattstore lacks.

United processes, standardization and continuous improvements

The company has implemented processes and standardized ways-of-working which are similar on the different sites. This includes LEAN-inspired ways of working since a huge cost is also currently waste, as well as more and greater ownership of processes within the warehouse. The firm also use piece work pay in the manual warehouse (not in automation), which puts great emphasis on the processes, since such a salary model has incentives to be fast, and the traceability is thereby important. This is why processes in the warehouse are needed to be correct the respondent claims.

Part of the corporation's ways-of-working, is also continuous improvement work. When deviations and unusual happenings occur, such as when there are rarely great shortages, actions take place to prevent it. "It's important to put workers in charge to solve such deviations, and hopefully such focused actions lead to zero deviations in the end", he continuous.

Benchmarking internally between sites

The respondent doesn't support external benchmarking. However, since the company's sites and warehouse processes have similar layout and the company uses both a LEAN-inspired version as well as piecework pay in their distribution centers, benchmarking is conducted internally. Thereby, enhanced warehouse performance is made possible, he continuous. The company is also trying to improve the follow-up work.

The food company's vital few

- Cost per SKU
- Service level towards stores (transport)
- Automation/machine availability
- Packaging waste
- Lead-times

Performance measurement in general is important for the company, and it's also critical on several levels, such as to improve decision-making. Yet it's hard to establish proper measures the interviewee says, and it's important that the individuals working in the facilities realize one's impact on the KPI.

Table 7 Company summary - The furniture company

Industry	Global Furniture Retail
Type of products	FMCG / Furniture and Kitchen
Type of warehouse	Manual & Semi-automated, the new are automated
Type of WMS	Astro WMS
Number of sites	>40
Picks per week	-
Implemented SCOR model	No

With its extensive quantity of SKUs and high number of distribution centers, the company came to realize the use of Consafe Logistics' best-of-breed solution - the Astro WMS - for warehouse management activities. Today, the company has been a customer for six years.

Strategic goals, currently one which aims to grow to company until 2020, sets out the basis for the firm's cornerstones and thereby the company's KPIs for their supply chain. Strong focus is thereby put on aligning processes in their operations, and based on these processes, the structure of warehouse metrics is laid out which link up to top KPIs. However, even though great effort is put on metrics, and especially productivity measures, no real time data is available via the company's several different IT systems she claims, which in total make it hard to get an overview of the data.

Currently, performance is measured on a weekly basis for the distribution centers, but if the visualization could be improved, it could facilitate decision-making in their warehouses the interviewee means. The company divides its warehouse processes similar to Bartholdi & Hackman (2011) and analogues to their literature, the firm divides their movements as inbound (put away), internal (includes replenishment), and an outbound (dispatch) flow.

The main conclusions are presented below:

Poor real-time visualization of KPIs/metrics

Although the company links their metrics to strategic goals, it's hard for the corporation to visualize the KPIs on a global level and extract holistic information. Collaborations have also been conducted with Consafe Logistics to establish a working dashboard, but now, they currently only have a KPI overview, but it lack real-time monitoring. Astro WMS is an intelligent tool, and the data is there, but the visibility isn't easy and it lack overview, which makes it hard to get an intertwined overview according to the interviewee. No clear data warehouse doesn't exist either, but they often miss-use the business intelligence / performance management tool COGNOS for one. This can be the reason to why the company uses excel and access as two of the most frequently used tools to visualize metrics in this matter.

Everyone is in charge - continuous improvements

"Everyone is in charge, and everyone can suggest things that can continuously be improved", se says. When things are conducted or solved in a brilliant way, this gets communicated to managers. However, it takes time to realize an improvement since if an improvement isn't standardized, the communication will be harder between the distribution centers.

Benchmarking

Analogues to the food and beverage company, the furniture company states that their supply chain isn't comparable to others. However, the firm wants to benchmark, and attempts to do so are performed. The issue for the company is that due to the multiple configurations of their distribution centers, internal benchmarking is hard, and external benchmarking isn't applicable since "we are not comparable", as said.

Nevertheless, they do participate on different benchmarking events, which mean that the company grasps ideas from other companies, essentially when it comes to the usage of Consafe Logistics' Astro WMS. The firm is also collaborating with a university as an effort to get at least external input.

End-to-end possibilities through standardization

Unlike companies that aren't the owner of their own supply chain, the company can better make use of its resources and standardize throughout the supply chain. Thereby, the company is able to reach high quality, the interviewee says, and further imply that one cannot realize end-to-end possibilities if you don't own the whole supply chain.

The furniture company's vital few

- Cost (on all levels)
- Sales
- Availability of products (fulfillment of customer order, i.e. on time, correct)
- Filling rate (connected to sustainability)

Warehouse and distribution metrics:

- Productivities (Full Pallet, Picking, Transit)
- Handling Costs (all costs connected to handling goods)
- Filling Rate (utilization of trucks according to customer)
- Lead-time
- Internal Damages
- Store Reported Damages

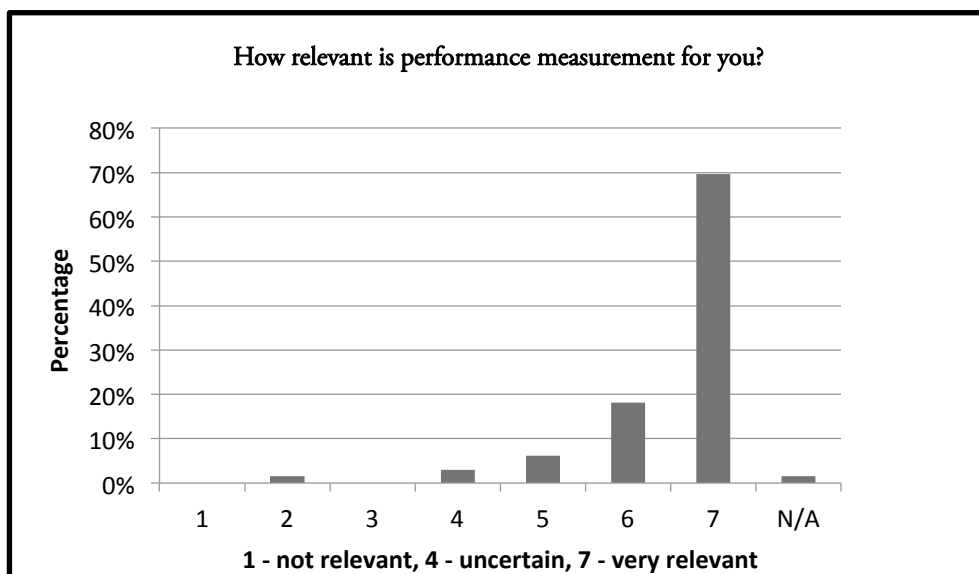
The company's metrics are often linked up to top KPIs as stated before, and in regards to their operational warehouse processes, the company has strong emphasis on productivity figures. These can further be broken down to time and volume (e.g. picking productivity: picking order lines divided by picking hours).

4.3. The web-based survey

The web-based survey consisted of 35 questions and the content in the survey was based on relevant literature and what's been said during the pre-study and the initial interviews at Consafe Logistics as well as on what the two experts at Consafe Logistics wanted to include who participated when the survey was constructed. The survey consisted of 12 open-ended questions and 23 closed questions. The first 23 questions were almost all metric-related questions and were divided into warehouse activities, e.g. Receiving, Put-away, Storing, Picking, Packing and Shipping except the first question which weren't linked to any specific process. The rest of the questions were of general type and graded on a 1-7 scale. As already stated the survey ended up with a response rate of 17.4%.

Respondents tend to find performance measurement very relevant, which can be seen in Chart 1 below. Almost 90% answered that it's relevant or very relevant (indicated by "6" and "7" in the chart below).

Chart 1 Distribution of responses regarding performance measurement



In terms of the open-ended questions, especially in regards to the first open-ended question, it's indicated that customers measure a variety of things in their warehouses, and the metric definitions were often very dissimilar. In the

first question, (*In your warehouse, what are the most important metrics for warehouse performance measurement?*), respondents weren't affected by any influences by the authors such as pre-determined warehouse process descriptions or equivalent, which made them answer what actually is considered to be important to measure in their specific warehouse.

Concerning the closed metric questions, respondents tended to find several quite important, some less important. A synopsis of the responses is presented in Table 8, which indicates that warehouse managers think that metrics that were included in inbound processes, storage activities and outbound processes were almost of same value (59%, 60% and 59% respectively) when the answers were summarized.

Table 8 % of customers that answered "yes" on the closed metric questions

	%
Inbound metrics	59%
- Receiving metrics	71%
- Put-away & replenishment metrics	47%
Storage metrics	60%
Outbound metrics	59%
- Picking metrics	64%
- Shipping, loading & delivery metrics	54%
Return metrics	43%

In Appendix 1, Chart 3, it's shown that customers are operating mostly make-to-stock flows, and Question 31 indicates that 74% have a strategy linked to performance measurement and KPIs or metrics. However, Question 32 showed that only 31% of the customers could easily access their performance data.

For further reading regarding the web-based survey, see the comprehensive Appendix 1, or section 2.4 *Empirical information* or continue to read in the next chapter (5 *Analysis*) where it's described how the information provided by the respondents were summarized and analyzed.

5 ANALYSIS

The analysis mainly focused on finding the answers to the research questions, emphasis was therefore put on two things, the SCOR model and how well it fits in warehousing (both regarding processes and metrics) as well as the results from the web-based survey. The analysis of the survey enabled the opportunity to answer the first and partly the second research question. In the analysis of the third research question a model was designed and an example of how it can be applied is described. Benefits, weaknesses and prerequisites to using the new model will also briefly be discussed. Finally a summary and conclusions of the analysis will be presented in the end of this chapter.

5.1 The first research question

What types of metrics do Consafe Logistics' customers use today regarding warehouse management?

All closed metric questions as well as the open metric questions, except Questions 1, were constructed using warehouse activities presented in Chapter 3.1.1 *Warehouse activities*. To begin analyze the web-based survey, the answers from the 68 different respondents were exported from EasyResearch and summarized in excel-sheets. Several respondents only answered partially on the questions. The excel-commando “filter” was used for the open-ended questions in order to select a suitable sample of the text. Respondents whose answers were considered incomplete were filtered out, such as “Hi” or “asdf” as specified earlier in section 2.5 *Analysis methods*.

In order to answer what types of metrics that are used today by Consafe Logistics' customers regarding warehousing, the web-based survey was first summarized in tables and charts, which can be found in Appendix 1.

Table 8, showed how many of the respondents that answered “yes” to the closed questions regarding metrics that were asked for in the questionnaire. Receiving metrics, part of the inbound metric category had the highest percentage with its 71%, followed by picking metrics part of the outbound metrics category which 64% were measuring. This indicate that customers use several of the metrics that were included in the closed questions, however since both return and put-away & replenishment had a much lower percentage it might question whether the closed questions actually captured what types of metrics customers currently use.

In addition, even though all these metrics were applicable to warehousing, the distribution of different questions between the different warehouse activities was quite dissimilar. For example, three closed questions were dedicated to shipping, six to picking and ten to storage and replenishment, which would have given uneven input on how many metrics that belong to a certain category in this analysis. More attention was therefore given to the open-ended questions.

The first open-ended question covered the customers' most important metrics. It was also the broadest question regarding warehouse measurement and received most respondent's answers since it was mandatory. To this study, that question was also one of the most important, which is why it was positioned first. It was actually also the only mandatory open-ended question, which contributed to that nearly none partially answered this question compared to the other open-ended questions, see Appendix 1, Chart 1, for this illustration.

This question was arguably the most central question to answer research question 1 due to the fact that the customer typed more or less exactly what they measure. Thereby, no influence by warehouse theory or SCOR theory could misguide them on what measurements they actually are using in their warehouse operations. The other open-ended questions would probably not give additional insights into fulfilling the purpose to develop a PMS for warehouse activities based on the SCOR model or to answer the first research question which is why these were left out.

Since the closed metric questions didn't cover an equal amount of metrics for every single warehouse category and were considered more important for Consafe Logistics rather than answering what type of different metrics the customers are using, they were only simply used to analyze the context of the first open-ended question, and were therefore not either included in Tables or Charts of the rest of the analysis.

In terms of the first open-ended question, all 68 customers, contributed with 193 metrics that were considered as their most important metrics. Inadequate responses were filtered out as mentioned above. As described in Chapter 2.5 *Analysis methods*, content analysis was applied to develop metric-categories concerning these responses and worked as a basis for this analysis. These categories are shown in Table 9. The share of customers that use these metric-categories, the corresponding number of metrics in respective metric-category, as well as the share of all metrics are also illustrated in the table. The reason to why there aren't sub-categories on all metric-categories is simply because Return metrics, Customer complaint metrics and Safety & illness metrics included very few metrics (1 to 3 metrics). And concerning the metric-category Storage metrics, this wasn't either sub-categorized since storage doesn't include

sub-activities, which is the case for inbound and outbound according to Bartholdi & Hackman. None of the companies that were interviewed mention that such sub-categories would exist in regards to Storage either.

Table 9 Analysis of customer responses in regards to the first open-ended question

	% of customers that use metrics in this category	Number of metrics	Share of all metrics
Metric-category:	%	#	%
Inbound metrics	8%	12	6%
- Receiving metrics	13%	10	5%
- Put-away & replenishment metrics	3%	2	1%
Storage metrics	22%	20	10%
Outbound metrics	33%	73	38%
- Picking metrics	60%	47	24%
- Packing metrics	7%	5	3%
- Shipping, loading & delivery metrics	33%	21	11%
Return metrics	1%	1	0.5%
Failure metrics	14%	16	8%
- Damages metrics	8%	7	4%
- Quality metrics	10%	9	5%
Customer complaint metrics	3%	2	1%
Safety & illness metrics	3%	3	2%
Overall metrics	16%	66	34%
- Labor metrics	19%	14	7%
- Lead time metrics	6%	4	2%
- Productivity metrics	19%	15	8%
- Other overall metrics	21%	33	17%
Total	-	193	100%

Even though Table 9 indicate that many of the metrics used by the customers can be linked to the same metric category, the numerous definitions provided by the clients may emphasize that supply chains are dissimilar, which also was stated by both employees at Consafe Logistics during the initial meetings at the company (see Chapter 2.1 *Situation analysis*) and during the pre-study. Hence, probably all supply chain organizations have their own developed metrics regardless of what process level they may be linked to. It might be possible to translate those metrics, to more standardized SCOR metrics.

Outbound metrics seem to be most valuable

Furthermore, most metrics used by the customers are probably connected to the outbound flow of the warehouse, this study shows that 33% of the customer use metrics in this metric-category. 73 of the most important metrics or 38% are used in this category. Out of those 38%, picking metrics represented 24%, which were the most expressible since packing metrics and shipping metrics represented only 3% and 11% respectively. An explanation to why picking metrics were the most representable might be due to the fact that picking represent most of a warehouse's expenses according to Bartholdi & Hackman which is probably why metrics such as "order lines picked per hour" is of high value for the customers. Questions 12 in Appendix 1 with its topic "if picks per person and time unit is measured", also show that a lot of consideration were paid to such picking metrics, since 85% stated that this was measured. Therefore this could be vital to include in a performance measurement system.

Outbound metrics related to shipping and loading metrics were probably also quite important to the customers since 33% of the customers use such metrics. Question 17 in Appendix 1 further implies that those metrics were important. However, questions arise whether how much attention that is paid once orders have been shipped, 92% of the customer answered yes to "if orders are shipped on time", but there were only 43% that mentioned that they measure shipping documentation accuracy (see Appendix 1). Maybe it could be valuable to include such metrics and processes in a PMS model, which might increase Consafe Logistics competitiveness when it comes to metrics after the goods have been called off.

Storage metrics also important

Table 9 shows that storage metrics are probably also considered to be important by the customers. 22% of the customers use metrics in this category, or 10% of all metrics were related to this category. Here metrics that measure "inventory accuracy" are the most representable one. The emphasis put on storage metrics may show that if the storage is handled in a proper way, the challenges in the warehouse could easier be dealt with (presented in Chapter 3.2 *Warehouse management*). It also indicates that Consafe Logistics WMS

solutions are probably relatively robust regarding storing activities. Besides, the closed question 9 in Appendix 1 support that metrics related to storage is important to customers since e.g. 85% measure inventory accuracy.

Inbound metrics seem to be less utilized

It may be questionable however, why only 8% of the customers use metrics that are related to the inbound flow, since receiving and put-away represents 25% of the cost in a warehouse according to Bartholdi & Hackman, which must be seen as a considerable amount. Only 2 (or 1%) of the most important metrics were related to put-away and r replenishment, which could indicate that the importance to control if goods are replenished correctly may be overlooked. Maybe the customers capture this later when i.e. stocktaking of the inventory is performed. In other words, maybe there is little action to proactively make sure that the storage is handled in a proper way since replenishments don't seem to be a high priority to the customers. The closed question 9 in Appendix 1, didn't either give any additional sign that replenishment metrics were a high priority to the customers. Therefore, it might as well be something to put emphasis on in a PMS model.

Returns appear to be almost ignored

Returns are expressed only by 0.5% of the most important metrics used by the customers. It means that only 1 customer mentioned return metrics as part of their top priority. As 8% of the customers stated that they were an e-commerce or catalog fulfillment distribution center in question 25 (see Appendix 1), 1 customer could be considered to be low. It might specify that the customers do not find returns as important or maybe they lack knowledge about the considerable amount of return-rates related to e-commerce, which is mentioned by Bartholdi & Hackman. However, in the closed question 19 in Appendix 1 the customers specified that 65% measure the number of returns as part of the return process, even though it wasn't perhaps part of their most important metrics. Hence, it may be less valuable to look at returns when looking at a new PMS. However, it might be discussed due the upswing of e-commerce companies stated by Kripashankar et al. (2013) and there a PMS model that would include return metrics could increase Consafe Logistics' warehouse services in the future, if such were to be included.

Additional metric-categories

In Table 9 it is indicated that a lot of metrics could be categorized into overall metrics, which measure certain things throughout the entire warehouse and couldn't be categorized accordingly with the other, better known flows. There were 16% of the customers that use metrics in the overall metric-category and here "other overall metrics" were the most expressible with 17% of all metrics.

Productivity metrics were also commonly expressed, according to the customers were 19% measured such metrics. An example is "Productivity per warehouse department" which the authors believed to be hard to categorize. Similarly, the lead-time metrics weren't either really defined properly by the customers and were therefore also added to the overall category. Labor metrics were likewise measured for several activities in the warehouse and was stated by 19% of the customers.

Furthermore, Failure-metrics were also quite important to the customers as 14% stated that damages or quality metrics are used. And even though warehouse companies normally assess quality when goods receive, the customers didn't express this. The same applied to damage metrics, which was used by 8%. An example of category failure-metrics is "internal handling damages – the value of local handling damages calculated as cubic meter sent out".

When it comes to the additional metric-categories, apart from quality metrics and damages metrics, it's believed that several of them will be hard to include in a PMS based on SCOR due to their specific level of detail.

Summary

The analysis summarized metric-categories used by the customers according warehouse activities. It showed that a lot of customers use metrics in essentially outbound and storage. Therefore this could be included in a potential PMS. Inbound metrics weren't expressed by customers to be as important, however since quality metrics had a quite high percentage, it's believed that such metrics could be grasped by the quality inspections normally used in receiving. And

when consideration is taken to that 25% of the cost is represented by inbound tasks (according to Bartholdi & Hackman), it's believed that these categories should be included in a PMS as well. Returns weren't either expressed by customers to be valuable, however with the increase of e-commerce sales, and that it might increase future selling capabilities for Consafe Logistics, this will also be looked into. In regards to the other additional metric-categories, it's believed that an inclusion of them in a SCOR PMS could be hard due to their specific level of detail.

5.2 The second research question

To what extent are metrics from the SCOR model applicable for Consafe Logistics' customers in warehouse management services?

To be able to review metrics the topic has been reviewed more closely, the two main findings have been literature written by Bolstorff & Rosenbaum (2011) and Lepori, Damand, & Barth (2013). In the book Supply Chain Excellence, a handbook for dramatic improvement using the SCOR model Bolstorff & Rosenbaum thoroughly analyzed all parts of a SCOR project. Lepori, Damand, & Barth's work is specialized towards SCOR in a warehouse environment.

According to Bolstorff & Rosenbaum there are three common approaches when selecting the right set of metrics. The first is education, SCOR definitions, calculations and collection requirements must be understood and compared against what's currently being measured, this to be able to decide whether to include, exclude or modify current KPIs. A second approach is to use his guides, they're built from multiple project experiences and included in his book. The third approach is to follow the SCORmark benchmark that also includes calculation components based on SCOR definitions. To know what metrics to consider can still be a very difficult task (Bolstorff & Rosenbaum 2011), especially when about 50% of the metrics from SCOR aren't applicable in warehousing activities (Lepori, Damand, & Barth, Benefits and limitations of the SCOR model in warehousing, 2013).

In this study a modification of the first approach was selected. The survey should give a good understanding on what's being measured in warehouses and

these measures was then to be compared against SCOR to find gaps and whether the SCOR model could be applicable for Consafe Logistics customers. The survey questions were therefore designed so that metrics definitions were asked for instead of commonly used metric names. This secured that metrics with different names than the SCOR model as well as the specific metrics provided by the two professionals at Consafe Logistics, still could be answered correctly by the customers.

To be able to address if customers' warehouse metrics could be linked to a potential SCOR PMS model, they needed further analysis. And as indicated by the percentage rates for the closed metric questions in Appendix 1 (or Table 9), several were considered to be valuable to the customers. Only 48% of the metrics included for the closed metric questions were identified using SCOR metrics though when the survey was developed, yet all were based on SCOR warehouse processes such as the deliver process - pick product.

Connection between customers' metrics and SCOR

Once the metrics from the first open-ended question had been categorized using content analysis and were segmented and summarized, an attempt was made to find a connection between customer metrics and SCOR. Versions 11 and 8 of SCOR as well as supply-chain.org were used to find correlated SCOR metrics. And since all SCOR metrics are coded with attribute (see section 3.3.4 *SCOR performance for further reading*), a new classification was made accordingly. This illustration is shown in Chart 2 below.

Chart 2 Customer metrics according to SCOR metrics

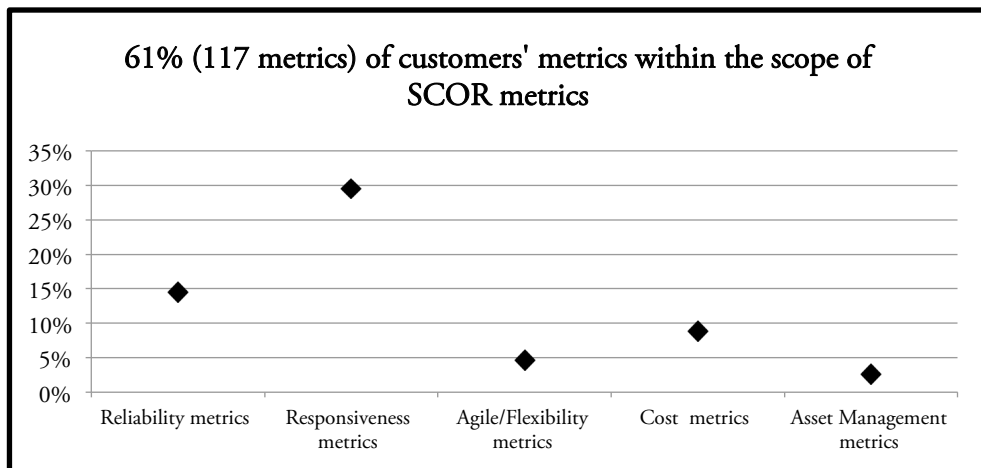


Chart 2, shows that 61% (or 117 metrics) were possible to translate to SCOR metrics, which often were level 3 metrics. It can further be seen that most metrics are related to responsiveness, i.e. the speed at which tasks are accomplished. Reliability metrics are also of great value. When looking at question 30 in Appendix 1 however reliability was the attribute that most customers considered to be of most value, thereafter came cost. Therefore, the analysis probably imply that the metrics used by the customers are to some extent different from what the customers believe, which may question the performance measurement knowledge among the customers. Some of Consafe Logistics' employees, presented in Chapter 4.1 *Situation Analysis*, also addressed that their customers possess little knowledge about performance measurement. The information presented in Chart 1 could thereby be used as guidance for Consafe Logistics when trying to direct customers on what kinds of metrics that should be used since all metrics in SCOR are expressed with attributes.

It can also be deduced when looking at Chart 2 that the authors couldn't identify 39% (or 76) of the customers' metrics according to SCOR metrics, which might emphasize Lepori, Damand, & Barth's (2013) finding that 50% of SCOR metrics aren't applicable in warehouse activities, which should be considered when the performance measurement system is constructed.

Most common customer metrics translated to SCOR metrics

In addition, when the analysis and translation of customer metrics to SCOR metrics had been made, some specific metrics were more common to use among the customers. Table 10 shows these metrics, which are converted into SCOR metrics and summarized according to the previous used metric-categories. For the inbound flow, RL.3.18: % Orders/Lines Processed Complete and RS.3.113: Receiving Product Cycle Time were most representable. Storage metrics were characterized by e.g. RS.3.47 % of SKUS available when needed and CO.3.171 Inventory days of supply. Outbound metrics were represented by e.g. RS.3.96 pick product cycle time and CO.3.171 Products shipped per delivery. For the failure metrics, RL.3.41 % of orders, which are delivered without damage, was the most used metric. For the overall metric-category, AG.3.45 logistics labor availability was an important

metric, and RS.2.1, 2.2 or 2.3 Source, Make or deliver cycle time was another important metric.

Table 10 most used metrics in every metric-category (customers' metrics translated to applicable SCOR metrics)

Metric category:	SCOR metric:	SCOR process:	%*
Inbound metrics⁴			
- Receiving metrics	RL.3.18: % Orders/Lines Processed Complete	Source	40%
	RS.3.113: Receiving Product Cycle Time	Source	30%
- Put-away metrics	-	-	-
Storage metrics			
	RS.3.47: % of SKUs available when needed	Deliver	40%
	RL.3.7: % Item Location Accuracy	Deliver	25%
	CO.3.151 or AM.3.17: Inventory Days of Supply	Deliver	20%
Outbound metrics			
- Picking metrics	RS.3.96: Pick Product Cycle Time	Deliver	64%
- Packing metrics	RS.3.95: Pack product cycle Time	Deliver	60%
- Shipping, loading & delivery metrics	CO.3.171: Products Shipped per delivery	Deliver	33%
	RL.3.33: Delivery Item Accuracy	Deliver	14%
Return metrics			
	Missing	-	-
Failure metrics			
- Damage metrics	RL.3.41: % of orders which are delivered without damage	Deliver	56%
- Quality metrics	Missing	-	-
Customer complaint metrics			
	Missing	-	-
Safety & illness metrics			
	Missing	-	-
Overall metrics			
- Labor metrics	AG.3.45: Logistics labor availability	Missing	29%
- Lead time metrics	RS 2.1, 2.2 or 2.3: Source, Make or Deliver Cycle Time	Source, Make, Deliver	75%
- Productivity metrics	Missing	-	-
- Other overall metrics	CO2.2, 2.3 or 2.4: Cost to Source, Make or Deliver	Source, Make, Deliver	18%

* as share of that metric-category

Even though Table 10 shows some more common metrics that customers use, it might be hard to base a PMS system on these metrics, since it could be hard to justify if they could be generalized to all Consafe Logistics' customer's different warehouse operations. Even more important is that it may be hard to link these specific metrics into a higher-level metric, which could be representable for the whole warehouse. The reason is because the composition of the metrics in Table 11 can't simply be aggregated to a higher level SCOR metric, which for example Figure 11 *Metrics from level 1, 2 and 3* illustrates, except maybe lead time metrics, which could link up to a total lead time starting with receiving and finishing when goods are delivered. However, since they lack a connection to a higher level no clear insight could be drawn even though they still (individually) might be important for a warehouse that can be valuable for Consafe Logistics to have in mind when discussing metrics with customers.

Processes

If only 61% of the metrics can be align to the SCOR model its arguably not much point in creating a performance measurement system based on SCOR metrics. The SCOR model is however composed by two parts: a process model and for each process SCOR proposes metrics (Lepori, Damand, & Barth, 2013). And the best way to build a PMS based on SCOR is not by deciding what metrics should be measured; rather a company should start with describing all processes in the supply chain (Magnusson, 2014)(Bolstorff & Rosenbaum 2011).

Therefore, the authors analyzed the customers' metrics also in regards to SCOR processes. This to find out if metrics were aligned to common warehouse activities, if that was the case a model that was focusing on the processes rather than a set of metrics would be preferred in the solution. Since processes weren't pre-defined regarding question 1, most of the analysis were once again directed to this question. The customers' metrics that could already be aligned to SCOR metrics (61% in Chart 1) were thus all linked to corresponding SCOR processes, which was found to match SCOR's processes (Source, Make, Deliver), and almost all was level 3 processes.

As an example, a customer responded that they measure “Receiving Time” which earlier was matched against the SCOR metric RS.3.113 – Receiving Product Cycle Time. The connected process in SCOR is – SOURCE 1.2 Receive Product, which is a level 3 process. This was repeated for every single metric with direct connection to SCOR metrics, and thereby the processes could be found, even though a lot of effort was needed to summarize them. The summary is presented in Table 11.

Table 11 SCOR processes related to the metrics applicable to SCOR (61%)

Processes	%	Number of metrics
Source	9%	11
Make	2%	2
Deliver	89%	104
Return	0%	0
Total	100%	117

The table shows that the connected processes may be valuable to a SCOR PMS model, since warehouse processes (Source, Make and Deliver) were found. No linkage could be made to return though. In regards to the metrics where no direct SCOR metrics could be identified (39%), an investigation whether they could be matched against a SCOR process instead had to be made. For example, a customer responded that they measure “Amount of wrong picks” which couldn’t be translated into a direct SCOR (level 3) metric. However, there is no doubt that the metric can be linked to the SCOR process “Pick Product”, which is a level 3 deliver process in SCOR. This was repeated for all those metrics and the summary is illustrated in Table 12.

Table 12 Metrics (39%) linked towards SCOR processes rather than SCOR metrics

Within the scope of SCOR processes	%	Number of metrics
- Level 3, deliver	29%	21
- Level 3, All source, make, deliver	45%	35
Sum	74%	56
Not within the scope of SCOR	%	Number of metrics
- Level 4, deliver	5%	4
- Level 4, All source, make, deliver	10%	8
- Level 4, return	1%	1
- No process identified	10%	7
Sum	26%	20
Total (all)	100%	76

Most of the processes found, 74%, could be identified as level 3 deliver processes, but 16% were considered to be company specific (level 4). 10% couldn't be linked to any SCOR process at all. Furthermore, several metrics that was found to be within the scope of SCOR processes were productivity metrics, which measured certain things throughout the entire warehouse. An example is "full pallet productivity - cubic meters shipped divided by total time spent on operational activities". This is shown in Table 12 as "Level 3, All source, make, deliver".

Summary

The analysis showed that out of the customers' most important metrics, 61% could directly be linked to metrics in SCOR. The analysis also showed that mostly level 3 SCOR processes could be found to all of these 61%. In regards to the 39% where no direct SCOR metric could be discovered, 74% could instead be linked towards SCOR processes, (mainly on level 3).

Thereby, a total of 89.6% of the customers' metrics can be linked to SCOR processes according to this analysis, see Table 13 for the illustration. The other 9.4% of customers' metrics can't be linked to SCOR processes as defined in SCOR today, because they're either company specific (level 4 or beyond) or are simply too complex to translate into an accurate SCOR process.

Table 13 Summary of customer metrics that can be linked to SCOR processes

	%	Number of metrics
Metrics with direct linkage to SCOR metrics (the 61%)	61%	117
Metrics with no direct linkage to SCOR metrics (the 39%)	29%	56
Sum, within the scope of SCOR processes	90%	173
Sum, not within the scope of SCOR processes	10%	20
Total	100%	193

The analysis also indicated some metrics that were used by several customers (See Table 9), but no clear insight could be drawn in regards to their connection into higher-level metric that could be used as vital metrics representing the overall health of the warehouse. Furthermore, it may also be hard to generalize those certain metrics to all customers because of the customer's diverse warehouse types (showed in Appendix 1, Question 25). However, the authors still believe that they could be valuable to Consafe Logistics employees when discussing metrics with customers, but they will not be included in the PMS.

The research however implied that SCOR processes had a higher match in terms of applicability to SCOR as mentioned earlier. Therefore, it might be more effective to construct a standardized PMS out of well-known processes instead of choosing a set of metrics, many warehouse operators could recognize it easier and thus the generalizability would be higher. Additionally, as can be seen throughout the entire project so far, SCOR uses quite complex coding. If the authors are able to make the coding user-friendlier, it may facilitate the understanding of the new performance measurement system.

This leads to the conclusion that the solution should rather than focusing on a certain set of metrics, focus on warehouse processes. If a process model that is aligned to the SCOR model is developed, SCOR can propose metrics that is based on the actual activities in the warehouse, which everyone can understand and therefore be more involved in.

5.3 The third research question

How should a possible performance measurement model for warehouse activities based on the SCOR model be designed and used?

After the conclusion was made that most metrics can be aligned to an equivalent processes in SCOR, focus was directed to creating the processes model that should be the foundation for the new performance measurement system. If this study could lead to the development of a general process model instead of a general set of metrics, the SCOR model could propose metrics for every company specific strategy through choosing what Performance attribute the company should focus on.

What the research showed was that level 3 processes are activities all companies must do to fulfill customer needs, since 90% of the warehouse processes could be aligned to level 3 processes in SCOR the objective to offer a standardized performance measurement system that would offer companies to follow up on their strategies with KPIs should be able to attain.

5.3.1 Workshop with SCC board member

To be able to get the best possible insights on the process model and how it should be applied to warehouses Lars Magnusson SCOR expert and SCC board member was contacted. He was willing to help analyze the question in a solution-oriented workshop.

With years of experience with aligning SCOR to all parts of the supply chain within Ericsson, Magnusson offered invaluable support to this study. A first sketch on a process model was developed, illustrated in Figure 14.

In terms of processes the SCOR model may be misinterpreted by managers based on the belief that all six level 1 processes must be part in each entity in a supply chain. This is however not the actual case, a regular warehouse for example can be composed of Plan, Source, Deliver and Return processes only. The measurements focused on in this study are those which can be retrieved from the Astro WMS and therefore closely tied to warehouse operations, Plan and Enable processes were therefore excluded.

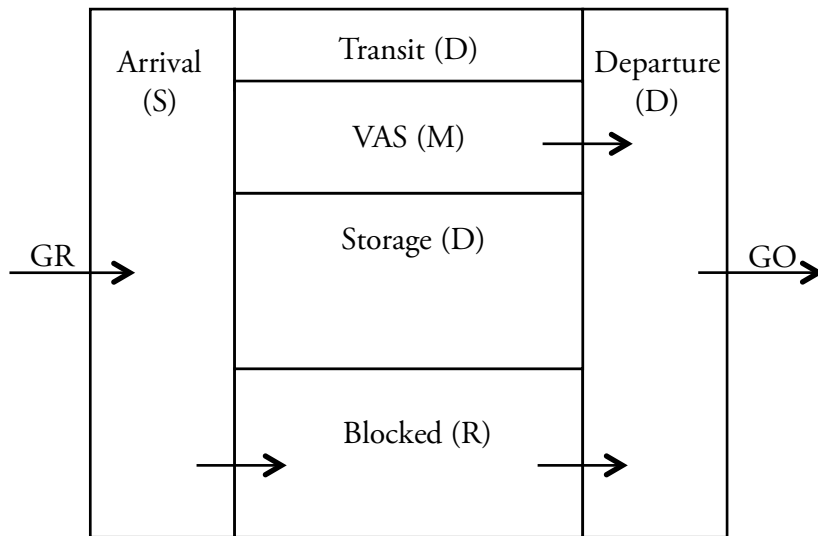


Figure 14 First sketch of the Process Model

S = Source process D = Deliver process M = Make process R = Return process

- GR - Goods receive
- GO - Goods out
- VAS - Value added services

“On a macro perspective a warehouse can be seen as a Source - Deliver process model but I believe it’s important to include value added services and define it as a make process” (Magnusson, 2014)

This initial model was a first step towards a process model within warehouse management. To make a more applicable model that fits renowned theory on the subject and SCOR process descriptions the model was going through some alterations and a complete second model is illustrated in Figure 15.

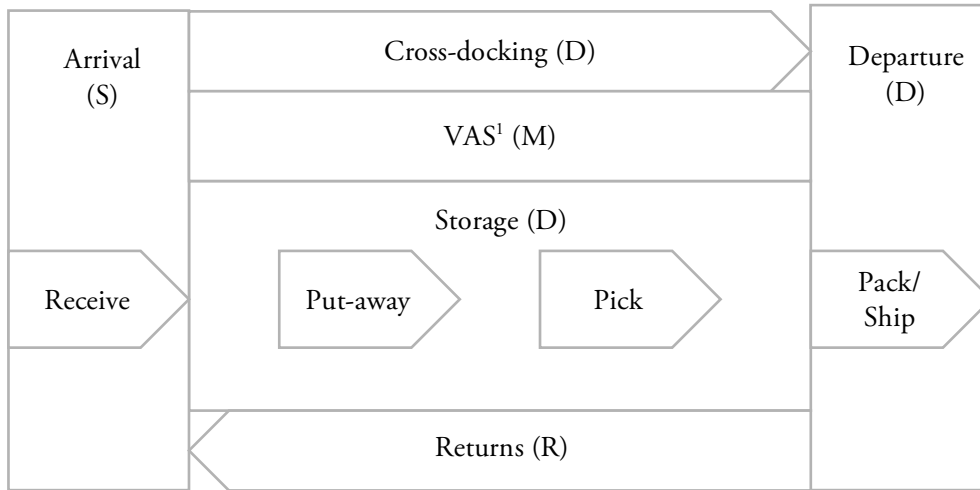


Figure 15 The Warehouse Process Model (PMS)

The design should enable Consafe Logistics personnel to find how each process should be defined according to SCOR, the model is constructed out of common warehouse blueprints and processes to make it comprehensible.

This model could support Consafe Logistics when mapping their customers warehouse activities. If the processes are aligned to SCOR, then metrics matching the certain company or strategy can be proposed from the SCOR model and conclusively make up a complete performance measurement system for warehousing activities.

5.3.2 Prerequisites for successful implementation

In this section some areas that have been found critical to accomplish a successful implementation of the SCOR model will be discussed.

For Consafe Logistics to be able to implement the SCOR model on all their customers' different supply chains there must be an extensive profiling of the warehouse and the processes involved. This have been their main focus of many years though and nothing new to them. We still want to share a possible method for warehouse profiling that includes the SCOR model and can be helpful to understand factors that affect the new process model.

To be able to offer customers to take part off the SCOR model in regards to both processes and metrics, some steps have to be followed in the implementation phase.

1. Map and define processes, material and data flows according to the warehouse process model
2. Select which performance attributes to focus on
3. Profile and measure current performance
4. Establish performance targets
5. Identify opportunities in SCOR, enable best practices
6. Continues improvements

Table 14 What must be investigated in a warehouse profiling

Facility layout	Resources	Activities, receipts/day
- Usable m ³ - Material and data flow diagrams	- Receiving operators/ inventory control - Order pickers/ packers/ inspectors - Replenishment operators - Shipping personnel	- Receive - Put-away - Store - Pick - Pack - Ship
Movement	Storage	Systems
- Fork lifts - Conveyers - Other automation	- Bulk - Pallet rack and flow rack - Bins/shelving - AS/RS - Industrial paternosters	- Types, applications, interfaces - RFID - Bar code scanners - Voice CRT's - Other terminals
Product profile	Other considerations	
- Number of SKU's - Any perishables - Any hazardous	- Shelf life - Tracking - Seasonal issues - Yard and transport management	

5.3.3 Applying the new warehouse performance model

To further analyze the new process model an example on how to use the model was conducted, this should in a practical way show how a complete (process model and metrics) SCOR based performance measurement system within warehousing can be achieved.

The purpose was to see if the PMS offered enough detail to support new implementations on a general basis. It should also be investigated if the 6-step method recommended by SCOR (see section 3.3.5 *Applying the SCOR model*) could result in a standardized method on how to create a warehouse performance measurement system.

1. Obtain generic process descriptions

The example is based on a previous Consafe Logistics customer implementation. The processes are therefore on beforehand defined from an activity profiling made in 2009.

Note: An activity profiling is conducted on all Consafe Logistics customers and would thus not be additional work for them if the PMS want to be used.

2. Map these generic descriptions to SCOR process IDs

What was done in extension to the already made activity descriptions in this step was aligning them to appropriate SCOR processes, which was done by using the new warehouse process model illustrated in Figure 15. In the activity-profiling document processes were defined and divided into six main areas the authors did a cross reference analysis in SCOR to find what processes they could align to, Table 15 shows that association.

Table 15 Activity profiling example

	Activity profiling description	SCOR-processes
Axx	Processes related to receiving	Source
Bxx	Processes related to order handling	Plan
Cxx	Processes related to expedition	Delivery
Dxx	Processes related to order assembly and dispatch	Delivery
Exx	Supporting processes	Enable
Fxx	Handling of returns, packaging material, return pallets and waste	Return

What can be seen from the mapping is that the enable and plan processes are not included in the scope of this study and the model is therefore not 100% functional with this old way of profiling a customer, however with the model implemented for new implementations all processes should be able to be matched against an included SCOR process.

3. Create swimming lanes to reflect organizational boundaries

To show an example of how to decompose further Axx - Processes related to receiving was selected, by looking further on Source processes two appropriate level 3 processes were found.

Source: Receive Product - *The process and associated activities of receiving products to contract requirements.*

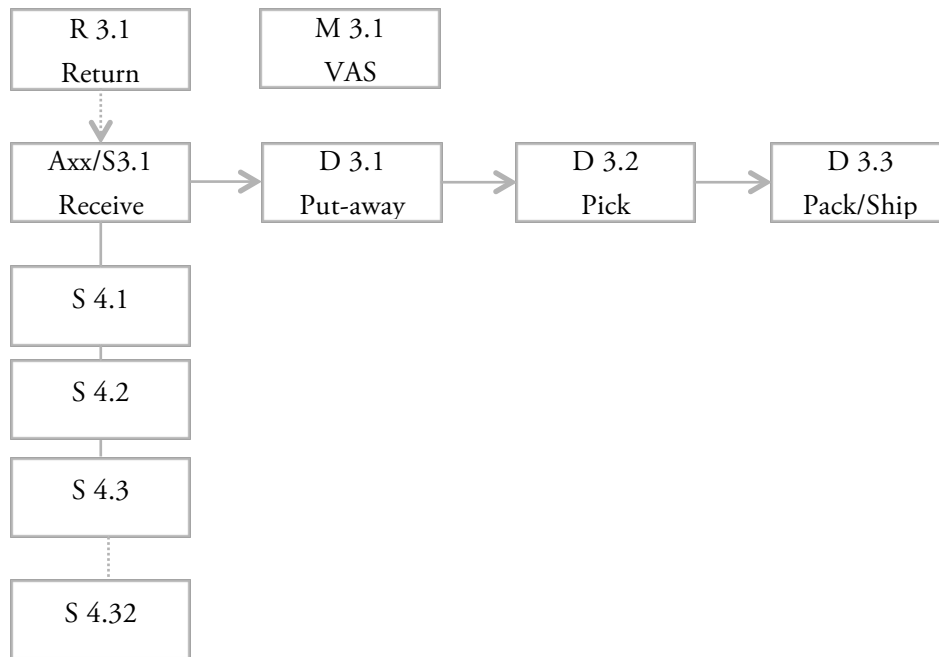
Source: Verify Product - *The process and actions required determining product conformance to requirements and criteria.*

In the profile document the processes related to receiving and storing are composed of 32 different activities. These are company specific activities documented by Consafe Logistics to be able to correctly set up the WMS. Because they are company specific they can be seen as level 4 SCOR processes, not included in the SCOR model's scope, but with the possibility to aggregate to level 3.

4. Create workflow with these SCOR processes

To illustrate this procedure a thread diagram (Figure 16) has been developed. SCOR recommends this model that could highlight certain information such as people and system interaction issues.

The denotations and numbers in the model should help understand from where in the activity profiling the processes have been gathered and how the warehouse processes model have been used to relate the activities to the correct SCOR process and level.



S = Source process D = Deliver process M = Make process R = Return process

Figure 16 An example of a decomposed Process Model

5. Add description to workflows to reflect inputs/outputs of the processes

To further investigate if the workflow, which can be seen as level 4, could be aligned towards SCOR, metrics from the previous found level 3 processes was extracted from the SCOR document.

The SCOR model proposes the following metrics.

Level 3: Receive Product:

RL3.20. % Orders/ Lines Received On-Time To Demand Requirement

RL 3.22. % Orders/ lines received with correct packaging

RL3.23. % Orders/ Lines Received with Correct Shipping Documents

Level 3: Verify Product:

RL.3.19. % Orders/ Lines Received Defect Free

RL.3.21. % Orders/ lines received with correct content

RL.3.24. % Orders/lines received damage free

As exemplified in Figure 17 below, these metrics are level 3 based measurements that can be aggregated first to level 2 metric (Perfect condition) and then towards the level 1 metric (Perfect order fulfillment).

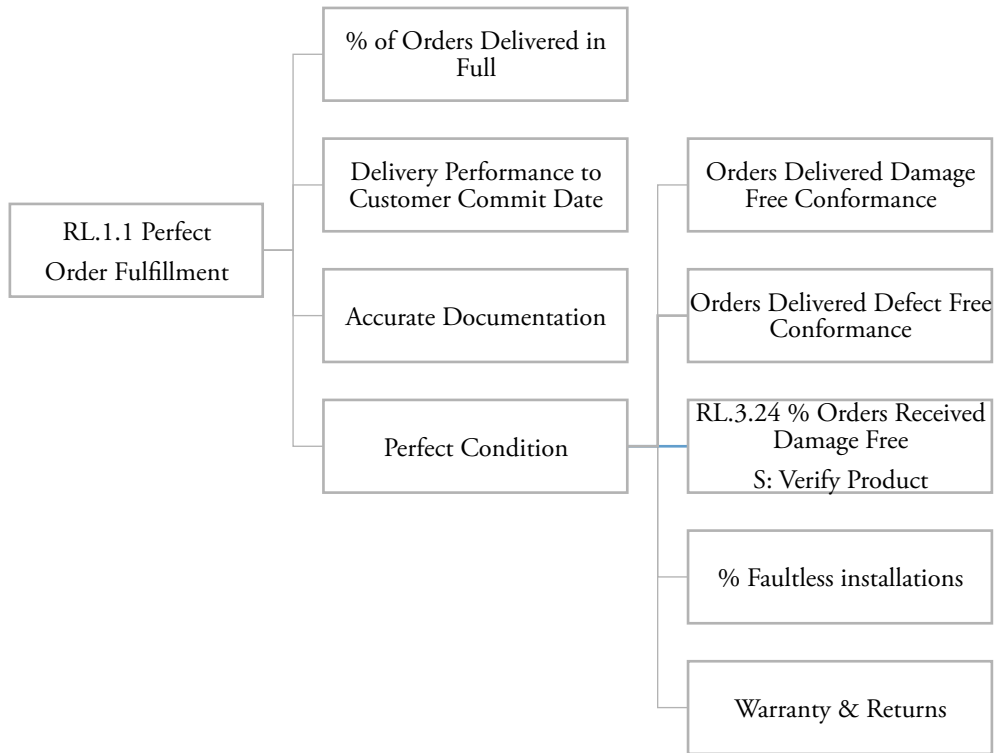


Figure 17 An example of a SCOR metric structure

6. Optionally add other relevant information

No further relevant information was found in this example.

It's important to critically analyze the new model and highlight concerns that any organizational change could lead to. Strengths and weaknesses with the new process model will therefore be discussed in the next section.

Effectiveness – Doing the right things

The SCOR models purpose is to improve effectiveness and efficiency in supply chains internationally and cross-industries, consequently this will be analyzed. The question to be asked is thus can this new model based on SCOR help companies do the right things and in the right way.

Criticism against SCOR has implied that the model is too focused on operational measurements and doesn't support long-term strategies.

“A weakness of the SCOR model is arguably that it mainly focuses on processes and efficiency but not on strategy. For that reason, firms that invest in implementing the SCOR model may not use it effectively, mainly because managers have difficulty relating it to SC strategies.” (Tang 2007)

SCOR doesn't clearly provide suggestions on what strategies that should be followed for certain supply chains, e.g. the supply chain of a food organization, neither on what metrics to have as KPIs. Picking a set of metrics and choosing what the “to be” state is also completely up to companies themselves. This can leave companies with a set of KPIs that are measuring processes that are not really important for them. This may be a risk, if a company for example benchmark on Cost, but have a much more flexible supply chain than most, the results will surely be misleading. This could lead to inappropriate use of resources and misdirected investments. This flaw in the SCOR model stresses management to make the right decisions for their supply chains.

If a company would like to increase effectiveness it's important to have a clear strategy to follow that suits the supply chain and the strategy must be very well communicated throughout the company. Even though the SCOR model won't do this work for organizations it can however be of great support, since once the organization decides upon what supply chain strategy to focus on, SCOR attributes reflect what metrics and thereby also what processes to focus on. By using the standardized structure and definitions in this new model people could arguably embrace the changes faster.

Efficiency – Doing the right things right

Mentioned before was that the SCOR model focuses on processes and efficiency, so surely the new model must help increase the operational performance within a warehouse? It's not always that simple of course, what was found in the research is that the availability of data is according to Consafe Logistics customer's quite low. To invest in latest technology and implementing systems used by large corporations without first having processes that provides good information and material flows will only enable operators to do things badly, faster.

Gartner also states that to be able to increase performance a company must first underpin what's causing the current measuring issues. "If the improvement gene is missing or weak no investment in faster, better or richer business intelligence, analytics or performance measurement applications and technology will yield breakthrough results". (Gartner, 2014) Rather in investing in new systems a company must understand the culture and build appropriate strategies to allow investments where the benefits will be direct. Many of the smaller companies should therefore rather focus on structuring their processes and improving consistency in their measuring efforts. One must not forget however that SCOR has a great support for practices within supply chain management that can really help improve processes and establish best practices.

The situation arguably looks different for Consafe Logistics customers. Consafe Logistics always inspect the company's processes and implements best practices. They also install certain measurement points and log all performance data. For companies that have reached this maturity level a PMS that offers them to benchmark against others and support improvements can be very beneficial.

Continuous improvements

Both processes and performance measurement systems rely on continuous improvements to really be successful. If performance systems never are criticized or up for evaluation it's easy that a measurement sticks in the organization long after a changed strategy came to place or the process gone through a BPR. This will reduce the value of the performance system and the possibilities to control of the supply chain will be weakened.

SCOR is better than most PMS in this aspect, maybe it's because practitioners developed it or maybe because the SCC supports it with continuous up-dates and training sessions. No matter which SCOR is really helpful when diagnosing a supply chain and it offers practices to improve in all areas, it's however up to management to choose where the investments should be focused. The new model developed in this study can also be seen as more flexible than a common PMS. Because the foundation is built on warehouse activities (processes) managers will be able to communicate changes and update the system when a process is changed.

Change management - not doing it without a WHY

A topic that should always be mentioned when discussing extensive change is how to support the organization throughout the process, it's known as change management. There are many examples involving the deployment of systems designed for solving functional and technical problems that have failed due to those organizations have been inconsiderate towards the issues that evolves during the adaptation procedures. (Grant, 2003)

The need for change management has been accelerating, mainly due to the change in information technology. Processes that were handled manually before are today automated and the information are stored in data warehouses. Everything changes faster and it's harder to overview the processes involved.

There are extensive studies on project management and the implementation of change management. They often offer advice on techniques and practices to use, hence the topic won't be discussed further the most important to remember is that any implementation that changes an organization on this altitude requires a strong change management strategy.

5.4 Summary & Conclusions of the analysis

RQ1

The analysis summarized metric-categories used by the customers according warehouse activities. It showed that a lot of customers use metrics in essentially outbound and storage. Therefore this could be included in a potential PMS. Inbound metrics weren't expressed by customers to be as important, however since quality metrics had a quite high percentage, it's believed that such metrics could be grasped by the quality inspections normally used in receiving. And when consideration is taken to that 25% of the cost is represented by inbound tasks (according to Bartholdi & Hackman), it's believed that these categories should be included in a PMS as well. Returns weren't either expressed by customers to be valuable, however with the increase of e-commerce sales, and that it might increase future selling capabilities for Consafe Logistics, this will also be looked into. In regards to the other additional metric-categories, it's believed that an inclusion of them in a SCOR PMS could be hard due to their specific level of detail.

RQ2

Gartner suggest that metrics should be standardized in the organization however not all supply chains can be controlled with the same set of metrics. All organizations must find their market area(s) where they want to be competitive and chose operations strategy after this area, which for example SCOR attributes can reflect. If this study would select a general set of metrics for every customer's strategy to follow, it would be contra productive.

"The SCOR model endorses 13 performance metrics. A company cannot be best in all 13 of the Level 1 metrics, so it should wisely target its strength in several, those by which it differentiates itself in the market, while ensuring that it stays competitive in the others." (Huang et. al 2006)

The conclusions are that the metrics used in warehouses today are best applicable to SCOR processes. The new warehouse performance system should therefore be structured based on a process model. To ensure that all customers no matter industry, country or strategy can use the model, a pre-determined set of metrics shouldn't be included in the solution, the process model and a

description on how to assemble company specific metrics should be the final outcome.

RQ3

A design and an example of how the new model for warehouse performance measurements were constructed in this section. It is believed that the model built based on both theoretical and practical input can be very helpful in the implementation phase when a WMS is introduced. The model is designed to fit common warehouse layouts and processes, the different main sections are paired to level 3 processes from the SCOR model. More detailed process descriptions can be defined in a thread diagram and aggregated towards SCOR. That would offer the model the opportunity to provide a set of metrics that includes standard definitions and calculations. According to this research the main benefit with the new model is that it would offer a complete solution, and that companies don't have to spend time on reinventing processes, metrics and metric calculations.

Surprisingly none of the interviewees mentioned improved performance as the most important reason for implementing the SCOR model. The main reason for this might be that the companies have already had other measurement systems in place, but in a change towards becoming more standardized throughout the organization have chosen this recognized model. The fact that the model allows supply chain partners to communicate better by providing standardized definitions for processes, process elements, and metrics (Tang, 2012) is possibly the main benefit, not improved performance. To facilitate the model companies should however always remember to work with continuous improvements, change management and to establish a correct warehouse profile.

6 CONCLUSIONS

In this chapter the constructed performance measurement system that was derived in the analysis is displayed. The other sections concern topics that reflect back on the entire study. The final sections include discussions regarding the result and if it can be linked back towards the purpose and the research issue. If the result is generalizable as well as suggestions for further work and research are also included in this chapter.

6.1 The warehouse performance system

Consafe Logistics customers are typically companies that distribute large volumes of goods and products through their warehouses, therefore they also find warehouse logistics as an opportunity to create competitive advantages. To be able to reach these advantages, the customers must come up with strategies that enable managers to focus efforts on what's most important to their organization, which is of course very individual due to the diversity of products and how the company want to differentiate. Consafe Logistics customers have become more and more aware that they need better performance measurement systems to be able to set these performance goals, and they also demand more visibility and opportunities to follow up on their WMS-services. Consafe Logistics would therefore like to offer a performance measurement solution that is international, easy to communicate and that works between different industries.

This research was to investigate if a standardized performance measurement model based on the SCOR model could be developed and used by Consafe Logistics customers. Both a theoretical and empirical research was needed to conduct this study. Three areas of related literature was investigated and the knowledge was used to construct a survey that should answer what types of metrics that are used by Consafe Logistics' customers today and if the metrics could be translated to SCOR definitions. What was found was that metrics used in warehouses today are only partially (61 %) translatable to the SCOR model, however warehouse activities are more cohesive (90 %). The conclusion was that the new system should be based on a process model. If Consafe Logistics could outline all activities using the new model each company could align their processes to the new model and it could offer the possibility to align a set of metrics using the SCOR model documentation.

A warehouse-focused process model was hence developed in this study, it was shaped during a solution-oriented workshop together with Lars Magnusson a SCOR expert and SCC board member. The model should work as support to match warehouse activities against correct SCOR processes. This enables SCOR to provide a set of metrics suited for each supply chain, however the company must select performance attributes themselves to align the set of

metrics towards their strategy. If the new model is used and companies chooses to align goals based by the appearance of their supply chain and vision they could better diagnose their operations performance and if many entities in a supply chain uses the SCOR model a more holistic perspective throughout the supply chain could be achieved and increased benefits to the end customer could follow.

The process model

In order to capture all possible activities within a warehouse, the following model, illustrated in Figure 18 has been constructed. The model is divided into common warehouse areas and should enable the recognition of the execution processes Source (S), Make (M) and Deliver (D). The value-adding service (VAS) area is complementary to fit organizations with additional activities such as: Assembly, Changing from pallet to store display or Repairs. The activities that can be aligned to SCOR Level 3 processes are extracted from renowned warehouse theory and validated by practitioners.

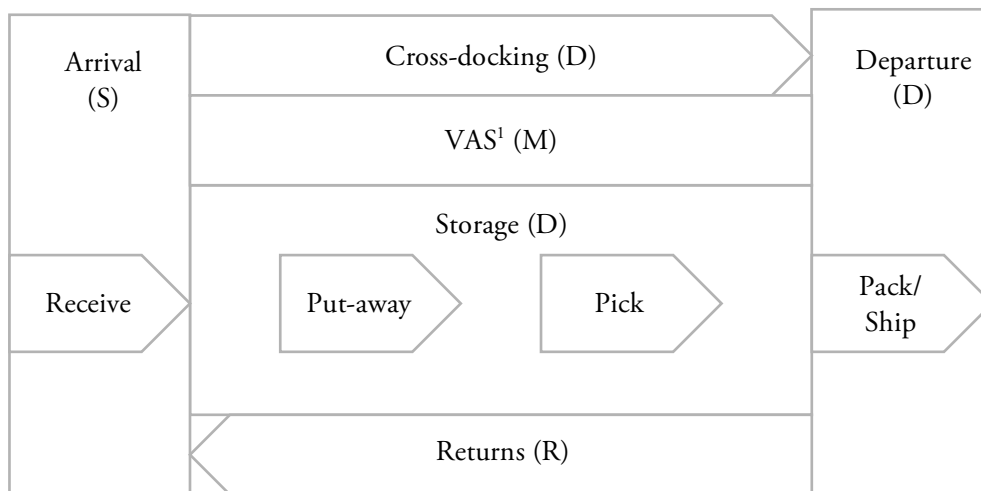


Figure 18 The Warehouse Process Model

When all activities have been documented and matched towards a SCOR level 3 processes they can be further described in company specific level 4 and 5 processes. The more detailed work descriptions makes it possible to together aggregate to a level 3 process that has corresponding metrics in SCOR.

The following thread diagram, Figure 19, shows a possible Level 4 solution where e.g. S 4.1 means a level 4 process for Source – arrival.

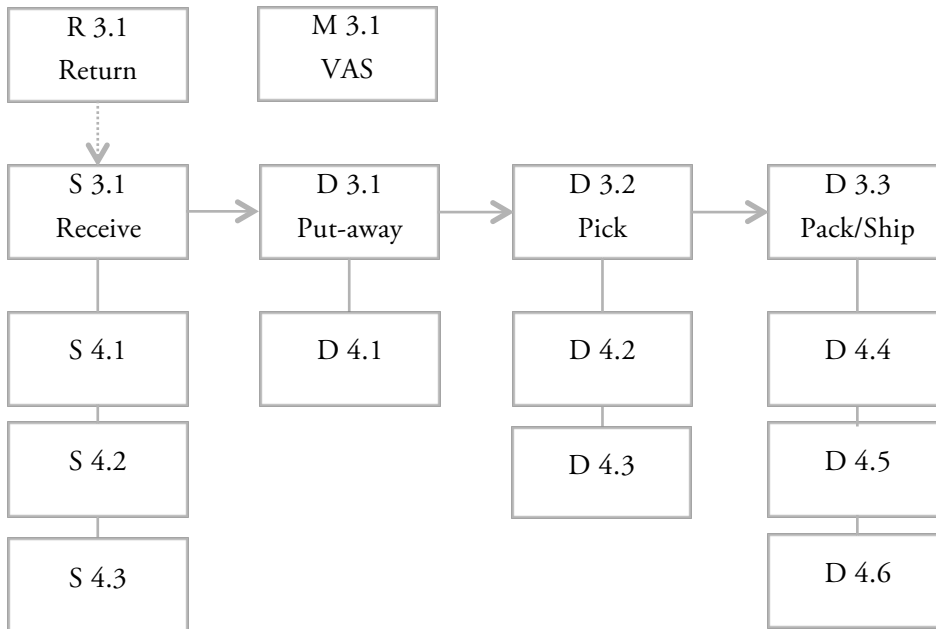


Figure 19 The decomposed process model

6.2 Warehouse performance metrics

Because metrics should be aligned to an organizations' strategy a recommended set of metrics for warehouses will not be presented in the result. Instead a guide for finding metrics aligned to the SCOR model was developed.

To be able to offer customers to take part off the SCOR model some steps have to be followed in the implementation phase.

1. Map and define processes, material and data flows according to the warehouse process model
2. Select which performance attributes to focus on
3. Profile and measure current performance
4. Establish performance targets
5. Identify opportunities in SCOR, enable best practices
6. Continuously improve processes and the performance system

6.3 Further recommendations

For Consafe Logistics the work can finally begin, the study have verified that the SCOR model is the right way to go when updating performance measurement systems for companies within the warehouse industry. Instead of trying to fit a set of metrics to every customer they can instead offer a customized measurement system with little additional work. When Consafe Logistics performs the process profiling at new customers they can now make use of the warehouse process model developed in this study to align processes towards the SCOR model. Consafe Logistics can by doing so use the SCOR document based on these processes as well as attributes to create a set of metrics for these processes and overall warehouse performance.

What Consafe Logistics must do in short term to make this happen is to look through what they currently measure in their WMS and translate these measurements into SCOR metrics. Many of the current metrics might be alternatives to what's provided by the SCOR model, which also this thesis verified, and then they'll have to consider whether to change to the SCOR model's way to calculate the metric, which is probably preferred.

In long term Consafe Logistics can hopefully use this study as a first stepping-stone towards a deeper knowledge about the SCOR model. That would enable them to enhance their expertise and cover more areas in the supply chain. Today Consafe Logistics are focusing on supply chain execution with further understanding about more strategic initiatives such as the SCOR model Consafe could also help customers improve the planning and management of the supply chain.

Further studies

Further work closely regarded to this study could be looking into and help Consafe Logistics translate their current warehouse performance metrics that are accessible through the WMS into SCOR metrics. This would be hard to perform in a thesis due to lack of contribution to academia but an internship or project course would suit this task perfectly.

When looking into the trends of performance measurements and warehouse management its clear that there are many areas that could be interesting for further studies. The linkage between WMS and other neighboring material

flow systems such as transport management systems or vendor managed inventory systems would certainly be valuable for improved supply chain efficiency, which also was reflected about in the analysis in terms of what happens after the orders have been shipped. A TMS or VMI project could investigate such considerations. Also how WMS can take part of the consumerization trend is believed to have great impact on how well WMS vendors will succeed in the always-toughening market and would therefore be an interesting area for investigation.

6.4 Consistency towards the purpose

The purpose was to develop a performance measurement system for warehouse activities based on the SCOR model. The SCOR model offers a complete solution for supply chain performance measurement, the results from this study however do not include planning and management processes (enable), which SCOR also covers, focus has been on operational efficiency. This delimitation has been made due to the fact that the data Consafe Logistics will have access to is limited to the information the Astro WMS can offer. This means that the solution will not provide a full SCOR performance measurement system.

If one thinks of performance measurement systems as a set of metrics this solution will neither be complete. The SCOR model does consist out of a process model and a set of metrics, one set of metrics can however never satisfy every different supply chain so to be able to maintain a general solution, a process model where every warehouse activity can be mapped has been developed. The SCOR model can then provide a set of metrics that suits a certain industry or strategy.

To summarize, this study have reached its purpose to develop a performance measurement system based on SCOR, the system is however focused on the operational tasks within warehousing. If Consafe Logistics implements the warehouse process model in their company profiling, a relevant set of metrics can easily be achieved for each new customer. In this way Consafe Logistics would save a lot of resources in trying to figure out what the clients want to measure.

6.5 Review of the approach and the research questions

In the early phase of a research it's important to figure out the purpose and the means on how to get there, it is common knowledge that this phase can't be stressed. To take in many different perspectives and really listen to the people the solution should benefit is crucial.

In this study the expected audience were from both academia and the company Consafe Logistics. To find a balance between extending current research on the SCOR model and creating a solution that offers possible business advantages for the Consafe Logistics has been an inspiring challenge. The situation analysis together with early notices from the University helped set and keep the study on course and the objectives was hence reached. Any research must also make delimitations and considerations regarding available resources, in this study time was a constraint and interesting areas was therefore sometimes left out, more information regarding this can be found in 1.4 *Research focus and delimitations*.

Which areas of related literature to study was also made clear early in the project after the research questions was set, the knowledge that was required to gather adequate empirical data was identified. A possible weakness however was that the case company choose to direct focus on one endorsed system rather than comparing different ones. This was proven not to be a problem because the SCOR model is widely renowned and de facto standard for modern supply chain measurement projects.

The pre-study offered possibilities to understand how warehousing is done in practice, i.e. what processes are the most important and how performance measurement are used to control the data and material flows. To analyze this type of open interviews are however difficult, it might therefore be hard to follow a read thread through this chapter. Hopefully it's clearer how the pre-study helped achieve the final result.

To answer the research questions however a broad investigation had to be made, the web-based survey ensured that a general solution could be accomplished however the response rate was 17.4 %, thus the generalizability needs to be questioned.

The first research question was possibly the most straightforward but at the same time the most extensive in terms of analysis. A survey was sent to all Consafe Logistics customers to be able to collect as much information about measurements in warehouse environment as possible. The fact that metrics are very unstandardized made the analysis quite time consuming and with the rather low response rate one can argue the effectiveness with this approach.

The fact that the final outcome is based mainly on a process model makes it possible that the solution would have looked the same even if the survey weren't carried out. If the time consumption are compared to how much valuable information was found, this research probably was not the most efficient to reach its purpose. However, because only one PMS was investigated it was crucial to know if it can be applied in warehouse environments, which the survey verified. It is also believed that the information attained is very important for Consafe Logistics future work towards a complete SCOR based performance measurement system offering for their different customers.

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APPENDICES

In Appendix 1, data from the web-based survey is presented. It starts with response rate, followed by introduction questions where e.g. respondents' most important metrics are presented. Thereafter, metrics linked to Bartholdi & Hackman's warehouse activities/processes as well as questions about performance measurement in general are presented. In the rating questions, 1 means not relevant, 4 means uncertain and 7 indicates that it is very relevant. Appendix 2 is an Email letter that accompanied the web-based survey

Appendix 1 The web based survey

*C. Question means that a question was closed; O. Question means that it was an open question.*C. Question means e.g. that this closed question was mandatory. The first question was also summarized according to content analysis; see Chapter 2.4.2 Analysis methods for further reading.*

Response rate

The survey was distributed to 447 of Consafe Logistics customers and there were roughly 17.4 % respondents as can be seen in Table 1. Unfortunately, 56 of those 447 recipients were no longer reachable, which makes it come down to 391 usable recipients.

Table 1 Overview of the web-based survey

The table also illustrates that there were 68 respondents. Several of them answered partially on the questions, and the drops were quite heavily in regards to the questions that weren't mandatory. The partial responses as well as the overall response rate of 17,4% is something thing that should be kept in mind concerning the generalization of the responses. Chart 1, below illustrates number of respondents as well as number of metrics for the opened-ended questions.

	Recipients	Not Reachable	Actual Recipients	Respondents	Percentage
Total	447	-	391	68	17,4%

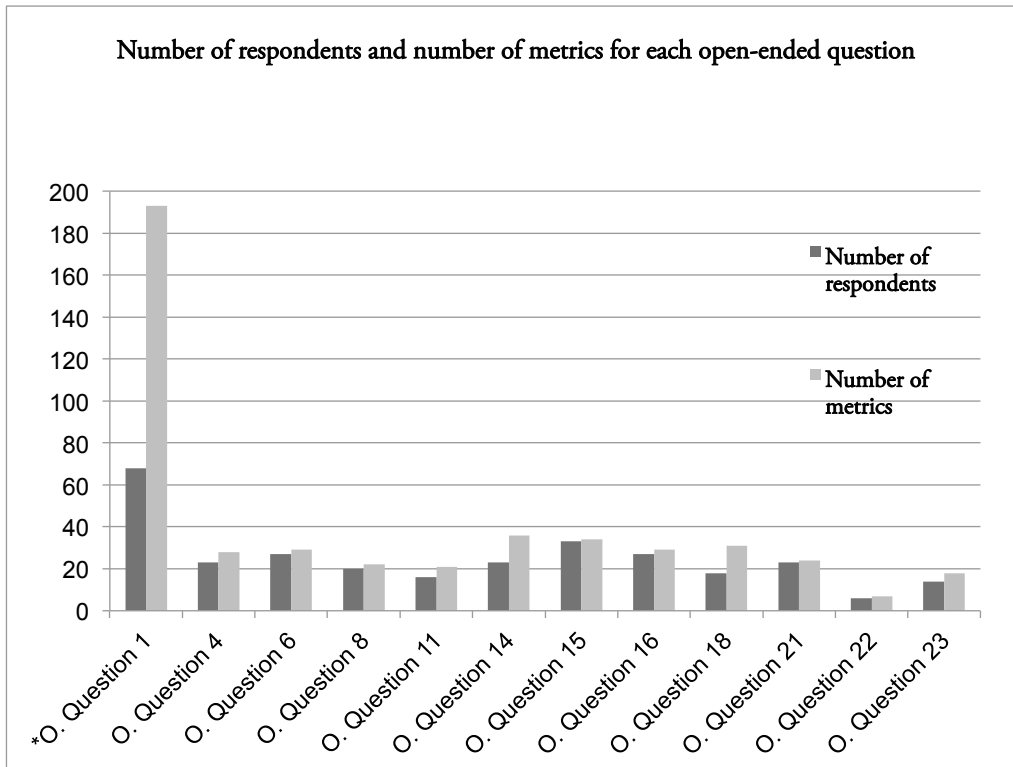


Chart 1 Distribution of respondents' answers

* Means that it was mandatory

Introduction questions

The introduction question caught what metrics the respondents perceive as their most important metrics as well as if performance measurement is important for them.

*O. Question 1. In your warehouse, what are the most important metrics for warehouse performance measurement?

With all respondents' contribution of their most important metrics, the survey ended up with about 200 answers, and almost all were different in their definition. Some of the answers couldn't either be classified as metrics, e.g. "Hi" or "asdf". Table 2, shows the metrics after content analysis was performed.

Table 2 Categorization of the respondents' metrics

	% of customers that use metrics in this category	Number of metrics	Share of all metrics
Metric-category:	%	#	%
Inbound metrics	8%	12	6%
- Receiving metrics	13%	10	5%
- Put-away & replenishment metrics	3%	2	1%
Storage metrics	22%	20	10%
Outbound metrics	33%	73	38%
- Picking metrics	60%	47	24%
- Packing metrics	7%	5	3%
- Shipping, loading & delivery metrics	33%	21	11%
Return metrics	1%	1	0.5%
Failure metrics	14%	16	8%
- Damages metrics	8%	7	4%
- Quality metrics	10%	9	5%
Customer complaint metrics	3%	2	1%
Safety & illness metrics	3%	3	2%
Overall metrics	16%	66	34%
- Labor metrics	19%	14	7%
- Lead time metrics	6%	4	2%
- Productivity metrics	19%	15	8%
- Other overall metrics	21%	33	17%
Total	-	193	100%

As can be seen, the respondents seem to use metrics in both inbound, outbound and storage activities. 33% found that outbound metrics were most important, 8% found that inbound metrics were most important and 22% answered that storage metrics were most important. Additional categorizations that were found were Failure, customer complaints safety & illness as well as overall metrics. Fewest found that return metrics were important.

It can also be seen that picking metrics were the most representable among outbound metrics, and out of Other metrics, overall metrics were most representable. Below follows two examples commonly mentioned metrics.

Metrics (example)

- “Picking order lines per hour” (Outbound metrics)
- “Full pallet productivity - how many cubic meter do we move in the warehouse every worked hour” (Productivity metrics)

C. Question 2. In this question, the authors wanted to grasp how important performance measurement was to the respondents. The result is presented in Chart 2.

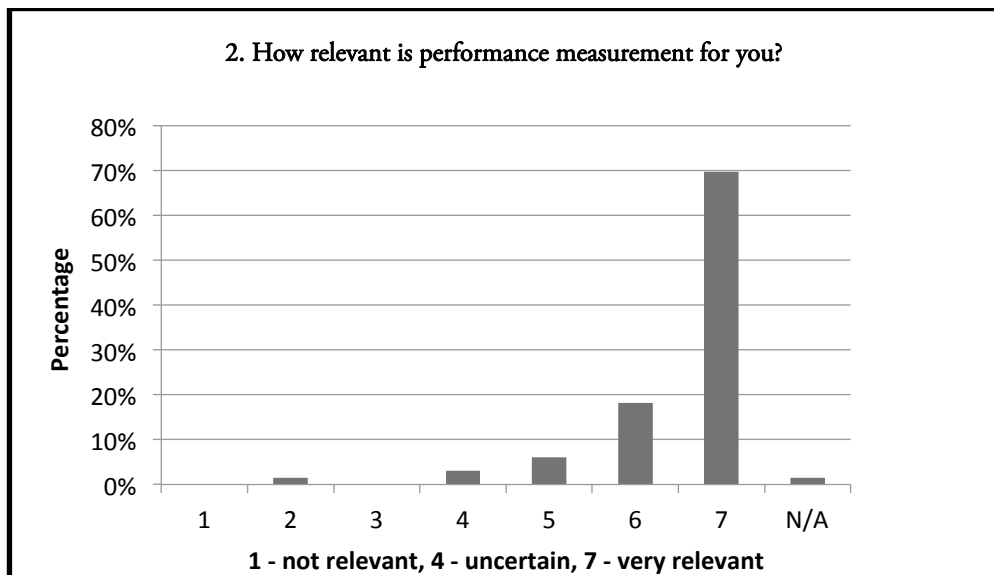


Chart 2 Distribution of responses regarding performance measurement

70 % of the respondents found performance measurement very relevant and 0% as not relevant. However, there was one respondent who didn't think that performance measurement was that important, and there was one who answered not applicable as can be seen in Chart 2.

Receiving

*C. Question 3. Table 3, shows what metrics that were considered as high or low priorities for the respondents related to receiving. The table shows that 81 % measure *if received orders have defects or damages*, 80 % measure *orders that are received with correct article(s)* and 75 % measure *orders that are received in correct quantities*. 63 % and 59 % found that *if orders are received on time* and *if received orders have correct documentation*, respectively, to be least important.

Table 3 Metrics related to receiving

3. In terms of receiving, do you measure:			
	Yes	No	N/A
Orders that are received in correct quantities?	75%	20.3%	4.7%
Orders that are received with correct article(s)?	79.7%	15.6%	4.7%
If orders are received on time?	62.5%	31.2%	6.2%
If received orders have defects or damages?	81.2%	12.5%	6.2%
If received orders have correct documentation?	59.4%	28.1%	12.5%

The table also shows that almost 13 % found the measurement *if received orders have correct documentation* as N/A on their operation(s).

O. Question 4. Do you use other metric(s) related to receiving, which haven't been addressed in the above questions?

Other measurements that were considered to be of value were related to quality checks and time. The respondents were all different in their definition of what to measure and not too many real metrics were mentioned. Below some examples are summarized.

Metrics (examples)

- “Express orders put on stock in less than 2 hours”
- “KPIs in order to calculate total time spent to palletize, strap and move the pallets into the racks”
- “Share of bad package”
- “Remaining shelf life of products”

Put-away

*C. Question 5. Table 4, illustrates metrics related to put-away, which shows that 65 % paid attention to *how many full pallets that are handled* and 40 % measures *how many less-than-full pallets that are handled*. 63 % didn't find *time delay, starting when a truck is available for unloading, to when the put-away starts* to be important.

Table 4 Metrics related to put-away

5. In terms of put-away, do you measure:			
	Yes	No	N/A
How many full pallets that are handled?	64.9%	33.3%	1.8%
How many less-than-full pallets that are handled?	40.4%	56.1%	3.5%
Time delay, starting when a truck is available for unloading, to when the put-away starts?	29.8%	63.2%	7.0%

O. Questions 6. In terms of put-away, do you measure if SKUs are stored in the wrong location, if yes, how?

The most representable measurement is that the respondents perform audits in different ways. An example is one who stated "free location audits and cycle counts, and track misplaced pallets to the co-worker" is performed. Another respondent specified that an operational responsible perform audits. Some examples of metrics the respondents perform are shown below.

Metrics (examples):

- "Inventory deviation: (rolling 12 months Gross value of inventory differences divided by average stock value for the last 12 months) * 100"
- "Number of wrong placed pallets divided by total number of pallets handled in put-away"

C. Question 7. In regards to cost and time in put-away, 73 % found time to be important and 30 % cost while 23 % couldn't tell.

Table 5 Cost and Time related to put-away (respondents should pick all applicable)

7. In terms of put-away, do you measure:	
	Percentage
Cost?	30,40%
Time?	73,20%
N/A	23,20%

O. Question 8. Do you use other metric(s) related to put-away activities, which haven't been addressed in the above questions?

Two major metrics are mentioned as other metrics related to put-away. These silo rejection rate and miss-placed pallet metrics.

Metrics (examples):

- Silo rejection rate
- % of pallets placed in inconvenient locations

Storing and replenishing

*C. Question 9. In Table 9 it can be seen that most of the respondents, 85 %, measures *inventory accuracy* and 76 % measure *damaged inventory* while only one third measure *if the correct quantity is replenished*. 39 % measure *if correct SKUs are replenished*. There are nearly 69 % that measure *stock turnover*.

Table 6 Metrics related to storage and replenishment

9. In terms of storing and replenishing, do you measure:			
	Yes	No	N/A
How many times the inventory turns? (i.e. stock turnover)	68.5%	25.9%	5.6%
The number of days of supply?	55.6%	35.2%	9.3%
Damaged inventory?	75.9%	18.5%	5.6%
Inventory accuracy? (if the actual inventory differs from reported/logged inventory)	85.2%	11.1%	3.7%
Number of replenishments per time unit? (e.g. hour, day week)	51.9%	38.9%	9.3%
How many full pallets that are replenished?	53.7%	38.9%	7.4%
How many less-than full pallets that are replenished?	27.8%	64.8%	7.4%
Number of replenishments per person and hour?	55.6%	38.9%	5.6%
If correct quantity is replenished?	33.3%	61.1%	5.6%
If correct SKUs are replenished?	38.9%	51.9%	9.3%

C. Question 10. Many of the respondents measure # *occupied locations*, 87 %, and nearly half, 43 %, pays attention to *volume utilization* as well which all are shown in Table 10.

Table 7 Utilization of storage

10. In terms of storage utilization, do you measure:	
	Percentage
# occupied locations?	86,80%
volume utilization (including locations' volume) ?	43,40%
N/A	3,80%

O. Question 11. Do you use other metric(s) related to storing and replenishing, which haven't been addressed in the above questions?

The best linkage of other storage and replenishment measurements is connected to when a location in the warehouse is “free” or “occupied/blocked” by another SKU. Fill rate is also mentioned as one metric that is used.

Metrics (examples)

- Number of locations in the warehouse that are “free” or occupied/blocked by other SKUs
- Fill rate

Picking

*C. Question 12. As illustrated by the responses in Table 8, *picks per person and time unit* is considered the most important measurement when it comes to picking where 85 % use this metric. It’s however less common to measure *the availability of SKUs when picking*, 55 % does not use this metric. Regarding picking errors, there are 77 % that keep track on the number of *incorrect picks in terms of quantity*, and 59 % of *incorrect picks in terms of SKUs*.

Table 8 Metrics related to picking

12. In terms of picking, do you measure:			
	Yes	No	N/A
Picks per person and time unit?	84.9%	11.3%	3.8%
Incorrect picks in terms of quantity	77.4%	18.9%	3.8%
Incorrect picks in terms of correct SKU(s)	58.5%	32.1%	9.4%
The availability of SKUs when picking? (i.e. how many times SKUs are missing at a picking location?)	41.5%	54.7%	3.8%

C. Question 13. Table 9 illustrates that time is more common to measure with its 83 % compared to cost and its 42 %.

Table 9 Cost and Time related to picking (respondents should chose all applicable)

13. In terms of picking, do you measure:	
	Percentage
Cost?	42,30%
Time?	82,70%
N/A	13,50%

O. Question 14. **Do you use other metric(s) related to picking, which** haven't been addressed in the above questions?

Additional picking metrics are linked to number of picks (often order lines) per time unit or per segment. Also incorrect picks in different manners are mentioned. Some mentioned metrics connected to weigh and volume as well.

Metrics (examples)

- Number of picks (order lines) per time unit, area or segment.
- Incorrect picks in different manner
- Weight and volume metrics, e.g. Total weight picked per person

Packing, shipping and transports

O. Question 15. In terms of shipping and transportation, do you measure: service level?

Most claim that service level is measured (even though the definition differs widely). Furthermost measures service level according to the percentage of orders that have been shipped or delivered, e.g. “number shipped order lines divided by number of ordered lines”.

O. Question 16. In terms of shipping, do you measure: fill rate? (If yes, please define and explain how this is performed.)

Unfortunately, people misunderstood this question as most of the respondents measure fill rate as volume in trailer, container or truck (as in *shipment load utilization* presented in Question 17) instead of "fraction of demand that is satisfied by stock on hand", which is defined by Axsäter (2007) in his book *Inventory Control*.

*C. Question 17. In the outbound flow, a common metric to use is *if orders are shipped on time*, which Table 10 illustrates with 92 %, but as can be seen there are however less common to measure *shipment load utilization*, which is shown by its 59 %. Documentation accuracy is only measured by 43 %.

Table 10 Metrics related to pack, ship and transport

17. In terms of packing, shipping and transporting, do you measure:			
	Yes	No	N/A
Shipping documentation accuracy?	42.9%	51%	6.1%
If orders are shipped on time?	91.8%	6.1%	2%
Shipment load utilization? (i.e. if the number of possible orders are maximized for transport)	28.6%	59.2%	12.2%

O. Question 18. Do you use other metric(s) related to packing, shipping and transportation, which haven't been addressed in the above questions?

Most respondents found damages as the most important measurement, apart from the metrics presented in Question 17. Truck loading time as well as lead-time are also considered vital.

Metrics

- Different measures for damages
- Truck loading time
- Lead time

Returns

*C. Question 19. In regards to returning, 65 % percent reported that *the number of returns* is measured and as little as 18 % stated that *the number of returns within warranty time* is used as can be seen in Table 11.

Table 11 Metrics related to returns

19. In terms of returning, do you measure:			
	Yes	No	N/A
The number of returns?	65.3%	28.6%	6.1%
The number of returns within warranty time?	18.4%	73.5%	8.2%

C. Question 20. As Table 12 illustrates, 40 % do not find cost and time as applicable to their operations although 49 % measure cost and 40 % measure time.

Table 4 Cost and Time related returns (respondents should chose all applicable)

20. In terms of returning, do you measure:	
	Percentage
Cost?	48,9%
Time?	40,0%
N/A	40,0%

O. Question 21. Do you measure/document the reason for a return, if yes, how?

The majority documents the reason for a return. Some use some sort of claim. And some simply answered “yes”. One respondent’s answered “I think this is described in the system. It's no information that we seek in logistics.” Or “The sales unit is deciding what is coming back to the warehouse.”

O. Question 22. Do you use other metric(s) related to returns, which haven't been addressed in the above questions? **General**

Very few answered this question (7 answers). One of the few respondents mentioned “Lead time from return request until the goods are put back in stock”.

O. Question 23. Is there anything else you consider to be important in the context of metrics?

No direct classification could be found here either, but among the answers were e.g. “sickness rate”, “season turnover”, “overall result that can say how the warehouse process is working”, “safety” and security”, “back-orders”, “% of downtime in an automated warehouse and energy consumption”.

There were some answers which were connected to Astro WMS, e.g. ”very important to be able to calculate full pallet productivity using Astro times in a relevant way” and “interest is to evaluate as much as possible directly with WMS support to avoid manual handling”.

General questions

C. Question 24. Not unexpectedly, the most important function according to the respondents is warehouse operations (98%), which is found to be very important or almost very important, followed by Transportation (67%), which Table 13 illustrates. Service is also considered quite important to the respondents but sales/marketing (32%) and manufacturing (23%) aren't considered as the main functions. Manufacturing is also the one with lowest score.

Table 13 The importance of different functions

24. How important are the following functions to your organization?								
	1	2	3	4	5	6	7	N/A
Sales / Marketing	0%	4%	4%	9%	11%	23%	32%	17%
Service	0%	0%	0%	6%	6%	21%	58%	8%
Procurement & purchasing	0%	4%	0%	17%	15%	23%	35%	6%
Manufacturing	10%	10%	2%	13%	2%	13%	23%	27%
Warehouse operations	0%	0%	0%	0%	0%	16%	82%	2%
Transportations	0%	0%	0%	0%	4%	25%	67%	4%
Finance & Human resources	0%	2%	4%	8%	19%	17%	44%	6%

The table also illustrates that manufacturing, procurement as well as finance & H&R sometimes are considered to have very little importance.

C. Question 25. How would you define your warehouse?

Nearly 40% of the respondents are represented by retail distribution centers, followed by 15% warehouse linked to production. 12 % were characterized by 3PL warehouses or as a service part distribution center.

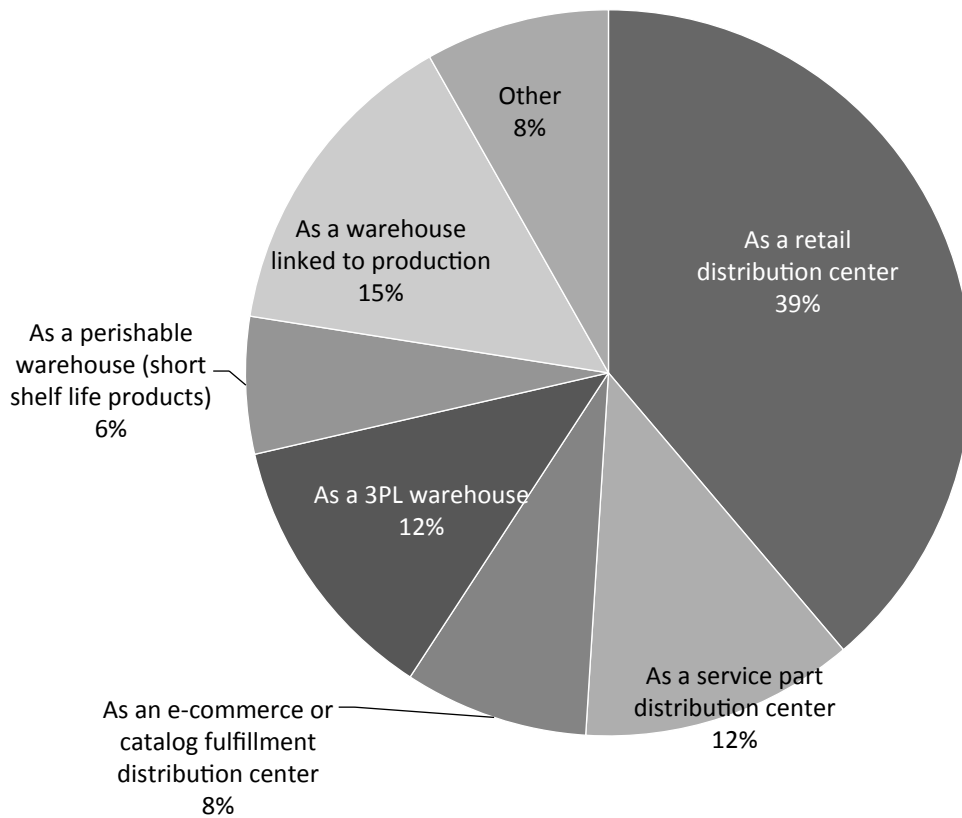


Chart 3 How do you define your warehouse?

C. Question 26. Choose the option that best corresponds to your business' area of service:

The respondents' locations are widely spread as indicated by Chart x. 35% are operating in a single country and 31 % are global.

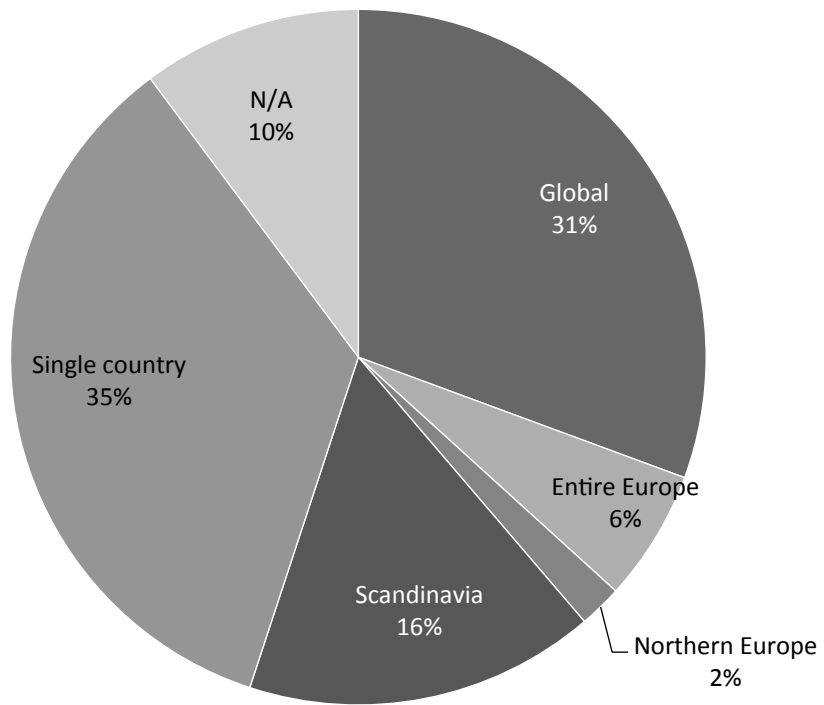


Chart 4 Business of service (location)

C. Question 27. How many numbers of employees are running your warehouse operations?

As Chart 5 indicates, about 50% of the respondents have more than 100 employees that operate their warehouse. 25% are between 11 to 50 co-workers.

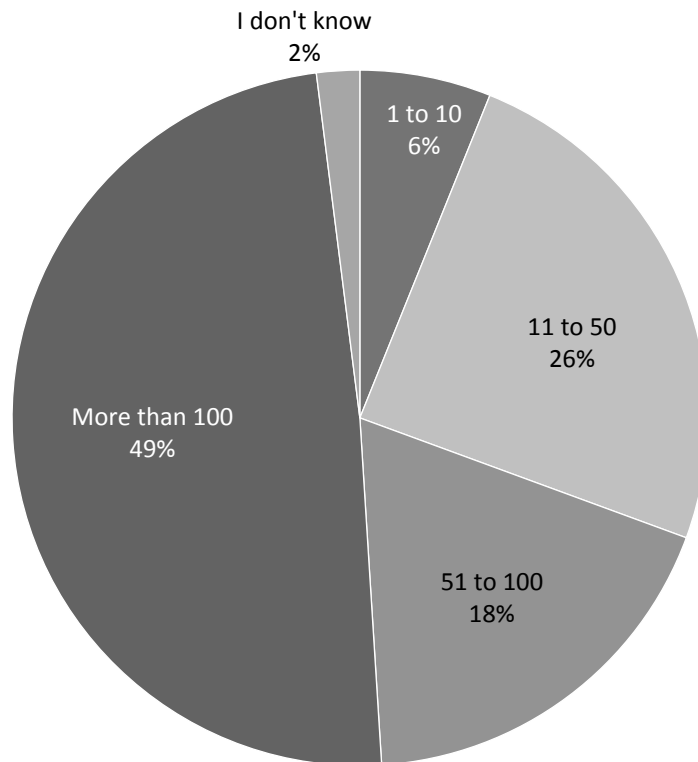


Chart 5 Number of employees running warehouse operations

C. Question 28. How many numbers of SKUs do you have in your warehouse(s)?

Almost half of the respondents answered that they've got more than 10,000 SKUs. However, 13% are not sure.

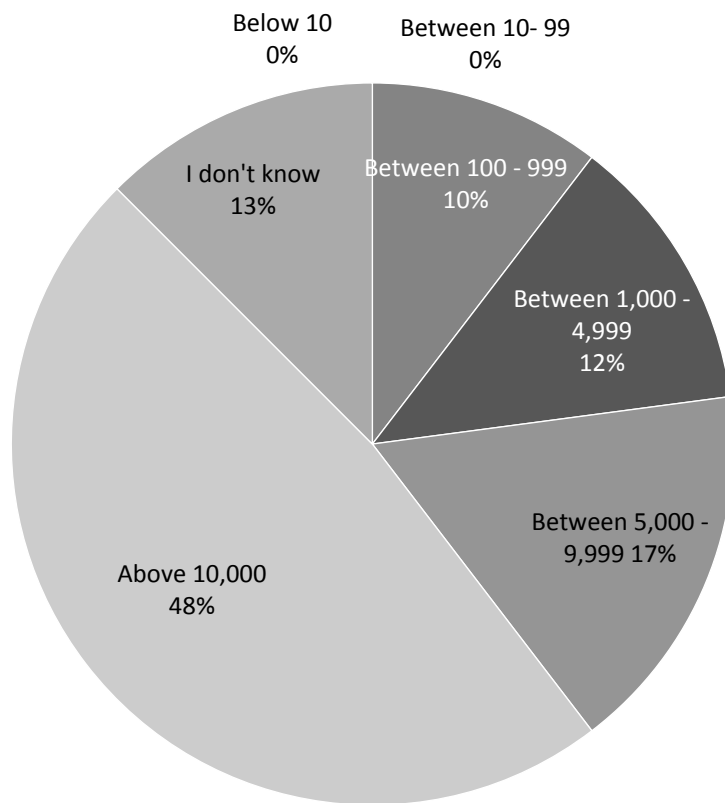


Chart 6 Number of SKUs

*C. Question 29. The following table, Table 14, shows that a standardized performance measurement system is thought as more than relevant by 22 % and very significant by 41%. However, accurate data is considered to be very important or more than important by 92% of the informants, followed by real-time (84%), support decision making (80%) and visibility (78%). There is less interest for a learning system, where only 40% believe it's very important or more than vital.

Table 5 Performance measurement significance

29. What's important in your warehouse in terms of performance measurement?								
	1	2	3	4	5	6	7	N/A
Real-time	0%	0%	2%	4%	8%	27%	57%	2%
Reliability (accurate data)	0%	0%	0%	0%	6%	18%	74%	2%
Overview/Visibility (easy to present data)	0%	0%	0%	0%	18%	29%	49%	4%
Support decision making	0%	2%	0%	0%	14%	35%	45%	4%
Learning system (adaptive system)	0%	4%	4%	10%	35%	18%	22%	6%
Transparency	0%	0%	2%	2%	16%	31%	43%	6%
Standardized performance measurement system within the SC	0%	0%	0%	4%	25%	22%	41%	8%

*C. Question 30. Table 15 shows that the respondents find high quality, where 98% stated it to be more important or very relevant, and on time delivery, where 96% considered it more important or very important, as more vital compared to short time delivery which has 79%.

Table 156 Importance of success factors and attributes

30. Importance of warehouse success factors:								
	1	2	3	4	5	6	7	N/A
High quality	0%	0%	0%	0%	0%	12%	86%	2%
Short delivery time	0%	0%	0%	6%	12%	22%	57%	2%
On time delivery	0%	0%	0%	0%	0%	12%	84%	4%
Reliability	0%	0%	0%	0%	0%	14%	84%	2%
Responsiveness	0%	0%	0%	2%	12%	27%	57%	2%
Agile/Flexibility	0%	0%	0%	4%	12%	27%	55%	2%
Cost	0%	0%	0%	0%	6%	20%	69%	4%
Asset management (to efficiently utilize assets)	0%	0%	0%	0%	25%	29%	41%	6%

Reliability is considered to have most importance (98%) of the attributes followed by cost (89%), however it's easy to see that most of defendants believed that almost every attribute has a high level of importance in the warehouse operations.

C. Question 31. Does your organization have strategy linked to performance measurement and KPIs?

This question shows that 74% believed that the strategy is linked to performance measurement and KPIs in their organization.

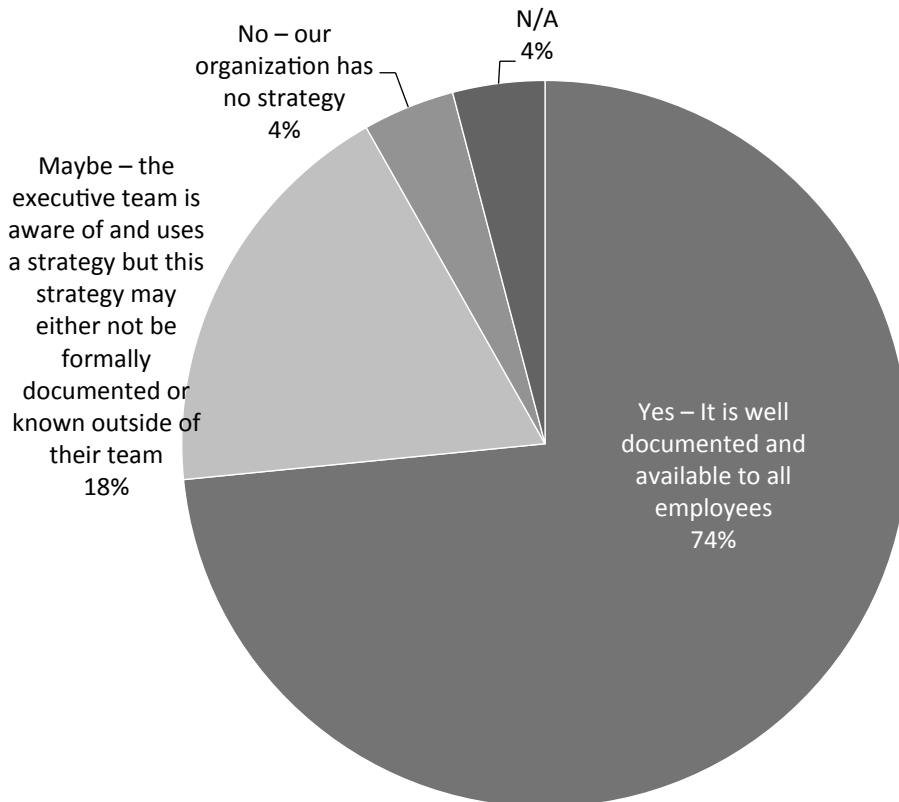


Chart 7 Linkage to performance measurement and metrics/KPIs

C. Question 32. Does your organization have enough performance data?

Here, 72 % stated the data is there, but 41% says that it's hard to access and 26% does not have enough performance data.

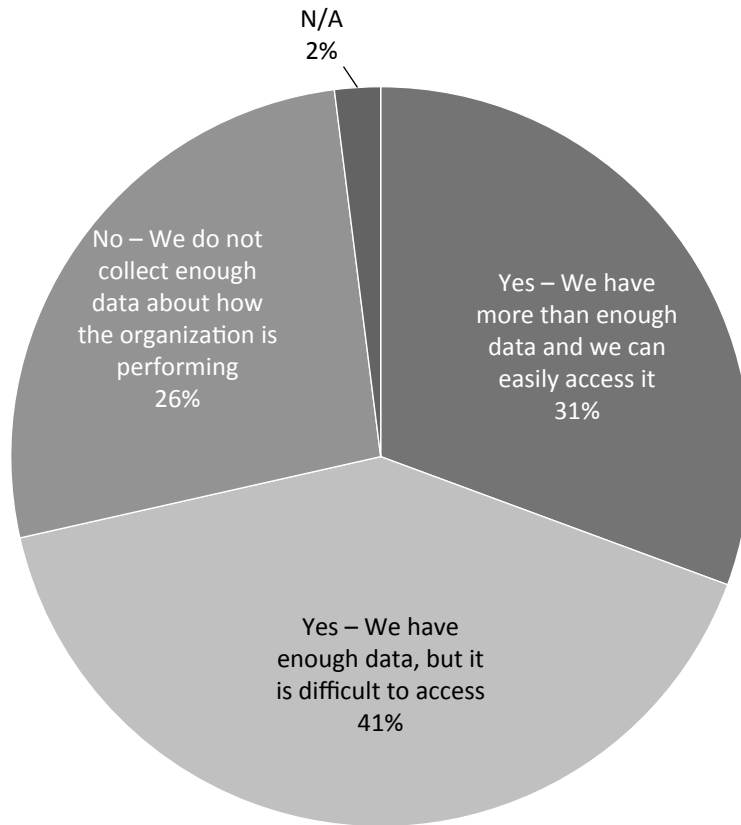


Chart 8 Enough performance data

C. Question 33. How deep into your organization does performance reporting link to the organization's strategic objectives?

59% specified that the reporting is very well developed and 31% state that it is well developed while 6% reported that it is only senior managers that access performance reporting.

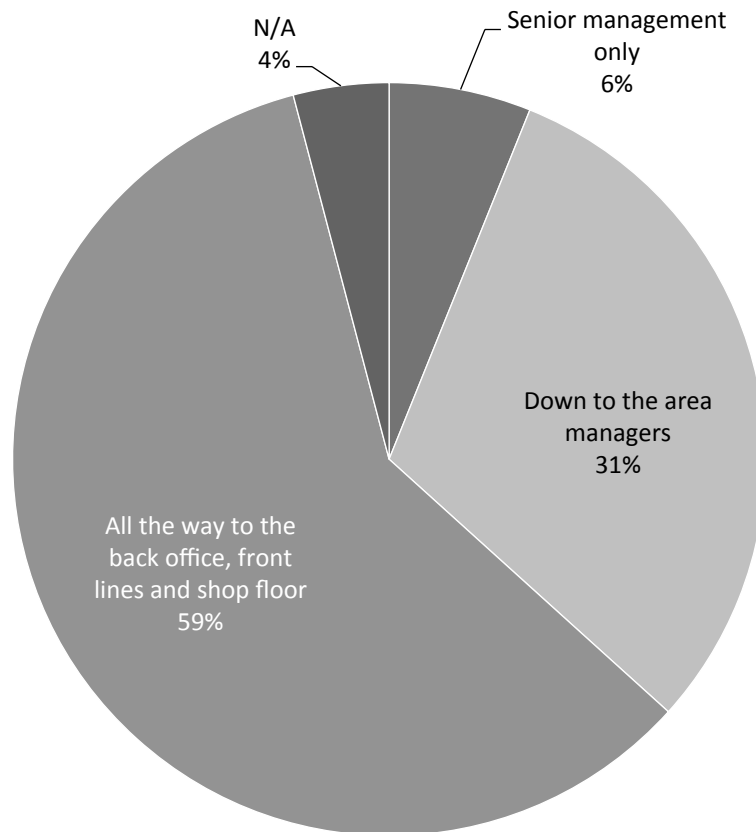


Chart 9 Performance reporting and its connection to strategic objectives

C. Question 34. Could your organization build linked scorecards, dashboards and other business analytics?

Most respondents stated that this can be done with some effort (63%), while 19% reported it to be easy and 14% that the required data isn't available to build e.g. dashboards or linked scorecards.

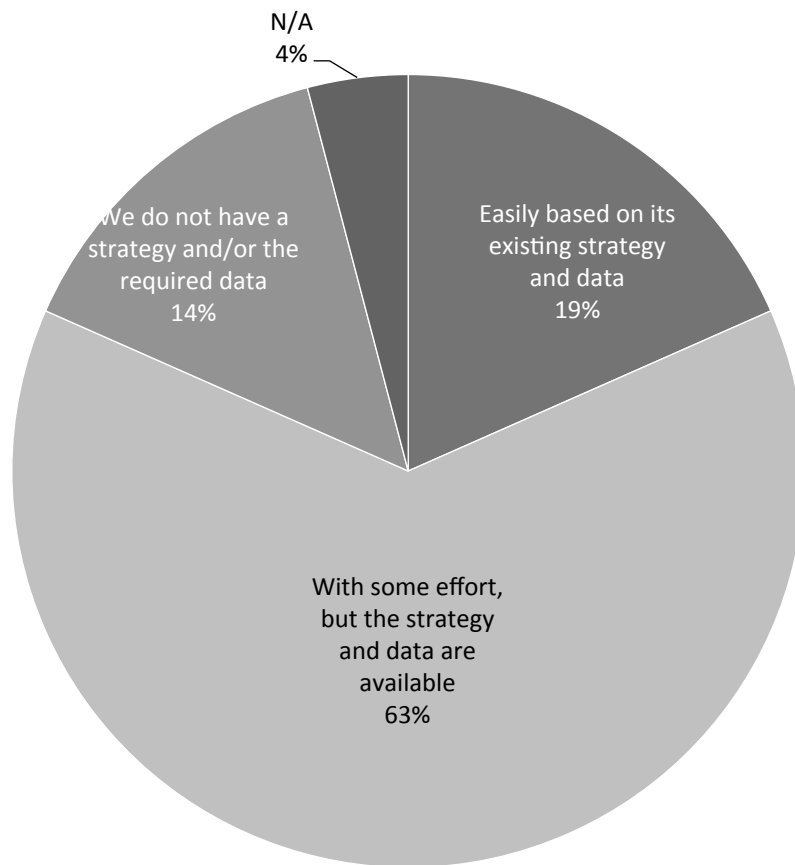


Chart 10 Possibility to make business analytics tools

C. Question 35. Which of following reporting practices and time horizons does your organization use (select all applicable)

Most defendants reported that either monthly, daily or weekly meetings are conducted in their organizations. 13 % specified that this is only performed on a quarterly basis.

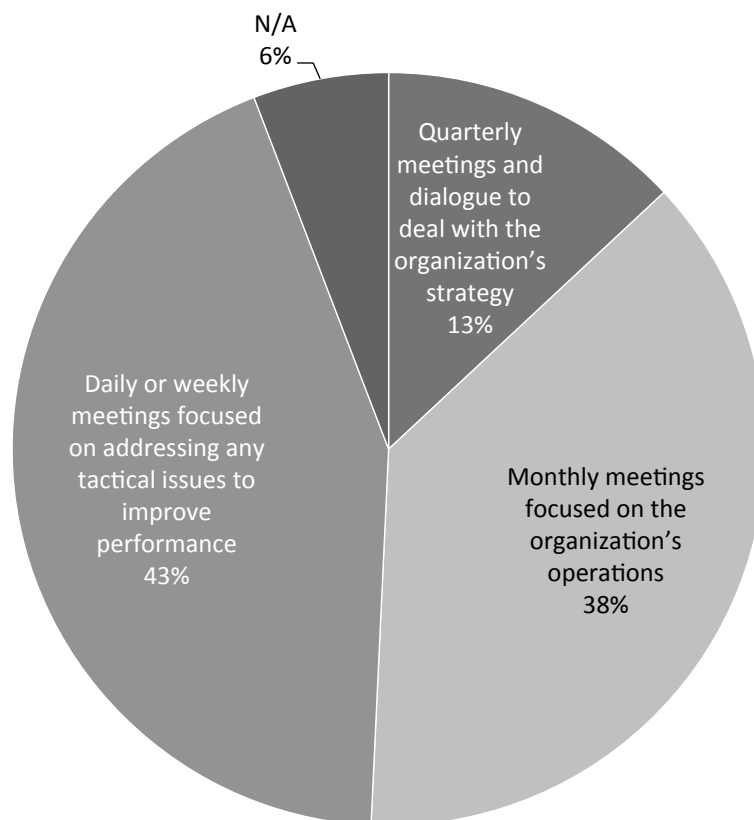


Chart 11 Reporting practices

Appendix 2 – Email letter to the web-based survey

Survey letter

The web-based survey was sent out three times, whereof two reminders.

Dear customer,

Consafe Logistics Sweden is in collaboration with Lund University conducting a research on warehouse performance metrics and KPIs. As a part of the research we are looking for your help in answering a short (5-8 min) confidential web-based survey. The aim is to investigate the possibilities of constructing a standardized cross-industry performance measurement system for warehousing.

The survey is directed towards all customers with a WMS solution from Consafe Logistics. From your company/site you've been selected as recipient, we believe that your expertise can help us to better understand the needs and objectives in warehouse performance measurement. If you're interested in the topic and want to know the results of the research you're welcome to receive a PDF-copy of the rapport when it's completed in June 2014.

The survey can be answered until the 2/5, if you take a few minutes from your time to complete the survey we'll be very thankful.

Please note that your answers are anonymous. You will reach the questionnaire using the link below:

[link]

Best Regards,

Mikael Brorsson, Consafe Logistics
Per Axelsson, Lund University
Jonathan Frankel, Lund University