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A packaging cost model for Ericsson AB

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FOREWORD

This master thesis has been conducted at the Department of Design Sciences at the Faculty of Engineering. This thesis is a final examination in the pursuit of a master's degree in mechanical engineering at Lund University. The thesis has been conducted between September 2008 and January 2009.

The project was initiated by Mats Lundgren, Ericsson AB, in conversation with the Division of Packaging Logistics. Problem description, Delimitation and Vision have been discussed and formed together with Mats Lundgren and Birgitta Ekelund, Ericsson AB.

We would like to thank the project group Packaging Material Management at Ericsson in Gävle, for all information they have been sharing with us and the time they have spent helping us when problems have occurred. We would also like to thank other people at Ericsson who have helped us during this thesis.

Finally, we would especially like to thank our supervisor Mats Johnsson, Associate Professor at the Division of Packaging Logistics at Lund University, for all the help we have received during the thesis.

Lund, January 2009.

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ABSTRACT

Title:	A packaging cost model for Ericsson AB
Authors:	Patrik de la Motte Patrik Persson
Supervisor:	Associate Professor Mats Johnsson, *Department of Packaging Logistics,* Lund University, Faculty of Engineering.
Problem Definition:	Ericsson wants to increase their focus on reducing the total cost of packaging for the company in the whole world. They want to create a simple calculation model that can calculate the total packaging cost and compare different packaging solutions (country, freight, packaging, and product) in order to find the most cost effective packaging solution. This will facilitate the development of future packaging and also reduce the company's total costs relating to the supply chain.
Purpose:	The purpose of the thesis is to create a calculation model which makes it possible to compare a couple of packaging solutions, this will finally show the total cost of the packaging. The calculation model is supposed to be able to handle different transport modes, different destinations and different kinds of packaging solutions, and it should also be "factory" independent.
Methodology:	There was a pre-existing problem that should be solved, as such, the approach of the thesis will be problem-solving. The authors will first collect empirical information. Once this research is done, theories will be presented based on the empirical information. Finally an analysis will be conducted. This approach is called inductive approach. Qualitative data is collected through structured and semi-structured interviews, written literature and observations made by the authors.

Conclusion:

The calculation model will be helping Ericsson with their cost reduction regarding existing and new packaging solutions. All the six cost parameters can be followed through the whole calculation model to see how the areas change depending on which parameters that are changed. It is easy to use the calculation model and the total cost will be presented in both figures and diagrams to make it even more clear for the user. The calculation model is meant to be used by Ericsson's packaging engineers, and the calculation model can be used globally. There are only a few parameters that need to be changed for the user in China compared to Sweden.

Ericsson needs to involve more than one supplier for their packaging material, in order to reduce the purchasing price. Packaging engineers should use their competence more by constructing the packaging, and not letting the supplier do all the work.

Table of content

1 INTRODUCTION

In this chapter the background of the thesis will be presented. This will be followed by a problem description, which focus the thesis will have, what the goal is and which delimitations the authors are using. Finally a time schedule and the disposition of the thesis are presented.

1.1 Background

Nowadays, more and more companies consider packaging important and it has become a popular topic for discussion. Companies have started to realize that it is possible to save money by focusing more on packaging. A lot of money can be saved, simply by changing the packaging, such as changing the material or redesign the packaging for example.

Ericsson AB is a company that never had showed any bigger interest in packaging, they just wanted a packaging that could protect their products. The company has been using the same packaging for a long time, and had never experience any problem with it, and it also had a good strength, so why would they change a winning concept?

No one in the whole company actually knew which department or person who was responsible for packaging issues, purchasing of packaging material etcetera. However, a group of people started two years ago to work with packaging at Ericsson to see how it works. They were mapping out the packaging flow and what costs that appear. Even the management at Ericsson realized that there was a great potential to save money in this area. At the moment there are more than ten people who are working with packaging issues to reduce costs at Ericsson.

1.2 Problem description

Ericsson wants to increase their focus on reducing the total cost of packaging for the company in the whole world. Ericsson does not have any method or decision-making program when it comes to calculating this kind of cost or how to managing the packaging logistics issue. At the end of the year 2007, a project group was formed at Ericsson, called Packaging Material Management (PMM). PMM's aim is to make the area packaging work in an efficient way and to reduce the total cost of packaging. Ericsson wants to create a simple calculation model that can calculate the total packaging cost and compare different packaging solutions (country, freight, packaging, and product) in order to find the most cost effective packaging solution. This will facilitate the development of future packaging and also reduce the company's total costs relating to the supply chain.

1.3 Focus

The focus in this thesis will be on mapping out the current flow through the whole supply chain, in order to understand the underlying cost factors. The authors will start from the six cost parameters (see Figure 1) that PMM created. The thesis will then primarily focus on the two major cost areas, material and freight. The authors will also map out how all the six parameters affect each other.

Figure 1 - Six cost parameters

1.4 Vision

The goal is to create a calculation model which makes it possible to compare a couple of packaging solutions, this will finally show the total cost for the packaging. The calculation model is supposed to be able to handle different transport modes, different destinations and different kinds of packaging solutions, and it should also be "factory" independent. By using this calculation model, the packaging flow will be better utilised and the packaging cost will be reduced.

1.5 Delimitations

Different delimitations must be considered so that the scope is not too broad and that the main issue is not overcome by other problems. This study will only focus on the flow from one product family (Radio Base Stations), thus enabling a greater focuses on the problem description.

The study covers Ericsson globally, however, our focus will only be on the outbound flow for packaging from the plant in Gävle. There will also be some delimitation in regards to the six cost parameters. We will primarily study the two parameters, material and freight. These two parameters have the biggest importance for the total cost of logistics, and there are more available data on these two as well. The other parameters will also be considered.

1.6 Target group

The target group for this thesis is mainly the project group (PMM) at Ericsson, but other employees will hopefully have an interest in this report as well. The thesis with the calculation model, may affect the way of working with packaging in the future for Ericsson.

Other target group include students, who are interested in packaging logistics and of course the staff at the Packaging Logistics department at Lund University. Other companies will also have an interest in reading this thesis for their future work with packaging costs.

1.7 Time Schedule

A graphical view over time schedule can be seen in Figure 2. The project started in June with a kick off meeting with PMM, Ericsson in Gävle. The thesis estimates to be present in middle of January.

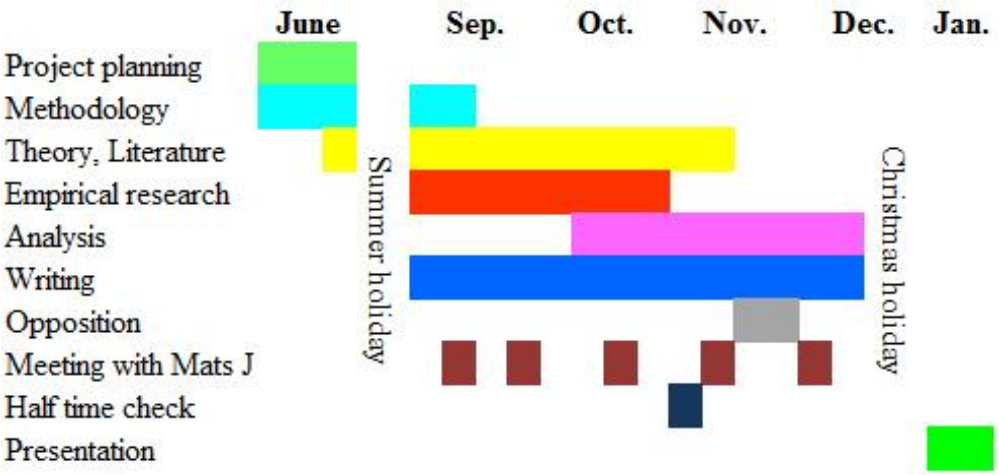

Figure 2 - Time Schedule

1. Meeting in Gävle, Ericsson, 2008-06-18
2. Opposition on another master thesis. Location: Lund
3. Half time, meeting where we will discuss how the work goes on and how the work will be evaluated, associated prof. Mats Johnsson will participate. Location: Gävle 2008-10-31
4. Presentation in Gävle 2009-01-14
5. Presentation in Lund 2009-01-16

1.8 Disposition

The aim of this part is to give the reader an overview over the different chapters. The eight different chapters will be presented as well as a short description of each one of them. This will make it easier for the reader to understand and follow the thesis.

- **Chapter 1 – *Introduction***. An introduction to the thesis will be given with the background described. Then the problem description and the focus are discussed. Thereafter the vision, delimitations and target group are presented. Finally, the time table for the thesis is outlined.

- **Chapter 2 – *Methodology***. This chapter discusses various methods and approaches used for collecting data. It will declare our chosen methods as well.

- **Chapter 3 – *Company presentation.*** This chapter presents the company, the history of Ericsson as well as the different business units.

- **Chapter 4 – *Theory***. This chapter describes the relevant theory and expressions that are used during the whole thesis. The theory will help the author to come to a conclusion.

- **Chapter 5 – *Empirical research.*** This chapter is based on the information collected during the research at Ericsson AB. The six cost parameters and what the parameters include will be presented here as well.

- **Chapter 6 – *Model description.*** The calculation model will in this chapter be presented, how it looks like and how the model works in practice.

- **Chapter 7 – *Analysis.*** An analysis of the empirical findings by using theory will be made in this chapter, as well as how Ericsson will manage to use the calculation model.

- **Chapter 8 – *Conclusions and Recommendations.*** The authors' conclusions and recommendations will be presented in this chapter.

2 METHODOLOGY

In this chapter different kinds of methodology are presented and discussed. Firstly, a general presentation of the different methods will be made, and then finally the method used in this thesis will be presented.

2.1 Description of methodology

Methodology is a fundamentally approach where framework and different principles are being set up in order to show how the work should proceed.[1] The choice of method is made after the purpose is determined, but before the remaining part of the study is conducted. It is important to show an awareness of the different methods available, as well as which practical approach is the most appropriate.[2] The choice of method depends on the purpose and nature of the thesis. Different options and approaches are described below.[3]

- *Descriptive* – the main purpose for studies using this method is to describe and find out how something works or how it will be performed
- *Exploratory* – the purpose with the study is to understand how something works or how it is carried out on a deeper level
- *Explanatory* – studies are designed to find the cause, as well as explanations of how something works or will be performed
- *Problem-solving* – the aim with the study is to find a solution to a problem that has been identified

Four methods, which are considered to be the most relevant for the performance of a scientific study, are the following:[4]

- *Survey* – description and compilation of the current state of the objective of the study. Surveys are intended to describe a question with a wide scope.
- *Case study* - used in a study where the aim is to bring in-depth description of a phenomenon or an objective, used primarily for the study of contemporary phenomena.
- *Experiment* – it is a method used when surveys or case studies are insufficient to find the cause. With the help of experiments, it is possible to make an analysis by comparing two or more options, and

[1] Höst, Regnell, Runeson, *Att genomföra examensarbete, page* 29
[2] Björklund & Paulsson, *Seminarieboken - att skriva, presentera och opponera, page* 57
[3] Höst, Regnell, Runeson, *Att genomföra examensarbete, page* 29
[4] Ibid, *page* 30-39

then investigate various parameters' impact on the studied phenomenon by variation and repetition.

- *Action research* – is used when the aim is to improve something slightly while studies are made in the area, it is similar to problem solving. The first step in action research is to observe a situation in order to identify or clarify the problem which is to be solved. The next step is to make a proposal for how the problem is to be solved, and then implement it. The last step of evaluating the solution, is important. The process is iterative, and continues until the problems are solved.

There are mainly two different approaches used in different scientific reports; *deductive*, the way of demonstration and *inductive*, the discovery way.[5] Deductive approach starts with already existing theories and general principles, from these a hypotheses is defined. Inductive approach starts from the other end, beginning with the information that is collected, empiric and then formulates a general theory.[6] Deductive and inductive approach is illustrated in Figure 3.

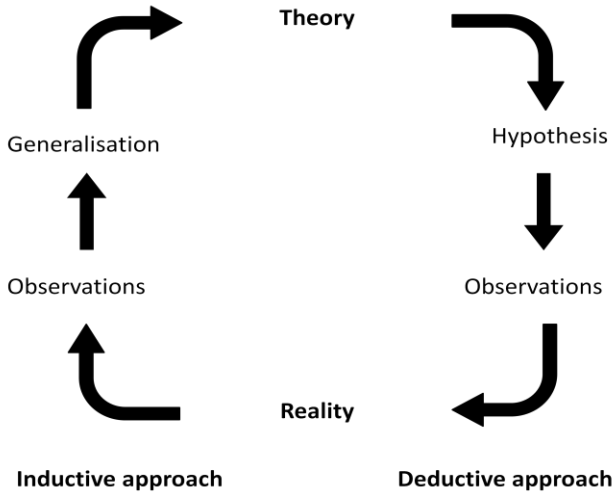

Figure 3 - Inductive and deductive approach[7]

[5] Holme, Solvang, *Forskningsmetodik - om kvalitativa och kvantitativa metoder, page* 51
[6] Patel, Davidsson, *Forskningsmetodikens grunder - att planera, genomföra och rapportera en undersökning, page* 21
[7] Eriksson, Wiedersheim, *Att utreda, forska och rapportera, page* 220

2.2 Data Collection

Data collection can be done with several different techniques depending on the nature of the problem. Interviews, literature, observations and surveys are examples of different methods. It is important to consider the type of data and information that is of interest, as the various methods are appropriate for different purposes.[8] Below is a description of some methods.

Literature

Any kind of written materials such as books, brochures and scientific papers are seen as literature. This information is called secondary data, which means that the information has been collected for another purpose than that of the current study. As a result, the information may be angled or not comprehensive, which should be considered.[9]

Interviews

An interview can be seen as a systematic hearing of a person in a specific subject area.[10] Mostly interviews are made as a personal meeting, face to face meeting, but interviews can be done through telephone or email as well.[11] The information that is collected during an interview is called primary data, this information is collected in order to be used in the study. There are mainly three different types of interviews. Structured interview is when all the questions are prepared in advance and the questions follow a particular order. An interview can also be semi-structured, which means that the topics are predetermined and the questions are being formed while the respondent replies. The final type of an interview is when the questions arise afterwards and it looks more like a conversation, this type of interview is called unstructured. The person who is doing the interview should be aware of how the questions are leading and try to avoid those kinds of questions. Interviews can be made by one or more examiners and the same applies to the number of interview objects.[12] Recording the interviews with some kind of device is preferable. The examiner should also take notes during the interview as a supplement to the recording.[13]

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[8] Björklund & Paulsson, *Seminarieboken - att skriva, presentera och opponera, page* 66
[9] Ibid, *page* 67
[10] Höst, Regnell, Runeson, *Att genomföra examensarbete, page* 89
[11] Patel, Davidsson, *Forskningsmetodikens grunder - att planera, genomföra och rapportera en undersökning, page* 60
[12] Björklund & Paulsson, *Seminarieboken - att skriva, presentera och opponera, page* 68
[13] Höst, Regnell, Runeson, *Att genomföra examensarbete, page* 92

Survey
The purpose with surveys is to collect opinions and views from a broader group of people. Surveys consist of a number of standard questions with associated answers. Graduated answers is common as well as yes/no options, there is often a possibility for open and descriptive answers too. The disadvantage with this method is to know who the respondent is and his/her function. There is also a risk of misinterpretation, compared with an interview.[14]

Presentations
Participation in various forms of presentations such as lectures and conferences can contribute with useful information for the study. The form of the presentations may differ a lot and the most suitable form depends on what kind of study that is being conducted. The information that is presented during the presentations is secondary data and it requires extra consideration, as to whom the information is for, and how the information is outlined.[15]

Observations
There are a variety of ways to carry out observations. A participating observation is when the observer is actively participating in the observation activity. Observers can observe the event from the outside as well, so-called full observation. Different types of tools can be used by the observer, like timers etcetera, but also subjective estimates can be used in the observation. Observation is a method which takes a lot of time. However, the method has the ability to provide more objective information.[16]

Experiment
This method is based on using an artificial reality or a physical experiment, where given variables can be varied in a controlled manner. Different tests are performed on the model to obtain the measurement results. The disadvantage of this method is that it is very time consuming, and that it is difficult to reflect the complexity of reality.[17]

Data collected by other
There are four different kinds of data that others have collected: processed material, available statistics, index data and archival data. These data have been collected in other purposes than what the study refers to. This makes it important to critically inspect the material and analysis.[18]

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[14] Björklund & Paulsson, *Seminarieboken - att skriva, presentera och opponera, page* 67-70
[15] Ibid, *page* 69, 71
[16] Ibid, *page* 69, 71
[17] Ibid, *page* 69, 71
[18] Höst, Regnell, Runeson, *Att genomföra examensarbete, page* 98

2.3 The project's credibility

Validation, reliability and objectivity can be seen as three dimensions to evaluating the credibility of a study. In scientific studies these must always be considered to obtain a credible study, according to a majority group of writers.[19]

Validity

The definition of validity refers to how well the instrument is measuring what it is supposed to measure. It is appropriate to separate two different parts of validity, inner and external validity. Inner validity refers to the compliance between theory and the measurable, and this can be investigated without collecting empirical data. External validity refers to the compliance between the operational definition and the reality. The instrument should therefore not give rise to any systematic measurement errors.[20]

Reliability

Reliability intends to describe the accuracy of the measuring instrument, namely the extent to which the result is the same if the study is repeated.[21] Reliability can be evaluated in a variety of ways. If the results are the same when another examiner uses the same approach as the previous examiner was using, then the reliability can be considered high. Another good indicator of reliability is whether the results would be the same when the study is carried out at a different time and with other selections than before.[22] A schematic illustration of validity and reliability can be seen in Figure 4.

Figure 4 - Validity and Reliability[23]

[19] Björklund & Paulsson, *Seminarieboken – att skriva, presentera och opponera*, page 59
[20] Eriksson & Wiedersheim-Paul, *Att utreda, forska och rapportera*, page 38-39
[21] Björklund & Paulsson, *Seminarieboken – att skriva, presentera och opponera*, page 59
[22] Eriksson & Wiedersheim-Paul, *Att utreda, forska och rapportera*, page 40
[23] Zikmund, *Business Research Methods*, page 284

Objectivity
The last of the three dimensions that describes a project's credibility is objectivity. Objectivity means the degree to which different values affect the result. The objectivity in a report can be increased by the authors' clear and well-reasoning description of the study, which gives the readers an opportunity to create their own views of the results of the studies.[24]

2.4 Qualitative and quantitative method

When all the information has been gathered as part of a development assignment, research project or investigative work, one can chose to either process and analyse through a qualitative or a quantitative approach. Quantitative method means that the processing is done by using statistical methods to analyze information in a numerical form. Methods to analyze and interpret the text information are usually known as qualitative method.[25] Whether the study is qualitative or quantitative is mainly due to what the purpose of the study is. Data collection methods such as interviews and observations are more often suitable for qualitative studies, whereas the mathematical models and surveys are better for quantitative studies.[26]

2.5 Our research approach

The approach of this study will be problem-solving, there was a pre-existing problem that should be solved by the authors. The aim of the thesis is to create a calculation model, and the thesis will also be analysing the various parameters that affect the total packaging cost. This makes the authors to choose a method called case study, where an inductive approach will be used.

The authors will collect empirical information first with help of interviews, presentations and observations. All the information will assist the authors to get a fundamental view and perspective for how all the functions in Ericsson work. After the empirical research is done, theories are presented based on the empirical information. When both empirical and theoretical information are collected an analysis will be conducted. The conclusion and recommendations will be based on the analysis.

[24] Björklund & Paulsson, *Seminarieboken – att skriva, presentera och opponera*, page 61-62
[25] Patrl & Davidson, *Forskningsmetodikens grunder*, page 90
[26] Björklund & Paulsson, *Seminarieboken – att skriva, presentera och opponera*, page 63

The authors have chosen to use both primary and secondary data for the study. A couple of interviews (primary data) to get information for the study have been made. The interviews have been both structured and semi-structured. The authors have attended many presentations to obtain information and become more familiar with the company. Observations in Ericsson's plant in Gävle have been made to collect different data and to see the production at the plant. The authors have also visited an exhibition, called Teknikmässan in Stockholm. The aim of the visit was to get inspiration from the area packing and wrapping.

Some data is collected by others, mainly data on transport costs, different products and packaging. The theory is mainly from written literature that the authors have studied earlier during the course of their studies. Due to the topic of the study and the nature of the problem, the authors have chosen to use a qualitative study.

While the study has been made in cooperation with Ericsson the authors have also obtained a good insight in the company. It is important to interview people with the right knowledge, in order to get useful information, the interviewed person should also receive detailed information about the purpose of the study. The people, who have been interviewed, have in this case the right level of knowledge, as they are working with matters within the specified field. To get a better validity, people in higher position should be interviewed instead. As these people where very busy, this has not been achieved. The reliability of the study can be considered as high, since a variety of personnel has been interviewed. The interviewee has received questions before the interview and if there have been any questions or diffuseness afterwards, contacts has been made through telephone or e-mail. This was made to increase the reliability.

Since none of the authors have any relation to the interviewee or company, the objectivity of the study has been maintained at a high level. However, the study is mainly written with information from one company, which brings on a risk that the information is weighted and a kind of partiality appears. Both authors have been involved in discussions about the study, discussion after interviews has been made as well to make sure that the answers are understood by the authors in a similar way. This is done to minimise the effect of one single person's effect on the results of the study. The authors have written most of the thesis in Lund, which may result in useful information from Ericsson in Gävle, have been missed.

3 Company description

This chapter will describe Ericsson as a company. The history of the company will be presented as well as its different business units.

3.1 History

Ericsson was established 1876 by a 30-year-old mechanic called Lars Magnus Ericsson. At that time the company was a repair shop for telegraph equipment. He saw the great potential of telephones and also recognised the need to improve the quality of the technology. In the late 1800s, Lars Magnus Ericsson was responsible for making Stockholm the city with the highest number of telephone users per head of population. The original name at the time of incorporation was Telefonaktiebolaget LM Ericsson.

Today Ericsson is a world leading provider of telecommunications and related services to mobile and fixed network operators globally. More than 1000 networks including all equipment, are used by more than 175 countries worldwide, and more than 40 percent of calls from mobiles are made through Eriksson's network. Ericsson is one of few companies in the world who can offer their customer an end-to-end solution for all major mobile communication standards.

Investing in research and development (R&D) is important for Ericsson. Ericsson is unique in that they have one of the industry's most comprehensive portfolio with over 23 000 patents.[27]

3.2 Business units

Ericsson consist of four different business units, see Figure 5. For more information about the different units, see below.[28]

[27] http://www.ericsson.com/ericsson/corpinfo/compfacts/history/years_leadership/index.shtml 2008-09-17

[28] http://www.ericsson.com/ericsson/corpinfo/compfacts/offering.shtml 2008-09-17

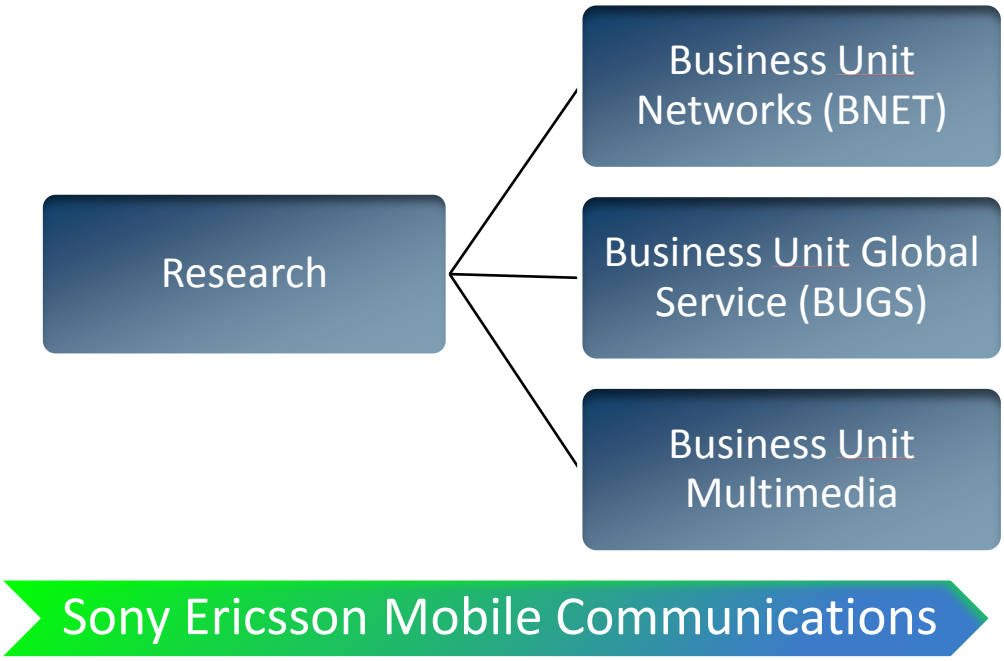

Figure 5 - Business units[29]

Networks (BNET) – This is Ericsson's largest business unit and counts for about two-thirds of net sales. Ericsson's industry-leading network solution include radio access network, (radio base station for GSM, 3G, Long Term Evolution (LTE)) core network solution, (like softswitch, Internet Protocol (IP), infrastructure, IMS, media gateways) transport solution (like microwave radio and optical fibre solution) and fixed access solution for fibre and copper. All solutions provide cost efficient management, thus the operators' costs will be reduced.

The majority of mobile users are still using GSM and every month another 30 to 40 million people are joining the GSM community. Ericsson is one of few companies that still develop new technology for GSM. When it comes to mobile networks, Ericsson is the world's principal supplier. About 50 percent of the operators with mobile broadband have chosen Ericsson as their provider. Ericsson is also active on the fixed broadband market.

Global service (BUGS)– Ericsson's services portfolio consists of network rollout and professional services, such as managed services, education and consulting. System integration and customer support are included in the portfolio as well. Ericsson is the industry leader in managed services, managing networks that serve more than 120 million subscribers. Services are

[29] http://www.ericsson.com/ericsson/corpinfo/organiz.shtml 2008-09-17

a strategically important area. This was something that Ericsson was aware of at an early stage, and at the end of 1990, Ericsson was the first provider to form a services business unit. Today the service unit are leading the industry, with 24 000 professionals in 140 countries. By using experience, skills and scale, Ericsson supports their customers to expand their businesses. This business unit represents more than 22 percent of net sales.

Multimedia – This business unit was established on 1st of January, 2007 and the business development is currently progressing. This area consists of service layer products, revenue management system, enterprise solution and mobile platforms. The portfolio has been reinforced by companies like TANDBERG Television, Mobeon and Drutt Corporation. The sale of multimedia represents about eight percent of net sales. As this business is fairly new, Ericsson expects growth and margins to fluctuate.

3.3 Mobile communication

Sony Ericsson was established in October 2001, and is a joint venture owned equally by Sony Corporation and Ericsson. Sony Ericsson delivers leading-edge mobile phones and other mobile communication devices. The joint venture combines the mobile communication expertise of Ericsson with Sony Corporations expertise of consumer electronics and content. This cooperation forms an essential part of Ericsson's end-to-end capability for mobile multimedia services. The sales for Sony Ericsson are not included in Ericsson's reported sales. Ericsson has a separate account to show this revenue, "Share in earnings of Joint Ventures and Associated Companies".[30]

[30] http://www.ericsson.com/ericsson/corpinfo/compfacts/offering.shtml 2008-09-17

4 THEORY

In this chapter the authors will present the theories that are used in this thesis. First the major theory will be presented, followed by the theories related to the six cost parameters.

4.1 Lean Production

The Toyoda family established in 1937 a company called "the Toyota Motor Company". The name Toyota was decided through a public contest. The first thirteen years Toyota produced 2685 cars, which can be compared to the American car company Ford, that produced 7000 cars every single day in the year 1950. During spring that year Eiji Toyoda went to Detroit to carefully study the Ford factory. After the study were made, Eiji and his colleague Taiichi Ohno found out that mass production (Ford was using the manufacturing method called mass production) would never work in Japan because of the circumstances in the country during that time. The circumstances were:

- The Japanese market demanded flexibility
- The Japanese workers were not willing to work under the principles of mass production and there where no "guest workers" available in Japan.
- There were no financial resources to purchase the latest production technology in the scale that mass production required.
- There were a lot of competitive car producers in the world which already were using the principles of mass production.

This was the basis for a new philosophy in the manufacturing industry which later would be known as Lean Production.[31]

The main focus with Lean Production is to prevent every kind of waste with different resources, create value, work with processes etcetera. Processes, products, volumes and employees should create fast and flexible flows. A cost that arises from slow processes is one of the problems that Lean Production should eliminate. There are five different steps that a company needs to follow in order to achieve an efficient Lean Production:[32]

1. *Customer benefits* – Value that is important for the customer, the value of a product or a service, the price and the delivery time. This requires knowledge about the customer.

[31] Womack, T. Jones & Roos, *The Machine that changed the world*, page. 47-49
[32] Lumsden, *Logistikens Grunder*, page 278-279

2. *Identify products and processes which create value in the company* – An analysis over the whole value chain to see what activities that is necessary and what can be eliminated.
3. *Continuous flow* – Analyze the whole flow and if there are problems, solve the problems to make the process more efficient. The analysis will show which phases in the flow that require changes.
4. *Create a demand through manufacturing* – Production will strictly be made to customer orders. This will eliminate overproduction, unnecessary storage costs and transport costs.
5. *Endeavour for perfection* – Changes in the world require processes that can be reviewed and improved continuously, so that the company can be competitive in the long-term.

Elimination of waste

The most distinguished principle of The Toyota Way and Lean Production is to identify and eliminate waste in all activities. Waste can be defined as activities that do not add value to the product. Waste has to be eliminated because it is a huge cost for the company and the customers are not willing to pay for the waste. During the time when Toyota developed their production system, there was a lack of resources which made elimination of waste as a necessary prerequisite for the production system.[33] Products made in each factory may be different, but the typical waste found in factories is similar. Toyota tried to improve its activities for many years, and they finally identified seven different types of wastes to be the most significant ones:[34]

1. *Waste from overproduction* – To produce more than what is requested/required by the customer.
2. *Waste of waiting time* – Production staffs who are waiting for a machine during its operation or when a product is waiting for the next step in the process, this all contributes to waste.
3. *Transportation waste* – Unnecessary transport should be minimised, and various stages of handling in the warehouse and production should be reduced to decrease waste.
4. *Processing waste* – To process a product more than the customer requires and is willing to pay for is a form of waste. Even using wrong manufacturing methods for different products is a form of waste.
5. *Inventory waste* – Larger amounts of stock than what is necessary in any part of the supply chain generates both costs and concealing problems. It is preferable to keep the amount of stock low.

[33] Åhlström, *Sequences in the Process of Adopting Lean Production*, page 21
[34] Dept. of Industrial Management & Logistics, *Kompendium i produktionsledning: Eliminating waste*, page 12-19

6. *Waste of motion* – Movements made by employees that are not made to create value, for example searching for tools, and reaching for something, or walking longer distance in the factory than necessary.
7. *Waste from product defects* – To produce and send defective products to the customer is a waste and should be avoided, otherwise the future business with the customer and market share may be lost.

4.2 Packaging Logistics

Packaging logistics is a new area of logistics where packaging can be considered as a part of the logistics chain and not as before, when the packaging was an isolated part with mainly a protected function. Understanding the importance of the packaging as a major component in the logistics chain has increased significantly in recent years.[35] By definition, packaging logistics is an approach which aims to develop packaging and packaging system that support the logistics process and meet the end users requirements. Packaging logistics' most significant contribution to logistics is to create additional value, this is not only important for end users, it is also important for all the actors in the distribution chain. Additional value in this case means undamaged products, easy handling of the packaging and packaging that is easy to dispose.[36]

Pallet

Pallet is the common name for the equipment used to facilitate handling and stacking for a larger amount of packaging. A pallet can be used to avoid damages on the products, since the pallet make it easier to handle the products. There are a number of pallets, many are adjusted to a specific mode of transportation.[37] The material of the pallet is usually made of wood, which has a great friction between the vehicle and the pallet. The pallets can even be made of plastic and metal, but wood pallet is cheaper and it is easier to repair it. All of Europe, except United Kingdom, does have the same dimension system for pallets. The system is built on a module with a dimension of 400 x 600 mm. As a consequence of standardization of pallets, most of the packaging and packaging solutions are built on this module. The most common pallet is called EUR-pallet, and the dimension is 800 x 1200 mm. Most of the pallets that are used are returnable pallets, which mean that it is possible to reuse the pallets. A pallet which only can be used once is called one time pallet. The one time pallet is often weaker than a returnable pallet and the purchasing price is 30-50 percent lower compared to a returnable pallet. Using returnable pallets is usually cheaper in the long run because they

[35] Lumsden, *Logistikens Grunder*, page 481
[36] Packforsk, *Förpackningslogistik*, page 33
[37] Ibid, page 26

are used several times. The dimension of the pallet should make it possible to achieve a sufficient utilisation rate in the vehicle. The problem is that there are different inner dimensions in truck, rail and containers, which makes it difficult to standardize the pallet. The following dimensions on pallets have been standardizing by International Organization for Standardization (ISO):[38]

- 800 x 1200 mm (EUR-Pallet)
- 1200 x 1600 mm (Sea-Pallet)
- 800 x 1000 mm
- 1000 x 1200 mm
- 1200 x 1800 mm

To not utilised the capacity in full, will create huge costs for handling, storing and transportation. As such, the shape of the packaging and the pallet is very important.[39]

Transport packaging

The type of transport packaging that is used depends on the product and the packaging. To decide the dimensions of the packaging it is necessary to consider the wrapping method, how fragile the product is, the mode of transportation and the receiver country. It is important not to over pack and on the same time not to under pack. To over pack means when more packaging material is used than what is necessary, this leads to unnecessarily expensive packaging, increased distribution costs and greater environmental impact. To under pack is when the packaging does not meet the necessary requirements to protect the product, this can lead to damage products. Finding the balance between packaging cost and product protection is difficult. Even economic damages occur in the form of delayed deliveries, increased service costs, resulting in a bad experience, which lead to discontented customers. From an environmental point of view, to under pack products, has a greater affect in comparison to over pack.[40]

Product and packaging development

By developing products and packaging at the same time the mode of operation for the packaging will be optimised. A development process that takes place simultaneously will optimise the product and the packaging through the whole life cycle in consideration to market needs, quality, lead time and costs. An

[38] Lumsden, *Logiskens Grunder*, page 521-523
[39] Packforsk, *Förpackningslogistik*, page 26
[40] Ibid, page 26

optimal product and packaging development requires knowledge of the interactions between product durability, distribution and packaging.[41]

4.3 Supply Chain

The definition of a supply chain is the sum of all activities that is associated with the flow and transformation of goods, from raw material to finished products, and the flow of information between the involved organisations.[42]

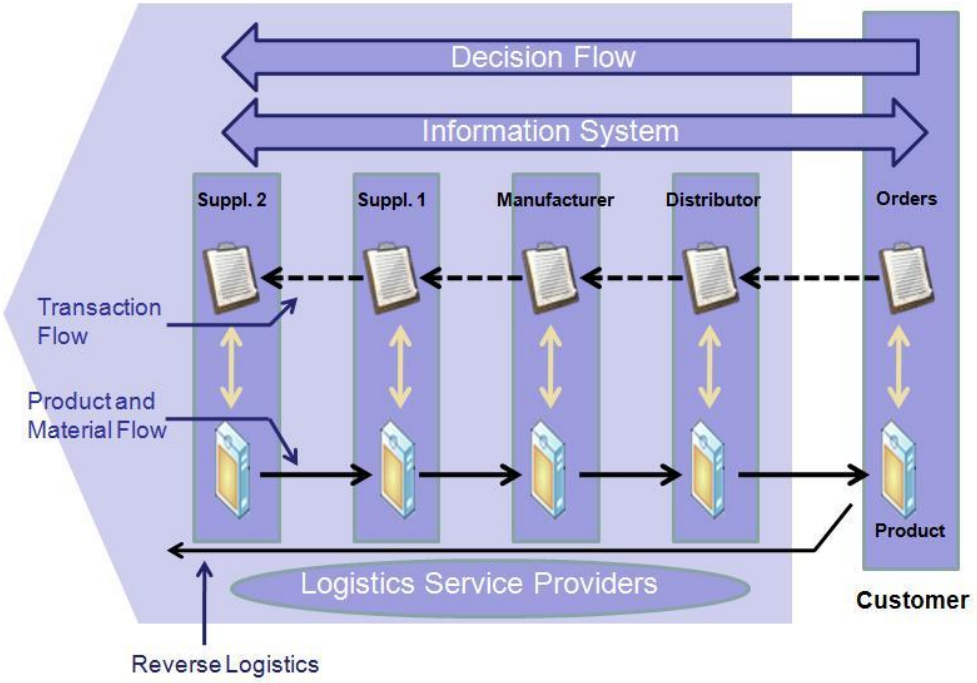

Figure 6 - Supply Chain[43]

The supply chain begins with the customer and it moves for example through four different stages, which can be seen in Figure 6. In reality the supply chain may be even longer. The decision flow includes determining the choice of structure, partners and processes. The transaction flow consists of financial documents and payments between operators. Movements of products and materials are beginning at the supplier level and they are then processed through the processes and activities along the whole chain until it reaches the end customer. After the product has been consumed, product recycling becomes a material flow backwards to a point of reuse, if it is possible. The physical movements between the various actors are done by different

[41] Packforsk, *Förpackningslogistik*, page 90-91
[42] Handfield & Nichols, *Introduction of supply chain management*, page 2
[43] Schary & Skjott-Larsen, *Managing the Global Supply Chain*, page 33

transporters, this can be either internal or external transporters. Information flow, which includes orders and product movements, should be available for all participants in the supply chain for both directions.[44]

Centralised or decentralised

The positioning of logistics activities are an important aspect to know how the companies should be managed. Positioning means where in the organisation activities will be placed. Activities can for large companies be held near the central offices or be spread out over the entire organisation.

A decentralised organisation means that the activities are spread out in various parts of the organisation and has advantages in terms of faster and more customised logistics for the individual customer. Decentralisation is preferable when the product lines are different in terms of logistics, manufacturing, marketing and when there are few economies of scales.

The main reason that companies choose to use a centralised organisation is to improve the control over the logistics activities and exploit economies of scale. When all the logistical activities are managed and coordinated by a centralised organisation, it is easier to counteract the imbalances between the divisions or factories as the comprehensive view is improved. The technical development in form of data processing has made it efficient to centralise activities such as order placement and inventory.[45]

Single and multiple sourcing

A company needs to decide whether they want to purchase the product from one supplier or from several suppliers. The company can become too dependent if they only purchase the product from one supplier. However, if the product is or can be purchased from more than one supplier, the supply risk is lesser than if only one supplier is used and it is possible to expose the supplier to competition if several suppliers are available.[46] More advantages and disadvantages can be seen in Table 1.

[44] Schary & Skjott-Larsen, *Managing the Global Supply Chain,* page 39
[45] Ballou, *Business Logistics/Supply Chain Management,* page. 705
[46] Van Weele, *Purchasing & Supply Chain Management,* page 161

Table 1 - Single & Multiple sourcing[47]

	Single sourcing	Multiple sourcing
Advantage	+ Better relationship, partnership + Better communication + More economy of scale, get lower costs and better negotiation against supplier + Easier to work, more focussed on processes and production innovation.	+ Push prices through competition + Supplier can be changed if delivery problems arise + Broad skills to be used from the supplier
Disadvantage	- Sensitivity in deliveries - Sensitive to volume fluctuations - Increased dependency and risk - The supplier can push the price upwards	- Difficult to build a commitment with the suppliers. - Working with communication is important - Difficult to maintain economies of scales - Suppliers less inclined to invest in new processes

Outsourcing

Outsourcing is performed when another company provides a service at least as efficiently as the company itself, but to a lower price. By outsourcing an activity, management and capital resources will be feed up and be able to focus on the company's core activity. Companies that outsource an activity can concentrate all their resources on areas that give the company a competitive advantage, and they are able to reach a higher rate of return. The disadvantage with outsourcing is that the company may lose its core competence and get very dependent on another company.[48]

4.4 Material

The main task of the packaging is to protect the product. Packaging should protect the product during transport and handling. There are many different packaging materials, all with their own unique characteristics, which combined gives a whole new packaging solution.[49]

[47] Andreas Norrman, Associate Professor Lunds University , *Lecture in Industrial Purchasing*, 2008-04-03, slide 37

[48] Schary & Skjott-Larsen, *Managing the Global Supply Chain*, page 58

[49] Packforsk, *Packet book of packaging*, page 59

Plywood
The plywood packaging is an important wooden creation. It is often used for transport of heavy gods and when it is necessary to stack in high staples.[50] The plywood packaging consist of a number of glue laminated wooden layers, each layer is turned 90 degrees in relation to previous layer, this to give a great strength in all directions of the plywood. The material has good bending stiffness and tensile strength as well. The absorption skills are good for plywood.[51]

Corrugated board
Corrugated board is a material which is easy to adapt to customer demand for packaging. The material can have different characteristics depending on the quality of the paper. The properties of the corrugated board can be chosen from a number of different thicknesses and qualities, it is all depending on the requirements from the packaging user. Almost all production of corrugated board is by special orders, customised packaging adapted for specific demands. The plane layer is called liner and the corrugated layer is called fluting. Corrugated board is material-saving, there is hardly any other material that gives it such as rigidity using so little material. Different kinds of wet-strengths qualities of corrugated board have been developed as well. The material can nowadays withstand moisture and other climatically stresses, this makes the area of use even wider.

Corrugated board is available in a number of varieties, adapted to meet the demands the product have on the packaging when it comes to strength and shock. In principle the following aspects decides the quality of the corrugated board, number of liner and fluting layers, the height of the corrugation and the paper quality. The profile of the corrugated board, the flute height, decides how thick the corrugated board will be. The thickness is given as a letter code and the most common types are designated B, C and E. F, G and N have also become interesting.[52] For more information about the different types of corrugated board, see Table 2.

[50] Packforsk, *Packet book of packaging,* page 59
[51] Jönsson, *Packaging Technology for the Logistician,* page 57
[52] Packforsk, *Packet book of packaging,* page 58, 64-65

Table 2 - Flute information in corrugated board[53]

Flute	Wave height, mm	No of waves/m
A	4,8	110
C	3,6	130
B	2,4	150
E	1,2	290
F	0,7	350
G&N	0,5	550

There are four different types of structure when it comes to corrugated board:[54]

- *Single-faced* corrugated board has one fluting layer and only one liner layer. It is therefore possible to roll-up the material and send it in reels. It is mostly used as wrapping material.
- *Single wall* corrugated board has one fluting layer with one liner layer on each side. Single wall is made with all common flutes.
- *Double wall* is a corrugated board with two fluting layers and three liner layers. They are delivered as sheets or finished flat packages.
- *Triple wall* corrugated board has three fluting layers and four liner layers. This one is delivered in sheets and finished flat packages as well.

Plastic films

Plastic is made from polymers and additives. A polymer consists of small molecules joined together. Depending on the chemistry of the molecules and in which way they are joined together, the polymers can have complete different properties. Examples of additives are fillers, stabilisers and softeners, which make the polymers suitable to use in practice.[55]

A lot of plastic films are made from synthetic and natural polymers to be used for packaging purposes. The most common material is polyethylene.[56] Plastic films have a great scope of use, it holds the goods together and protects the products against moisture and dirt.[57]

[53] Packforsk, *Packet book of packaging*, page 65
[54] Ibid, page 65
[55] Packforsk, *Förpackningslogistik*, page 16
[56] Jönsson, *Packaging Technology for the Logistician*, page 49
[57] Packforsk, *Förpackningslogistik*, page 17

4.5 Handling

It is important that the packaging is easy to handle in the plant. The requirement for manoeuvring depends on the style of the packaging (for example weight, volume, center of mass and something to hold on to) and the place in the flow. An efficient packaging system will reduce the handling costs and the risk of injuries for the staff working in the different flows. To facilitate the different handlings operations, the packaging should be easy to pack, easy to grip, easy to open, easy to pick up the gods, adapted to the manner of storage, easy to compress and adapted for reuse.

How the packaging should be handled depends on the design of the packaging and how the working environment looks like where the packaging is supposed to be handled. Handling operations and other equipment decide whether the packaging is manoeuvrable. A packaging may be too heavy to lift manually, but with a lifting tool it will be easier. Further, whether the packaging is manoeuvrable, also depends on the surrounding systems. The manual handling is not only dependent on the packaging, it is also dependent on people, as a person will always be in the handling system.

Automation of the packaging work is mostly done at various places in the distribution chain, for example, to pack the goods, picking from storage area etcetera. The shape of the packaging will of course affect the efficiency in the automated system. Other factors affecting the efficiency are the product, packaging material, machines in the plant, and other equipment. Even after the automation is made there are still a number of tasks around the machines, which need to be carried out by humans. To achieve the best efficiency as possible, the manual work that is required for automation should be eliminated as much as possible.[58]

4.6 Storage

Many people think that storage is something bad and should be avoided, despite that there are in reality several storage areas in almost every production company. Different parts of the company have different opinions about whether storage is good or not. The finance department wants the lowest possible storage levels, to avoid unnecessary frozen capital. The production wants to be able to have a high utilisation rate at their machines, which means that they usually prefer long production runs. To be able to do this the production needs to have products in stock.

[58] Packforsk, *Förpackningslogistik*, page 76-79

Lower storage levels means that less storage space and less shelving are required. On the other hand lower storage levels require more frequent in and out deliveries, which of course require more effort from the staff. Building storage should not be the first way to handle problems and should only be an alternative when no better solution can be found.

As soon as storage is required for something, it requires staff that can take care of handling, inventory, registration etcetera. There are also needs for equipment in the form of forklifts, shelves and of course some storage areas. All these costs are usually called warehousing cost and can be considered to be independent of storage levels and are not changed when the volume vary in a small range.

Products in storage do not add value, which means that the money the company has purchased the products for are locked until the products are ready for the market. If the company has the opportunity to liberate a part of the money, it could spend it on something that would bring in some income, such as marketing efforts. This binding of capital means a loss of revenue and is usually called cost of capital. Many corporations express this in form of a rate of return, which represents the company's best accrual of interest. To calculate the inventory carrying cost, the medium stock levels and the cost of capital are used according to the following relationship:[59]

*Inventory Carrying Cost = cost of capital * medium stock levels * price*

Central storage or regional storage

The producing company does not always deliver directly to the end consumer. To utilise the transport more efficiently, several different storage locations may be used with the task of collecting different parts and products from many different production sites. An important reason to have both central and regional storage locations can be that the physical distances are large and customers are spread over a large geographical area. Another reason is to be able to offer the customers a shorter lead time, in order to achieve this, the storage facility must be close to the actual market. The main reason is of course to minimise the company's own transport cost.[60] A schematic illustration of central and regional storage can be seen in Figure 7.

[59] Aronsson, Ekdahl & Oskarsson, *Modern logistik – för ökad lönsamhet*, page 102-105
[60] Ibid, page 67-68

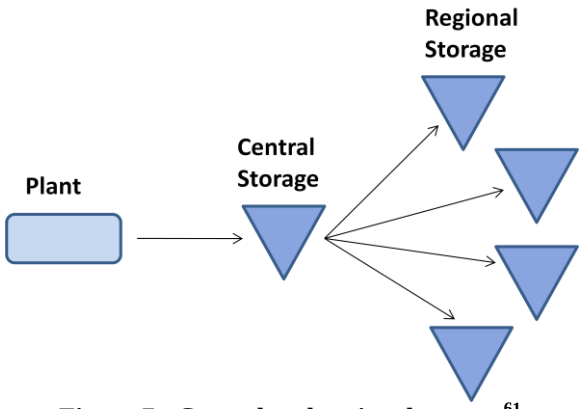

Figure 7 - Central and regional storage[61]

Vendor Managed Inventory (VMI)
VMI is a type of business model where the buyer of a product provides information to the supplier of that product and the supplier takes full responsibility for maintaining an agreed inventory of the material. This is often located close to where the buyer will consume the product. It is an efficient solution to enable the supplier to respond directly to actual demand without distortion and delay of decisions in the customer's purchasing organisation.[62]

From the manufacturers' and distributors' perspectives, there are both advantages and disadvantages. Advantages with VMI are that double inventory is eliminated and there is a good possibility to build up a relationship between the manufacturer and the distributor. A disadvantage with VMI is it requires a high level of communication and both parties need to be open with there business to enable the other party to plan and organise their work. Another disadvantage is the difficulty with unstable demand and as with other larger changes, difficulties with the implementation.[63]

4.7 Freight

Every time a company needs to move products from one point to another they need some kind of transport. There are mainly four different transport modes, truck, rail, sea and air. The transport should be performed to the lowest price, the shortest lead time and a high level of delivery service. In addition to these

[61] Aronsson, Ekdahl & Oskarsson, *Modern logistik – för ökad lönsamhet*, page 68
[62] Schary & Skjött-Larsen, *Managing the Global Supply Chain*, page 205
[63] Van Weele, *Purchasing & Supply Chain Management*, page 308-309

requirements, flexibility is also important, as well as the size of the volumes shipped and on which days shipments can be sent.[64]

Truck transport
Trucks' capacity is small in comparison to other modes of transportation, which means that the truck can easily be adjusted to a single customer's demand. This is also a presumption, for effective, and for the transport buyer, attractive direct relationships. A truck can easily be rerouted both before and during transport due to the high standard of the infrastructure. The flexibility is not only the trucks' ability to transport products between all destinations, they also have the opportunity to use a number of different types of trucks to fit the customers' demands.[65]

Rail transport
The railway is characterised nationally as well as internationally that it is sparser than the road network. It is important to know that most of the actual railway was built more than 100 years ago and was built for the demand at that time. During the past years, several smaller railway lines have been shut down. Most of the railway network is made of the main railway lines between the larger cities.

The thinning out of the railway can partly be explained by the fact that the railway is mostly used for large shipments. This means that the railway becomes the most profitable transportation option on those distances where large shipments are sent.

One way of increasing the usability of the railway is to increase the volumes by using another way of transporting goods from several suppliers by combining different modes of transport. For example, goods can be collected by truck from senders in a certain area, and they will finally be delivered together to a terminal in the specific region. All goods are then transported on the railway to a terminal in the actual area, where trucks take over the goods again and deliver to the right destination.[66]

Sea transport
Transports by sea have the largest cargo carrying capacity compared to other forms of transport such as truck, air and rail. Sea transport has also a very low variable costs. These two factors contribute to the fact that transport by sea is

[64] Aronsson, Ekdahl & Oskarsson, *Modern logistik – för ökad lönsamhet*, page 118-120
[65] Lumsden, *Logistikens Grunder*, page 114
[66] Ibid, page 135-136

usually the cheapest transport alternative when calculating the cost of weight per kilometre.[67]

Air transport

The demand for fast and safe transports has during the last decenniums increased as a consequence of the introduction of a new approach in production, using centralised storage and specific production for each customer. Aircraft is today the fastest way to transport both goods and passengers on longer distances. Air transport is an expensive transport method with both large fixed and variable costs. Transport cost per kilogram is therefore higher than for other transport modes.

Within air transport, cargo is considered regular and charter flights are kept separate. The regular traffic has fixed departure time, routes and arrival times and the price for cargo is determined by international tariffs. Air transport is separated from other forms of freight transports because of a small range of the total goods are transported in dedicated full freighters. Instead the goods are transported at passenger traffics lower deck, which means that the goods are transported at the passenger traffic conditions.

The time between order and delivery has become an important factor in the competition between different companies and products. One of air transports' prime features, is that it has a very short transport time. The products that reach the customer quickly have an intrinsic value linked to any advantage it can provide to the customer in its business. At the same time, shorter transportation time means that the frozen capital in transported goods decrease, which leads to a decrease of the cost of capital during the transportation as well. Because of this, four main types of products can be distinguished: [68]

- *Perishable products* – Several products can fast lose their value, for example perishable products like fruits, vegetables and flowers.
- *Products with news-value* – Products with a short life cycle, like newspaper and fashion products are also dependence of a fast transport so they are not outdated.
- *Products that require fast deliveries* – A manufacturing unit in a global supply chain can easily be hit by arrest due to lack of components or spare parts. Short transportation time can then save large amounts and the costs for the transports are secondary.

[67] Lumsden, *Logistikens Grunder*, page 163
[68] Ibid, page 193-201

- *High-grade products* – For products with high value per weight and per unit, short transport time, will be the most prominent competitive advantage. The reduction in frozen capital can motivate higher transportation costs

4.8 Damage

The function of the packaging is to protect the product against everything that can occur to damage the product. Damage may depend on a variety of things such as deficient packaging, the goods cannot be mixed with other goods, the goods cannot be secured when loaded, vehicles breakdowns and accidents, negligence and careless handling. The highest costs related to damage during transport are overseas transports. These transports have around three times higher damage costs compared to a transport within the country or region.[69] Depending on which transport mode that is chosen, different hazards appear which require an understanding for the packaging designer. Truck and rail have the same hazards. The dominating hazards are vibrations, which depends on the road surface, speed and loading. Bouncing is an important hazard for trucks as well, which is caused by poor infrastructure and poorly maintained roads. For sea transports the hazard are low frequency vibrations from the boats engines. Another problem when it comes to boat is the stowing conditions. Hazards such as high frequencies from engines, the low pressure and temperatures appear when air transport is used.[70]

To reduce damage during handling, it requires more careful methods, better training of the staff and improved packaging. There will always be some kind of cost related to damage during transport. No packaging can be made in such an efficient way, that it will protect the goods from all kinds of stress. The more efficient a packaging is made to protect the product, the more expensive it becomes, while the damages will be reduced. The economically most favorable situation occurs when the amount of packaging costs, including other attendant costs are as low as possible.[71] An illustration can be seen in Figure 8.

[69] Lumsden, *Logistikens Grunder*, page 494
[70] Jönsson, *Packaging Technology for the Logistician*, page 82
[71] Lumsden, *Logistikens Grunder*, page 494

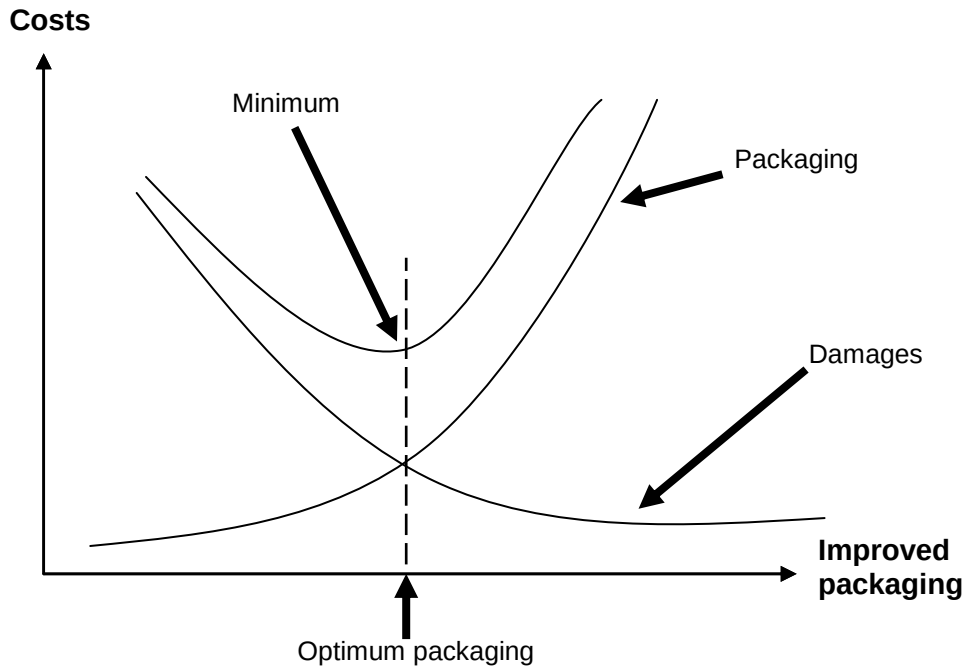

Figure 8 - The efficiency of the packaging[72]

4.9 Disposal

Recycling is when the entire used packaging or a part of it is processed in different ways so the packaging material can be reused as a new packaging or as another product. It is not always easy to get a complete material recovery from the packaging. The recycled packaging has to consist of one single homogenous material or components that easily can be separated from each other, in order to use the material again. Thus, the corrugated board is one of the materials that dominate the recycling of packaging. One problem is that the packaging material can not be recovered unlimited times, because the cellulose fiber of material based on paper gets worn out. The recovered material of paper has to be supplemented with newly produced material, and this is the reason why paper seldom is made from 100 percent recycled material.[73]

Used plastic products can be reused or recycled. When a plastic product has reached its use-by date, it is important that it is handled in a way that is environmentally acceptable. What seeks to increase the resource conservation and reduce the environmental impact. There are three different ways of handling products past their use-by date, mechanically recycled, commodity

[72] Lumsden, *Logistikens Grunder*, page 495
[73] Packforsk, *Packet book of packaging*, page 94

recovery and energy extraction. Energy extraction is using the high energy content, which is built into plastic materials and it is used to produce electricity or heat. This is a good alternative in case the environmental impacts from recycling are greater than the environmentally benefits. Plastic has high heat content while it is made of oil. By using plastic as a fuel, other natural resources such as oil, gas and coal can be saved. Soft plastic products are mainly recycled as energy extraction.[74]

[74] http://www.plastinformation.com/2006_Om_plast/Atervinning.aspx, 2008-11-03

5 EMPIRICAL RESEARCH

In this chapter the author will present how Packaging Material Management (PMM) work and what they do. A description of what the Packaging Engineering Group (PEG) does and a small presentation of one of Ericsson's products, Radio Base Stations (RBS). Finally the six cost parameters with containment will be presented.

5.1 Packaging Material Management (PMM)

PMM is a project group in the business unit called Business Unit Networks (BNET). PMM was formed at the end of year 2007, with the aim to take care of all packaging related issues/problems. Before this group was established, there were no clear directives in terms of packaging and there was no division/department that was responsible for packaging. No one did actually care about the cost for the packaging and no one knew the true cost of it. When sourcing purchased a product, they were unaware of the price they paid on the packaging. Ericsson has always used the same packaging supplier, and they have been using the same kind of packaging, no matter what packaging requirement each product had.[75]

PMM has the structure as you can see in Figure 9 where they have different areas of responsibility.[76]

[75] Presentation: *Lund Universitet 2008-06-18*, Mats Lundgren
[76] Ericsson AB, Intranet, 2008-09-18
http://internal.ericsson.com/page/hub_inside/products/packaging/pmt/dor.jsp

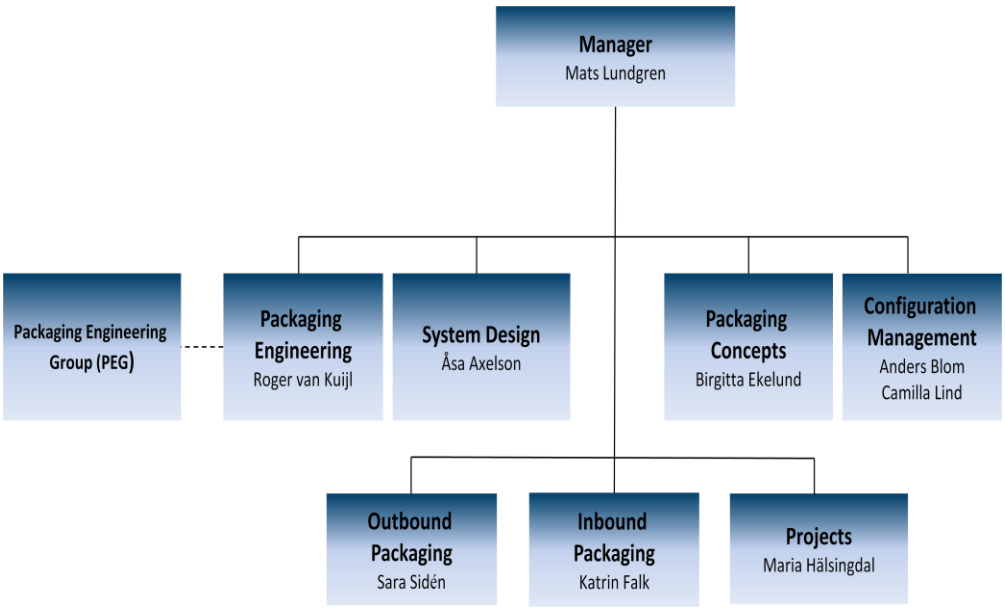

Figure 9 - organisation schedule[77]

Manager – Has an overall responsibility for packaging material, total cost and use within the Product Life Cycle.

Configuration Manager (CM) – Is responsible for maintaining and updating the product and documentations system. The CM from each site is also responsible for the release plan of that site.

Packaging Engineer – Is responsible for the requirements on the packaging material design, coordination of design reviews, review of test criteria and verifications. Coordinate with other sites.

Inbound Packaging – Taking care of all packaging that comes in to the different sites. Ericsson only wants specific kinds of packaging so it will be easier to handle the packaging at the different sites.

Outbound Packaging – Responsible for all the packaging out from the different sites, the packaging should have the right shape and good strength. The most cost efficient packaging should be used.

Packaging Concepts – Looks for new packaging concepts and tries to find improvements of existing concepts. Searching for the most cost efficient concept, focus on returnable solutions.

[77] Presentation: *PMM Organization,* Mats Lundgren

System Design – Is responsible for how the packaging system is built and is responsible for the roadmap, mapping out how the packaging flow looks like.

Projects – Handles different projects that concern packaging and packaging flow.

PMM wants the packaging and packaging material, through the whole life cycle, to be handled using the same processes and routines as any other Ericsson product.[78] The main goal for PMM is to reduce the cost related to packaging, which is the reason that Ericsson started this project. A lot of people think, "*Packaging, how difficult can it be, it is only a box"*. PMM will prove that packaging is more than just a box and that a lot of money can be saved.

The project group has formed a way of working where they are responsible for all kinds of packaging in Ericsson. The whole company should manage packaging material in the same logical way, no matter country or culture.[79] PMM wants to optimise and reduce the total cost of all packaging and packaging materials in all kind of flows, this among other things will be made through the calculation model. By using the Packaging Material Roadmap, the strategic direction of the area will easily be chosen for all personnel who are working with packaging.

PMM is also responsible for giving all the packaging and packaging material an item number, the number starts with RTK or RTJ depending of what kind of item it is. ABC-classes are the name that Ericsson is using for this. PMM is supposed to look for new packaging concepts and also improve existing concepts. Packaging business case model is used by PMM to see what costs are related to packaging. Other areas of responsibility for PMM include: Adoption Requirement Handling Process for packaging, Adoption Design and Release process for packaging.[80]

5.2 Packaging Engineering Group (PEG)

PEG is a group with packaging engineers from all sites, Borås, Coventry, Gävle, Jaiupur, Katrineholm, Kista, Kumla, Marcianise, Nanjing, Shanghai and Älvsjö. PEG is coordinated by PMM. PEG is an overall corporate packaging engineering flora. They are holding the packaging technical

[78] Ericsson AB, Intranet, 2008-09-18, http://internal.ericsson.com/page/hub_inside/products/packaging/index.jsp
[79] Mats Lundgren, Manager Packaging Material Management, Ericsson AB, 2008-09-03
[80] Presentation: *Communications 2008-06-25*, Mats Lundgren

competence within Ericsson. PEG is product and supplier independent and they observe new technical packaging solutions.[81] The packaging engineers from the Swedish sites have a close cooperation where they have a meeting once per month. The work is based on templates to be followed by the entire work process.

The packaging engineers are involved at the early stages in the development of a new product. This is made in cooperation with product designers. By being involved during the early stages, the packaging engineers have more power to influence the product's appearance. The packaging engineers do not design the packaging solution, their core work is to coordinate the work to the supplier and they are responsible for the documentations.

The packaging engineers will receive a paper from the product designers with various information about the product. This information is used to develop a new packaging of desired features. Next step is to contact their single packaging supplier. The supplier will receive a form where all the necessary data is written, the supplier can then produce a desired packaging that meet the requirements from Ericsson. After the supplier has produced the packaging, a strength test is made at a company called Packforsk, this is to ensure that the packaging pass the requirements. Finally, sourcing will negotiate with the supplier before the packaging will be ready to use, the packaging engineers are not involved in this last procedure.[82]

5.3 Packaging Material

At present time every Radio Base Stations (RBS) sent from Sweden are packed in a packaging that is made of plywood. RBS are pretty big and heavy, which makes it important to have a packaging that can handle quite a lot, both in handling and transport demands. In India there is a test where they are using corrugated board instead of plywood, this will reduce the weight by 36 percent and the material cost by 20 percent.[83] The packaging engineers is testing a new kind of packaging, it is a type of stretch film in which the hard edge protection are used as well, this will probably reduce the packaging cost a bit more.[84]

A company in the packaging industry called Boxon, believes that the best alternative to plywood is strong corrugated board. The flutes are closer to each other and the lines are more robust in a strong corrugated board compared to a

[81] Ericsson AB, Intranet, 2008-09-29,
http://internal.ericsson.com/page/hub_inside/products/packaging/org/peg.jsp
[82] Tony Westlund and Thomas Arneberth, Packaging Engineering, Ericsson AB, 2008-09-11
[83] Anders Blom, Configuration Management, Ericsson AB, 2008-09-11
[84] Tony Westlund and Thomas Arneberth, Packaging Engineering, Ericsson AB, 2008-09-11

regular one. According to Boxon, the weight of strong corrugated board is half of the weight compares to plywood, and this will reduce the transportation cost. There are more advantages with strong corrugated board such as it requires less storage space and it is easier to handle for the receiver. It is more ergonomic for the warehouse staff as well to handle strong corrugated board, while the weight is lower. The pallet can be made in strong corrugated board as well, which makes the packaging solution homogenous. This is unfortunately not possible for RBS, they are too heavy.[85]

5.4 Radio Base Stations (RBS)

RBS makes it possible to use mobile phones. The base station receives signals from mobile phones and transmits the signals to other mobile phones or fixed networks. RBS are connected to masts that are sending radio waves. The waves can only travel a specific distance and base stations can only carry a limited number of calls, which is why it is necessary to have many RBS. Without base stations it is not possible to make calls with mobile phones, and if the distance between two RBS is too far away from each other the calls will be interrupted.[86]

Ericsson's RBS product families consist of a range of different base stations, which have different capacities and can address a large variety of radio applications. For GSM radio network (2G) Ericsson's product families are called RBS 2000. The RBS 2000 family comprises of both indoor and outdoor RBS versions and offers RBS solutions for literally all needs. The RBS 3000 family (3G, WCDMA) meets the growing opportunity for mobile broadband.[87] For information about the different figures in RBS family, see Figure 10.

[85] Ralf Pålsson, Business Support, Boxon Pak AB, 2008-11-07
[86] http://www.mobilemastinfo.com/information/faqs.htm, 2008-11-25
[87] Ericsson AB, Intranet, 2008-11-25,
http://prodcat.ericsson.se/default.asp?ArticleId=7F1CD160-E13C-4D9A-B396-D0284A358D1A&N=27819

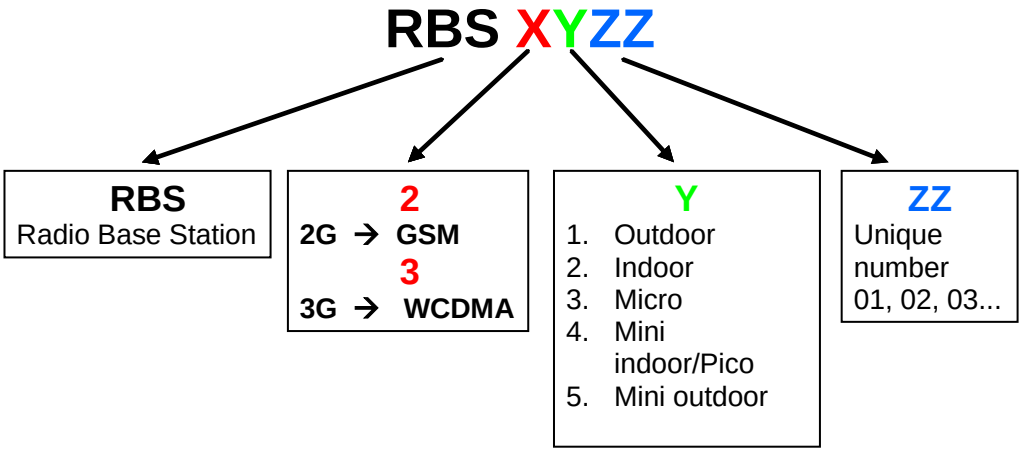

Figure 10 - RBS classification[88]

Different site products are needed to complete Ericsson's site solutions, which includes:

- Antenna systems (antenna, TMAs, filters, feeders)
- In-building system
- Installation materials and tools
- Power for outdoor and indoor RBS
- Positioning and synchronization products
- Transmission

Ericsson can support their customers to acquire, engineer and develop their RBS sites.[89] See Figure 11 for example of a Radio Base Station, RBS 2106.

[88] Torbjörn Jonsson E, Senior Adviser RAN Solution, *Introduction to Mobile Radio,* 2008-03-05

[89] http://www.ericsson.com/solutions/page.asp?ArticleId=9099DA17-1854-42CA-8F28-4C4BC6322087, 2008-11-25

Figure 11 - RBS 2106[90]

5.5 Six cost parameters

PMM has identified that the cost of packaging consists of six main areas, which is illustrated in six cost parameters. Inside of these parameters there are a variety of factors that affect the packaging cost. The six cost parameters are: Material, Handling, Storage, Freight, Damage and Disposal, see Figure 1. PMM believe that there is a potential to save several hundreds of millions Swedish kronor in a two year time frame by changing the packaging system. The two biggest cost items are Material and Freight. Disposal and Damage are difficult to calculate and PMM does not know how much the cost actually is, but they have made an assumption.[91]

[90] Ericsson AB, Intranet, 2008-11-25, https://rvi.se.ericsson.net/,DanaInfo=prodcat.ericsson.se+default.asp?ArticleId=D7969D30-E040-450D-9137-15D5D0706ADD&N=27990

[91] Presentation, *Lunds Universitet 2008-06-18,* Mats Lundgren

5.6 Material

Material includes the direct cost of the physical packaging material (for example: plywood, corrugated cardboard), both from factory, local materials as well as from customers. It also includes the inbound material, the cost of packaging products that are bought from suppliers. Other costs that are associated to inbound material are included as well, like freight and so on.[92]

The packaging that are used for RBS are purchased from Ericsson's single source supplier and are made of plywood. Example of a packaging for an indoor RBS (RBS 2206) can be seen in Figure 12. The price of this packaging depends on the size of the packaging.

Figure 12 - RBS packaging made of plywood[93]

To calculate when and how much to order, Ericsson uses both mathematical methods and for some products the suborder self estimate how much and when to order new packaging material. The order volume is based on the purchaser's and warehouse group leader's experience and how large the future orders are. The suborder is not experiencing this as a particularly bad method as the lead time for packaging material is only one day.[94]

5.7 Handling

This is the cost of handling packaging material, how much time that is spent on handling different types of packaging. This depends on the weight and the dimensions of the packaging. At the moment some packaging products are stored outside the plant, which means that the forklift driver has to drive long distances to pick up new packaging material. All the time spent on handling the packaging by staff and the costs that arise during this process, are included in this parameter. The cost of purchasing the material and the financial administration are included here as well. Repacking at the different plants takes a lot of time and needs to be considered too.[95]

[92] Presentation: *Cost of the box Rev C,* David Ekberg
[93] Jonas Nymans, Packing Instruction, 151 91-RTK 993 5612/4
[94] Daniel Pereira, Operational Sourcing/Material Management, Ericsson AB 2008-10-07
[95] Presentation: *Cost of the Box Rev C,* David Ekberg

The packaging materials for some RBS units are today delivered into a storage area outside the plant. All these products have separate assembly stations and are using different storages. This means that the handling time to drive the forklifts from the storage to the assembly stations is different.

The larger RBS units are delivered into the plant in Gävle in the same packaging that will be used in the outbound flow. This packaging will be stored at another storage area than the other packaging material. The storage is not situated in connection to the plant and therefore Ericsson has to hire a transport company whose single job is to transport products between the plant and the storage, located in Gävle.[96]

5.8 Storage

This includes the additional cost of warehousing the packaging. This depends on the size of the packaging, how many packages that are stored and for how long time the packaging is stored. The storage cost depends on the price of the packaging as well. A corrugated board would reduce the storage cost with at least 20 percent.[97]

Ericsson has no available data on how much of the total packaging material is being used in the production relative to the storage area. As the forklift driver has to bring in new material from the storage area, which in Gävle's case are some tents, several times every day, thus a majority of the material are stored outside the production.

The packaging materials in the tents are owned by the supplier and the usual scenario for this type of storage solutions, is that the ownership of the material will be transferred to Ericsson once they pick up the material at the tent. There are today, in Gävle, no possibilities to implement that kind of ownership deal, therefore the supplier owns the packaging material until the RBS unit is packed and ready to be shipped out. However, the supplier want to change this scenario so that the ownership is transferred when Ericsson starts using the packaging material.[98]

5.9 Freight

The freight cost includes the additional cost of transporting the packaging. This is driven both by weight and by size. A part of the cost is related to threshold values, for examples the height to fit into the lower deck of the aircrafts, and if the density is high (measurement cargo) the cost will be on the

[96] Daniel Pereira, Operational Sourcing/Material Management, Ericsson AB 2008-10-07
[97] Presentation: *Cost of the Box Rev C*, David Ekberg
[98] Daniel Pereira, Operational Sourcing/Material Management, Ericsson AB 2008-10-07

volume instead of the weight.[99] Ericsson is paying the transporters for weight (air) or for cubic meters (boat and truck). There is different freight breakpoint depending on what mode of transport that is used, for air it is 167 kg/m^3, for truck it is 330 kg/m^3 and for boat it is 1000 kg/m^3.[100]

Ericsson has a special department that has the overall responsibility for the functioning of the physical distribution and warehousing solution in the supply chain throughout the world, the name of the department is Ericsson Distribution Logistics (EDL). The core staff is represented by the organisational unit Central Distribution Logistics (CDL) which is situated in Kista. EDL is working with three main tasks:[101]

- To design, implement and maintain global distribution and warehousing process of a world class standard.
- To select, contract and maintain a suitable number of Distribution Service Providers (DSP's) and ensure their operational performance.
- To develop end-to-end distribution solutions for all customer flows.

At present Ericsson is using three different DSP's, the DSP's are DHL, Panalpina and Kuehne & Nagel. Schenker will soon become a DSP as well.[102] DSP is responsible for the main transport, the long transport that is made by aircraft, boat or truck. Provider Management's is responsible for negotiating with DSP to bring out different tariffs for each mode of transport. There are about 20 Market Distribution Management (MDM) in the world. MDM's tasks are to find the best local transporters and storages. MDM is working in the different markets that Ericsson is active in.

Ordering shipments from DSP is made by Customer Distribution Management (CDM). There are more than 250 people around the world who are working as a CDM. A CDM collects various orders and distribution orders to one destination, to finally make a shipment of all the orders. When the shipment is completed, a transport order is made to one of the DSP's. The DSP often picks up the shipment at a regional storage facility where different packaging units are collected from different factories in the same country or in other countries. Transports made from the factory to a regional storage facility are made by local transporters. Various suppliers sometimes transport goods to the regional storage facility as well to complete the shipment. This is done to avoid

[99] Presentation, *Cost of the Box Rev C,* David Ekberg
[100] Rickard Ström, Process Supervisor Warehousing, Ericsson AB, 2008-10-14
[101] Ericsson AB, Intranet, 2008-09-30,
http://internal.ericsson.com/page/hub_inside/company/distribution/about.jsp
[102] Helena Morberg, Other Operative Supply Ma, Ericsson AB, 2008-10-20

unnecessary transports. The DSP is transporting the goods to a local storage area in a specific country, this storage facility may be close to a harbor or an airport. From the local storage the goods will be transported by a local transporter to the customer.[103] For an illustration, see Figure 13.

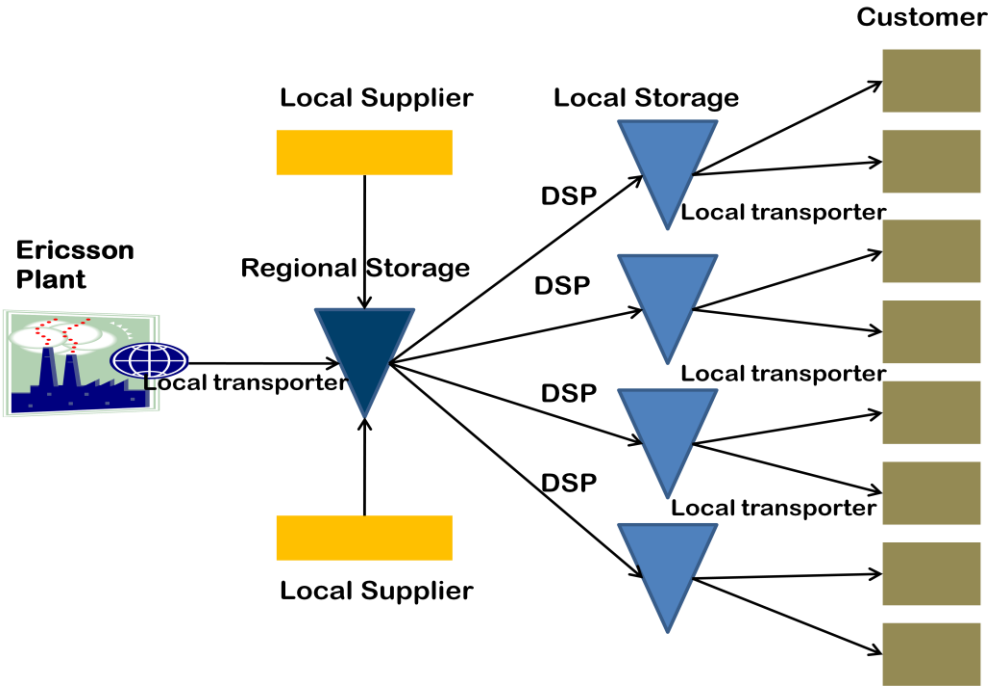

Figure 13 - Transport map with regional and local storage

CAT Logistics Services International

Ericsson's regional storage facility in Sweden is situated in Huddinge, Stockholm, and it is managed by CAT Logistics Services. When the storage facility was built in 1967, the storage was Ericsson's central storage facility and owned by Ericsson AB. In 1998, Ericsson outsourced this service to CAT and now CAT is handling a part of the storing and shipping overseas from the same storage as Ericsson owned before. It is not only Ericsson's products that are handled by CAT, there are two other companies that are using this service too. Ericsson's products are separated from the other company's products.

Upon Ericsson's request, CAT may repack the goods as well, it is mostly repacking of corrugated cardboard to plywood where the products come from different suppliers. About 10 percent of the products are repacked. 2000-3000 packaging units from Ericsson's plants and suppliers are handled by CAT every day, both ingoing and outgoing. The storage space is more than 50 000 m^2 and has more than 100 employees working with storing, packing and

[103] Rickard Ström, Process Supervisor Warehousing, Ericsson AB, 2008-10-14

shipping Ericsson's products. Another service that CAT is helping Ericsson with is storing spare parts. CAT is sending spare parts directly to Ericsson's customer because it is often very urgent and it is sent by air transport. Ericsson has spare parts in stock for at least ten years.

CAT is also providing Ericsson with handling of documents. Products are sent to CAT from all over the world to get their documentation. The goods are then coordinated together, for those with the same destination, and are then sent as one shipment with all the related documents, customs documents are an example.[104]

Future/Ongoing Process
CDM as a function is soon going to be replaced by a shipping department. This shipping department will be centralised, the department will choose DSP and mode of transportation. They will be responsible for creating a shipment as well and coordinate everything around the shipment. Departures, both in terms of air and boat, will take place on fixed days. The shipment must then be ready if it is supposed to be sent that week, otherwise the shipment will be postponed to the next week. EDL wants the shipment to be more coordinated, in order to send fewer shipments/orders to the same customer. Overall, this will generate lower prices from DSP.[105]

Insurance
Ericsson has three different insurances that cover everything during the transport, from the factory to the customer. In some countries the insurance is invalid because of the special rules they have in that country, unfortunately, Ericsson can not do anything about this.[106]

5.10 Damage

Damage includes all the additional costs due to damaged products. The products might need to go back to the site for replacement if it is in a bad condition, or spare parts may need to be sent to the customer.[107] Statistics on any damaged products or packaging that occurred during the transport is difficult to obtain. The reason is that it is difficult to know whether the damage is due to the transport or not. Therefore, this is never reported. Instead Ericsson is sending substitutes.[108]

[104] Rune Karlsson, Account Manager, CAT Logistics Services International, 2008-10-21
[105] Rickard Ström, Process Supervisor Warehousing, Ericsson AB, 2008-10-14
[106] Rickard Ström, Process Supervisor Warehousing, Ericsson AB, 2008-10-14
[107] Presentation, *Cost of the Box Rev C*, David Ekberg
[108] Rickard Ström, Process Supervisor Warehousing, Ericsson AB, 2008-10-14

5.11 Disposal

This includes the disposal cost of disposing the packaging in an environmentally friendly way. The cost of disposal is difficult to get the correct figures on, as such, Ericsson has estimated how large the costs are. Ericsson estimates that for about 50 percent of the packaging deliveries, they will not need a local disposal, as the packaging is reused by the community.[109]

Ericsson only has figures of the disposal costs from a few countries, and the costs are counted differently in different countries. Some countries are paying the recycling cost per packaging, other countries are paying per ton of recycled material. For example, companies in United Kingdom are paying 360 Swedish kronor per ton material in recycling cost, when the packaging material is made of plywood. Japan is paying 1 000 Swedish kronor per packaging in recycling cost for the same material.[110]

[109] Presentation, *Cost of the Box Rev C*, David Ekberg
[110] Mats Lundgren, Manager Packaging Material Management, Ericsson AB, 2008-10-31

6 Model description

In this chapter the calculation model will be described with help of the six cost parameters and the total cost will be showed in a diagram.

The calculation model should be able to calculate the total packaging cost as well as comparing and simulating the cost for the different packaging solutions. In order to find the most cost effective solution, the calculation model should be able to handle several parameters, such as the dimensions of the product and the packaging, different transport modes and several shipping destinations.

All of the six cost parameters (material, handling, storage, freight, damage and disposal) have their own data area where the user has to fill in respective packaging data. The user is allowed to compare up to four different packaging solutions and the total cost for each area is showed and marked by a colour depending on whether it is the cheapest or the most expensive solution. Green colour is used to show the cheapest solution and red the most expensive, which means that the total cost for each parameter lucidly can be compared. The calculation model has a delimitation, it is only able to calculate one-way packaging and not returnable or multi packaging. Within one-way packaging the calculation model handles both single product and several identical products in the same transport packaging.

The calculation model is made up of several areas interlocked with both the product itself and the packaging cost with the six parameters as the major parts of the model. All costs that can be considered equal independent of the packaging solution is not included in the calculation model. Examples of these costs are depreciation of forklifts, buildings and machines.

The first data area, which has to be filled in by the user, is actual product data with dimensions, weight, annual sales volume and cost of capital. If the user wants to compare different packaging solutions and the offers for the solutions are in different currencies, there is a possibility to choose which currency that should be used in the calculations.

The development of the calculation model is made with consideration for activities relating to the RBS units, however, this result in the calculation model not being a general tool for all kinds of products.

For a deeper understanding of the underlying calculations in the calculation model, see appendix (***Model description***).

6.1 Material

The first of the six cost parameters is material and the only cost that affects the total material cost is the purchase price. In case that there are several identical products in the same packaging, the purchase price is divided per product. The choice of material affects all the other parameters as well in some way, but the cost for the parameter ”Material” is the purchase price. The dimensions and the weight of the packaging are however important for future freight calculations and for calculating the disposal cost.

6.2 Handling

The parameter handling considers all handling times, from when the truck with packaging material arrives to the site until the products are assembled and ready to be shipped. The handling times are divided into two different categories. The first category is directly linked to the handling time of the packaging. The other category considers additional packaging time required for other handling processes, such as unloading goods and transporting pallets of packaging material within the site. The reason for this is to process for the user to show how different packaging solutions affect the direct handling time of the packaging. When the handling times are determinate, the next step is to convert these times to a cost. To be able to do this, a general figure is estimated, which represents the cost of one person working for one minute in production. In this cost, both wages and social charges are included. The cost depends on different countries and wages. There is a small fluctuation in wages within a country, but they are so small that a general figure for every country is an approximation that can be considered good enough. With this feature in the model it is possible to compare two identical packaging solutions that are being produced in different countries with different wages.

6.3 Storage

The storage cost, in the model, is divided into two parts. The first part calculates the storage cost for packaging being stored in the production, and the second calculates the cost for inventory of finished goods, which is usually stored outside of the production. To obtain a correct storage cost, the user of the model has to know four different parameters:

- For how long the packaging are being stored in average
- The price per square meter of production/inventory for finished goods
- How big area the packaging material is occupying in the storage area
- The cost of capital

These four parameters are used to calculate both inventory carrying cost and the warehousing cost. Finally, the user will receive the total storage cost from these two.

6.4 Freight

The freight cost is based on actual data from Ericsson so the prices underlying the calculation are no estimates. The user has to choose both where the packaging is delivered from and the destination.

There are only two transport modes, air transport and surface transport, as truck and sea transport are not concurrent. For surface transport, truck is used for shorter distances and sea transport for longer distances. The calculation model handles current breakpoints in both air transport and surface transport.

The destinations are divided into five regions, Western Europe (WE), Central Europe and Middle East (CEMA), Asia and Australia (APAC), Latin America (LA) and North America (NA). There are also two countries that have erupted from the regions, India and China, and that is because Ericsson ships large volumes to these countries. There is also one "region" called "World" and this region considers all transport from Ericsson as well as the allocation between air transports and surface transports, to every region. For the other seven regions, the freight cost is separated for air transport and surface transport. The calculation model also shows which one of the DSP's that is the cheapest alternative for the specific region and which transportation mode that should be used. For an illustration see Figure 14.

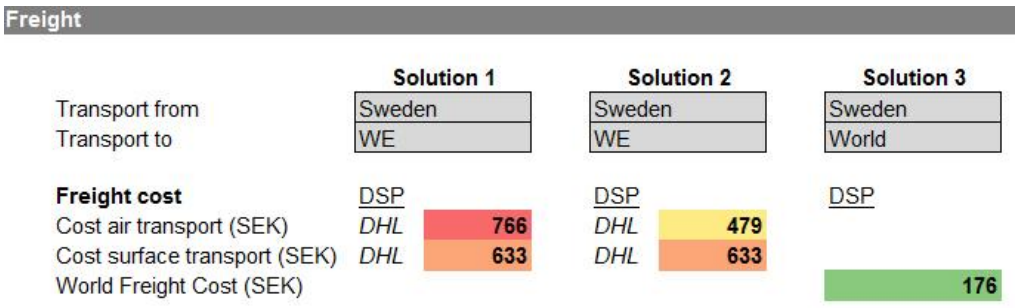

Figure 14 - Freight Cost

6.5 Damage

The material and the type of packaging solution chosen, affect the amount of damage to the packaging. As it is hard to decide what damages are directly related to the packaging, there is no or very little data on damage cost. This means that for this part of the model, it is hard to obtain an exact damage cost,

so the quality of the result depends on the user's ability to estimate how often there will be packaging damages and how big the cost will be per opportunity.

6.6 Disposal

The disposal cost depends on what kind of material is being used in the packaging. The recycling cost can either be calculated from a disposal cost per ton or per packaging. This recycling cost cannot be considered equal within a region as every country has different customs and taxes, which also varies depending on material. Therefore, the user has the opportunity to choose whether the specific destination has any recycling cost, and whether they have recycling cost per ton packaging material or per packaging.

6.7 Summary six cost parameters

The total packaging cost for all the six cost parameters are shown both with figures and with diagrams. There are two types of diagrams, circle diagram and bar diagram. The circle diagram shows the percentage breakdown between the six parameters, for each solution. For an illustration of the circle diagram see Figure 15. The bar diagram shows, in the same diagram, all solutions side by side in order to present the result lucidly for the user. There are three bar diagrams, one that presents the result percentage, one that presents the absolute cost for each parameter and finally one that shows the total packaging cost. The three bar diagrams can be seen in Figure 16, Figure 17 and Figure 18.

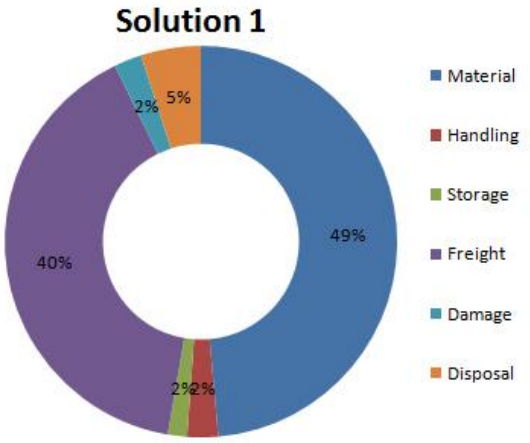

Figure 15 - Circle diagram

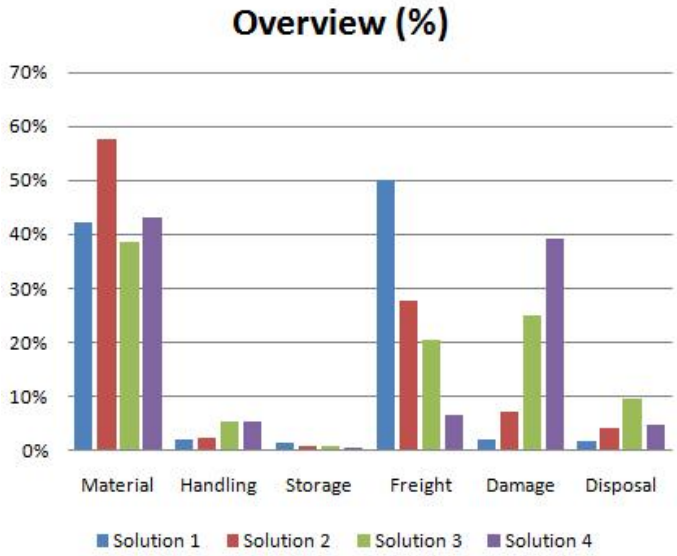

Figure 16 - Overview total cost (%)

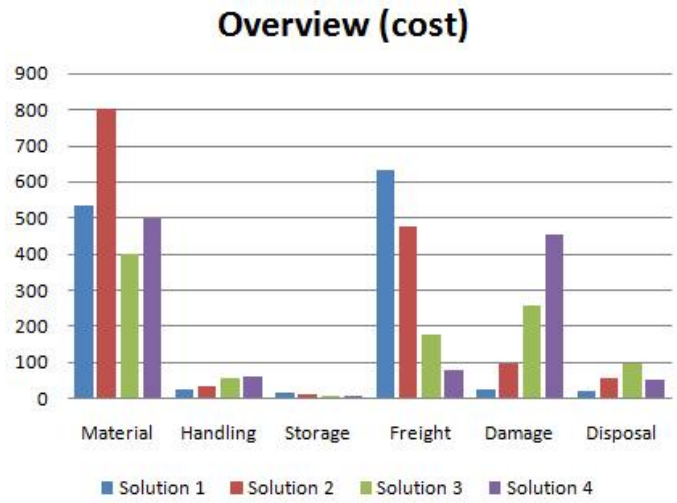

Figure 17 - Overview total cost

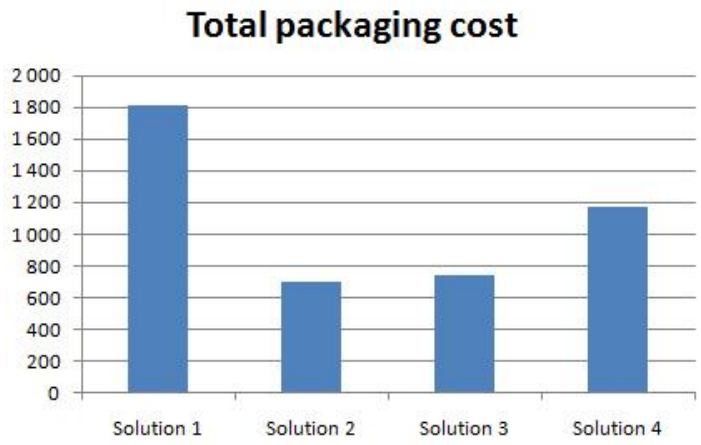

Figure 18 - Total packaging cost

6.8 Once-for-all costs

There are costs that occur during the development of a new packaging solution. These costs can be considered as once-for-all costs and in the model there is a separate sheet for these costs. The user has the opportunity to fill in once-for-all cost, like new machine cost, tool cost, labour cost etcetera. Both the once-for-all costs and the annual six parameters costs are summed and showed on a separate sheet, called results.

7 ANALYSIS

The authors will in this chapter discuss the empirical findings by using relevant theories. How the calculation model should be used will be analyzed as well.

7.1 Optimisation

Ericsson, as many other companies, has a focus on optimisation for all the products in the company. PMM wants the packaging to be handled in the same way as any other product in the range of Ericsson. This will result in packaging also having an optimisation of thinking. The calculation model will help PMM to optimise the total packaging cost.

Packaging Logistics

To reach an optimisation for packaging it is important that packaging will be involved in the whole logistics chain. The packaging should be developed and designed in an early stage together with the product design. This should be done to achieve the best utilisation rate of the packaging. If the product including the packaging is adjusted to standard pallets, it will achieve a higher utilisation rate in the transport. To avoid over-dimensions for the packaging and to reach a higher utilisation in the transport it is of importance to have a close cooperation together with product design. Finally this will create additional value to all the participants in the chain. For example, the packaging will get easier to handle, the weight will be lower, better utilisation etcetera.

Currently, some RBS units can be considered to be over packed with the plywood packaging, that is, the packaging is more solid than the product requires. Unnecessary costs will appear in the form of higher material costs and higher transport costs. If the product is under packed, the damage costs will increase, and this is not good for Ericsson. It is of importance to find a packaging that is somewhere in the middle of under and over pack. The authors think that Ericsson should have customised packaging depending on where and what mode of transport the packaging should be sent.

Supply Chain

If one participant in the supply chain decides to optimise their organisation, this will affect the whole supply chain in some way. PMM started to look over the packaging and understood the savings potential in it. This will affect the suppliers, as the demand will increase, and the supplier will then need to optimise their processes to be able to satisfy their customers. More efficient processes will reduce the cost for all activities in the organisation. If the

packaging cost is reduced and Ericsson's margin increase, in the end, this may lead to cheaper products for Ericsson's customers.

Centralised and decentralised

The packaging department, PMM, is situated in Gävle and PMM is responsible for all the activities that are related to packaging. To centralise the packaging organisation was probably made as a start to take care of packaging issues. A centralised department is good to get an overview for all sites in the world and which activities that are related to packaging. Communication between the different sites is made through the packaging engineers, they are responsible for ensuring that the right type of material is selected and that the strength in the packaging is correct. Packaging engineer is also handling all the contact with local suppliers. If Ericsson wants to continue to have PMM centralised, it is important that they are not only working with one site or one country's packaging, they have to treat all sites equally. Otherwise they would have to consider to decentralise the organisation to be able to optimise the packaging cost for all sites. It is important that this is done on a global basis and not just for one site or one country.

Packaging Engineer

Today Ericsson has packaging engineers at every site and their function is more like a coordinator rather than that of a technician. Packaging engineers is capable to construct a packaging with all the related requirements of a packaging. Currently packaging engineers sends out a specification for the demands placed on the packaging for its supplier, and then Ericsson's packaging supplier constructs a packaging after the requirements. When Ericsson is letting the supplier doing all the construction, the material price will increase due to the construction costs being included. They will also lose competence when they outsource this service. The cost to the company will be double, as they have the competence in the company, but they do not use it.

To use the calculation model in the right way, it is appropriate that packaging engineers constructs the packaging. Packaging engineers will be able to see what happens in the six different areas when data in one or several areas is changed. It is even possible to simulate different material solutions or packaging solutions, and the best result will probably be achieved if packaging engineers is responsible for the packaging construction. If packaging engineers function will be to construct packaging and if packaging engineers will be able to use the calculation model in the correct way, there are huge savings to be made, while the entire production process for packaging will be optimised.

7.2 Material

Plywood as a packaging material, has big advantages in the form of its good bending tensile and tensile strength, there are hardly any damages to the packaging caused by the material. The disadvantage with plywood is has a high purchase prise, it is very heavy and it is difficult to recycle, which leads to high transportation costs and high recycle costs. This is something Ericsson wants to avoid and new packaging material is probably the answer.

Corrugated board is a packaging material which is very useful for all kinds of products. There are a number of choices that can be made with the material, depending on which demand the customers have. Ericsson's products, like RBS, require a packaging that can protect it from all kinds of hazards during the whole chain. Strong corrugated board is an alternative for packaging material which is very stiff and it is almost impossible to break. Ericsson is searching for a packaging material that is not as heavy as plywood and is recyclable. Corrugated board is a good substitute to plywood in all kind of ways, and it does have the same protection against moisture as plywood.

Boxon thinks that strong corrugated board is the best alternative to plywood. It is possible to have a complete homogeneous packaging if the pallet is made of corrugated board as well and if the product does not weigh too much. An offer from Boxon shows that a packaging for a RBS 2116 made of strong corrugated board with a plywood pallet is 64 percent cheaper compared to a plywood packaging, and the weight is 36 percent lower. If the plywood pallet is exchanged to a pallet made of plastic, the price will be reduced by 70 percent and the weight will be 46 percent lower compared to a packaging solution made of plywood. By changing material the material cost, freight cost, storage cost and recycling cost will decrease, this can easily be showed in the calculation model. See appendix (Boxon offer) for the compilation of Boxon's offers.

Another packaging material that could be used for RBS is plastic film. Plastic protects the product against moisture and dirt, but not against shocks. The product will probably get damaged pretty often, for example, if the forklift driver bumps into the plastic packaging with the forks. In order to protect the product from edge jacking, edge protection will be used consisting of strong corrugated board. The top allows the packaging to stack on each other. A great advantage with plastic films as a packaging material is that the weight is very low. The pallet can be made of plywood or plastic, to reach the lowest weight a plastic pallet should be used.

A packaging solution from Boxon to RBS 2116, plastic film with edge protection, shows that the price will be reduced by 77 percent and the weight by 75 percent if a plywood pallet is being used. When a plastic pallet is used the price reduction will be 83 percent and the weight reduction will be 84 percent. For complete prices see appendix (***Boxon offer***). Plastic film as a packaging material can be a good alternative to short transports made with truck. The goods will not be loaded and unloaded several times when driving short distances or direct deliveries, which make this packaging solution a cheap alternative.

Comparing different packaging materials can easily be done with the calculation model. As soon as Ericsson has come up with a new solution, they can test it in the model to compare its weaknesses and strengths against other solutions. The model can also simulate the cheapest packaging solution to specific regions. This means that Ericsson can send different packaging material to different regions, depending on the requirements on the transport etcetera. Even if some of the cost will increase, the total cost can still be lower.

Single and multiple sourcing

Ericsson is using one single supplier, for all the packaging in the company, regardless what country the site is situated in. The single supplier has a great power and can virtually do whatever they want to do. Ericsson does not even draw their packaging solutions by themselves, which makes it possible for the supplier to construct the packaging solutions that give them the highest margins. Ericsson is today very dependent on their supplier, while the supplier has a great control over Ericsson's packaging. The risk for Ericsson is also very high and the packaging supplier can increase the price while they are handling all the deliveries of the packaging material to Ericsson's different plants.

To decrease the purchase price it is necessary to involve more than one supplier. Several suppliers will lead to tougher competition and most likely, lower prices. New packaging solutions are possible to obtain by using several suppliers and the competence will be broader. These new packaging solutions from different suppliers can easily be compared with the calculation model. It is important that the communication between Ericsson and the different suppliers is working to achieve a good result.

7.3 Handling

The packing stations at the plant in Gävle is suited for plywood. To change the packaging material will certainly have a great impact on how the handling system will look like if it would be replaced. There are some stations where a

robot is used and the robot will possible not be useful if the packaging solution is changed, alternatively, the robot has to be suited for the new solutions which will require some modification.

Manual work should be avoided if possible, there is a greater risk of injuries to the warehouse staff if they are performing manual work. It is difficult to have a complete automation of the production, as some tasks around the machine still have to be done by a human, especially packing. In countries like China and India where the labour costs are low, manual work is a better alternative than automation to keep the costs low. The calculation model will help Ericsson to compare the handling costs at the different sites in the world. Even if the handling costs will increase when they change the packaging material, and more manual work is necessary at the packing stations, the total packaging cost can still be lower.

7.4 Storage

At the moment Ericsson does not have any storage costs in the plant for packaging materials for RBS units, because the transfer of ownership of the packaging material does not occur until the products are packed and ready to leave the plant. From the plant the goods is travelled to the inventory of finished goods which is situated close to the plant in Gävle. At this storage facility a storage cost will arise, and this can vary depending on the amount of time the goods will be stored. Today, there is no functioning system that reports on when the ownership is transferred from the packaging supplier to Ericsson, and this is of course an advantage for Ericsson because they do not need to pay any storage costs for this material. A problem with VMI in this case, that is to let the supplier handle all the deliveries of the packaging material to the tent (storage area), and to not have a functioning reporting system when the material is picked up from the tents and transferred to the production, is that it will create a substantial dependency on the supplier. Ericsson would though, be paying a higher purchase price for the packaging material to cover the additional storage costs, that the packaging supplier has incurred.

It is important to have a similar storage system for all the sites in the world if the calculation model should be as efficient as possible. If there is more than one supplier that will deliver the packaging material, VMI is more difficult to implement, since the suppliers should be located in the local region to avoid long transports. It is not good that many suppliers have insight in Ericsson's business and there could be a conflict of interest between the suppliers. To reach an efficient VMI system as possible it is necessary to have a system that

integrates the companies' business system with each other. A good electronic system will help Ericsson to reduce their costs and to reduce lead time.

A big advantage with the calculation model is that it is able to compare different storage solutions, if it is better to store a big quantity of packaging material and only purchase for example once in a month, instead of filling up the warehouse frequently every second day. It is also possible to see the storage cost in the production and the cost in the inventory of finished goods, which is of interest to see where it is best to store the goods from an economic point of view.

7.5 Freight

The transport department EDL, is responsible for all the shipping of Ericsson's products and decides which transport mode to be selected. To reach the highest utilisation rate in the transport, the packaging has to be designed to suit the transport mode as good as possible. When the packaging is designed to suit the transport mode, it is important that the "right" transportation mode is selected. To get this to work smoothly, it is important that there is good communication between EDL and the packaging engineers. The calculation model will show the cheapest transportation mode, in this case air or surface, and which DSP that can offer it. To reach the lowest total cost, it is important that EDL finds out which transport mode and DSP that the packaging engineers have based their calculations on. If there is no communication between these two departments, the model is of no use.

A positive change regarding shipping, is that a shipping department will replace CDM. This department will be centralised and situated in Sweden. The control over all transportation will probably increase and with this type of organisation, the company will save costs. Shipments to the same destination/customer will be coordinated, all different products to the customer will be collected and sent together. Shipments sent by sea or air will in the future have fixed departure days to get higher utilisation in the transportation and shipments, this will decrease the transportation costs and perhaps the administration costs. It is probably necessary to have some kind of decentralised shipping department in the different countries, since the local storage and local transport needs to be booked. A good communication between the new shipping department and the people that handle the local transport booking is important.

CAT is a regional storage, but it works pretty much like a central storage. Products from all over the world are sent to CAT to coordinate with other products that are going to be sent to the same destination. The main reason that

products are shipped to CAT from all over the world, is because CAT provides all kinds of documentation, including the necessary customs documentation. To send all products to CAT for this reason is very unnecessary, the transportation costs become very high and there is obviously a great environmental impact as well.

Repacking is another activity that CAT is doing for Ericsson. This results in higher storage costs at CAT, than what it would have been without repacking. It is better if Ericsson or the suppliers are sending the correct packaging to begin with. Packaging with products that come from Ericsson's suppliers and have to be repacked, is generating extra work and extra costs. Ericsson should put pressure on their suppliers to pack the products in the recommended packaging from the beginning. This will certainly lead to lower storage costs for Ericsson, while the handling time will decrease.

Ericsson is a company that have used air transport a lot for transporting their products. The products and packaging are often very heavy, which makes transportation by air very expensive. To send spare parts by air is preferable while the customer needs the product as quickly as possible. A few of Ericsson's products can be seen as high-grade products, which would motivate air transport. But if the shipments are coordinated, all the products in the shipment will probably not be regarded as high-grade products and should be sent by sea transport instead.

Today, rail transport is not an alternative for Ericsson, according to EDL. Ericsson should rethink this, whether rail is an option or not. According to EDL, marshalling is a time-consuming and difficult task, which is why rail transport is not being used. Nowadays, marshalling is becoming more flexible, given that more companies choose rail as the transport mode. The container handling for sea freight is also time consuming as well as for air cargo. The authors think that rail is an excellent option instead of sea, truck and air. For heavy products that are going to be sent to Asia, or between the plants in Sweden and Asia, rail is a good option. From an environmentally and a cost efficient point of view, rail is a good alternative compare to the other transport modes and therefore should Ericsson consider using this transport mode.

The lead time will obviously be longer if another transport mode than air is being used. If the customer is supposed to get their goods at the right time, good planning is required. Ericsson's products are such character that the order is made months before delivering. Such products make the planning easier, which makes it possible to send these products with other modes of transport that takes longer time than air.

The authors have only considered the "main" cost of transportation, while PMM thought that this cost was the only cost that matters for packaging. But depending on which material the packaging is made of, some custom charges may occur depending on the delivery country. Even the route the transporter is choosing may affect the cost, for example, by not driving drive the truck through a specific country expensive road tolls can be avoided. This is something that should be investigated by EDL, if the transporter is choosing the "right" way.

7.6 Damage

Today there are no follow-up operations on damaged packaging, how the damage has occurred and why. The packaging has to meet the demands that are made on it, to protect the product. To know why a packaging is damaged, a good follow-up on the causes is necessary. The packaging can be damaged during transport, handling on site etcetera.

It is possible that the damage cost will increase if Ericsson changed the packaging material from plywood to another packaging solution. Today Ericsson does not have any damage cost that is related to the packaging, while plywood is such a robust material with good strength. The calculation model can easily compare different packaging solutions with each other. If the damage cost is the only cost that increase when a new packaging solution is used, this could still be a good alternative if the total packaging cost is lower compared to the other packaging solution.

7.7 Disposal

Ericsson does not have any correct figures on the disposal cost, they have just estimated this cost. It is actually only for United Kingdom and Japan they have received a disposal cost. The problem is that this cost can probably differ a lot between the countries in the various regions and between the different materials. For the developing countries, material such as plywood does not have any recycling cost as they are using the packaging as building material. Corrugated board or some other packaging material is perhaps not so appreciated in these countries, as they can not be able to use the material in the same measure. If Ericsson is using another material than plywood in the packaging for shipment to the developing countries, it could give Ericsson bad conscience as well as bad reputation in the rest of the world. The best solution when Ericsson is shipping to industrialized countries is to have packaging materials that do not generate high recycling costs, like corrugated board. Packaging made of plastic are easy to recycle as energy extraction or used as fuel, but this is only possible for industrialized countries.

The calculation model can compare the different packaging solutions according to the recycling cost. A disadvantage with the model is that the user has to have knowledge about the recycling cost.

7.8 Test simulation

The big advantage with the calculation model is that the model is able to compare four packaging solutions. The authors have made a test simulation with help of the calculation model and compared four packaging solutions. One solution is the current plywood packaging from Ericsson's single packaging supplier. The other three packaging solutions are developed by Boxon. The three solutions from Boxon can be found in appendix (***Boxon offer***) as ALT. 1, ALT. 2 and ALT. 3. The result of the test simulation can be seen in Figure 19, Figure 20 and Figure 21.

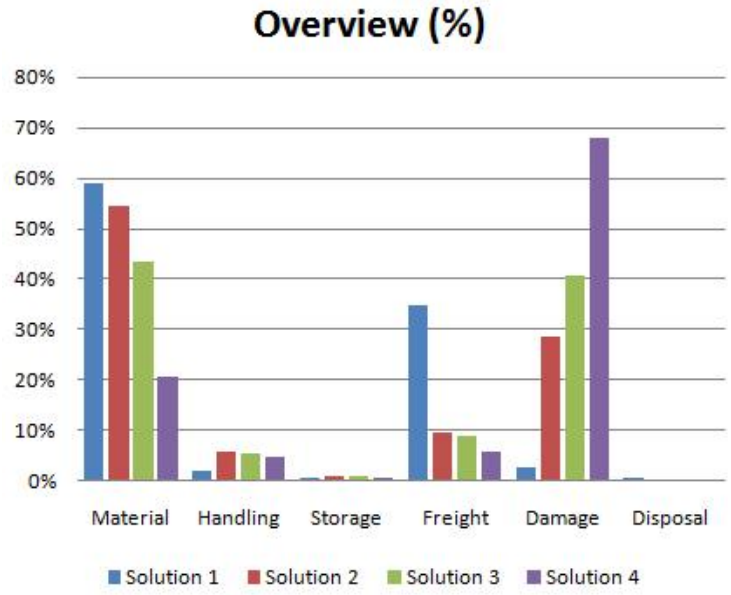

Figure 19 - Overview (%)

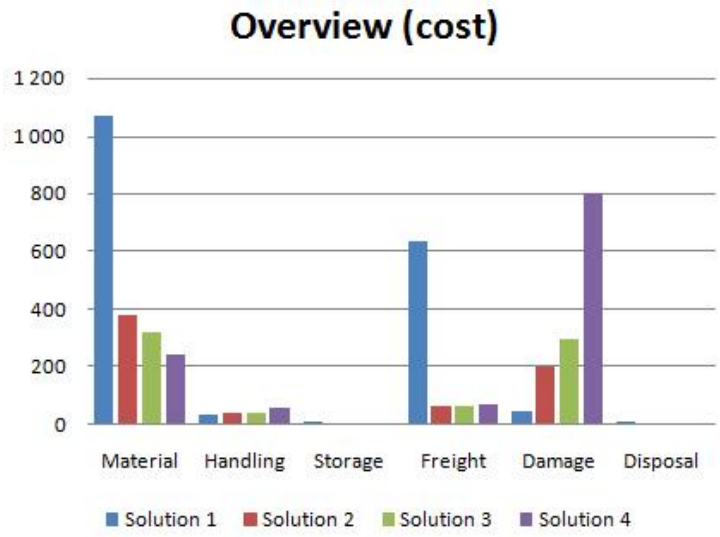

Figure 20 - Overview cost

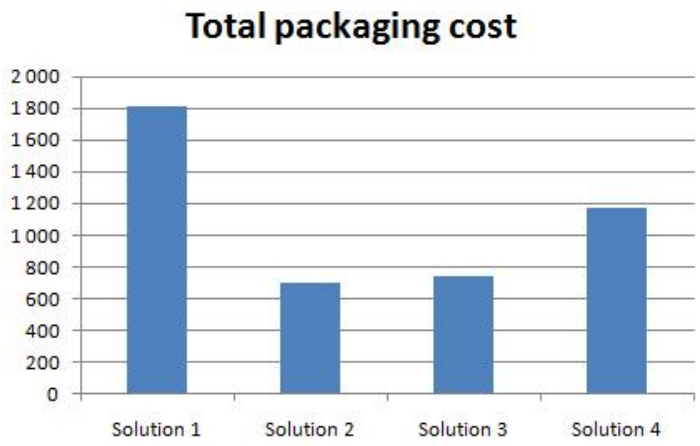

Figure 21 - Total Packaging Cost

For solution 1, which is the current solution, material cost and freight cost are the two biggest costs of the total packaging cost. For all four solutions both handling cost and storage cost are negligible. In current situation the two biggest cost parameters are material and freight, and the greatest cost reduction for new packaging solutions can be found in these two cost parameters. The total packaging cost for Boxon's three packaging solutions are lower compared to the current solution which shows that other packaging solutions and other packaging suppliers are interesting alternatives for Ericsson.

8 CONCLUSIONS AND RECOMMENDATIONS

In this chapter the report will be summarized, the authors' conclusions and recommendations will be presented based on the analysis.

The aim of the calculation model is to assist Ericsson to achieve reduced costs for their existing and new packaging solutions. The calculation model will follow all the six cost parameters to see how each area changes depending on which parameter that is changed. It is easy to use the calculation model and the total cost will be presented in both figures and diagrams to make it even more clear for the user. The calculation model is designed for the use of Ericsson's packaging engineers, and it can be used globally. There are only a few parameters that need to be changed for the users in China compared with the users in Sweden, and there are several different scenarios can be analysed.

During the development of the calculation model, the authors have reviewed the costs and activities that are behind the six parameters. The review of these costs has led the authors to the conclusion that some defects exist in these areas. Ericsson has a great competence in their packaging engineers, but they are not using them for the right job task. Today, the role of the packaging engineers is more like a coordinator and Ericsson is outsourcing the construction of the packaging to the only packaging supplier. By using one single supplier, Ericsson becomes very dependent on the supplier. Today the packaging supplier has a great power to determine how Ericsson's packaging should be constructed and designed. It is better that several packaging suppliers are involved to get several packaging solutions and to reduce the material cost. The packaging engineers should construct the packaging in a close cooperation together with product design to reach the lowest logistic cost.

With a new centralised department who is responsible for all the shipping, the shipments will be more coordinated and the transportation cost will decrease. To have fixed departure days during the week, the utilisation in shipments will increase and reduce the total transportation cost. Ericsson is often using air transport, which is expensive and not a good option from an environmentally point of view, considering to Ericsson's products. The products are of such a character that air transport is not an appropriate transport mode, instead Ericsson should use sea transport and consider to start using rail transport. As the lead time for transport will be longer, good planning is of great importance.

The total packaging cost will probably decrease if the packaging customised. The total material cost will decrease, since less material will be used in the

packaging and the product will not be over packed. Another cost that will be lower is freight cost, as the weight of the packaging will be lower and the packaging will be chosen depending on transportation mode. A cost that will increase is handling cost, but this cost will not be so high that the total cost of packaging will be higher compared to the current situation.

The authors recommend Ericsson to further develop the calculation model, since this thesis is only a beginning to calculate the packaging cost. To make it more useful and to be able to handle several tasks, the calculation model will require further modifications, and it should be created in another software program than Microsoft Excel. The development of the calculation model is made with consideration for activities relating to the RBS units, however, this results in the calculation model not being a general tool for all kinds of products.

If Ericsson will have a packaging department in the future, it will probably not need to be as wide-ranging as present. It is important to continue to have packaging engineers at every site in each country. Purchases and packaging issues can be handled centrally by sourcing and some packaging logisticians.

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Figure 12 – Presentation: Cost of the box Rev C, David Ekberg

Figure 13 – Jonas Nymans, Packing Instruction, 151 91-RTK 993 5612/4

Other figures are illustrated by the authors.

APPENDIX

Boxon offer

Boxon	Product A, 2116			Product B, 3308		
	Price (SEK)	Weight (kg)	Length (m)	Price (SEK)	Weight (kg)	Length (m)
ALT. 1						
Plywood pallet	160,00	7,3		87,00	3,1	
Corrugated board 0200	94,00	11,7		26,70	5,7	
Fitments, corrugated board 8 pcs	120,00	6,5		120,00	6,5	
Plastic pack band	6,30	0,0	12,9	2,10	0,0	4,1
Total:	**380**	**25,5**		**236**	**15,3**	
ALT. 2						
Same as alt. 1 but with Plastic pallet	102,00	3,5		45,00	1,0	
Total:	**322**	**21,7**		**194**	**13,2**	
ALT. 3						
Plastic stretch film	5,40	1,0	30,0	2,70	0,5	15,0
Edge protection	28,96	0,4		13,36	0,4	
Edge protection	9,88	0,4		7,44	0,4	
Edge protection	15,44	0,4		0,00	0,0	
Top, corrugated board 0300	16,50	0,6		9,50	0,2	
Plywood pallet	160,00	7,3		87,00	3,1	
Plastic pack band	6,30	0,0	12,9	2,10	0,0	4,2
Total:	**242**	**10,1**		**122**	**4,6**	
ALT. 4						
Same as alt. 3 but with Plastic pallet	102,00	3,5		45,00	1,0	
Total:	**184**	**6,3**		**80**	**2,5**	

The current packaging supplier	Product A, 2116			Product B, 3308		
	Price (SEK)	Weight (kg)	Length (m)	Price (SEK)	Weight (kg)	Length (m)
Current packaging solution						
Plywood	**1068**	**40,0**		**311**	**17,0**	

Comparison to Plywood	Product A, 2116		Product B, 3308	
	Price	Weight	Price	Weight
ALT. 1	64%	36%	24%	10%
ALT. 2	70%	46%	38%	22%
ALT. 3	77%	75%	61%	73%
ALT. 4	83%	84%	74%	85%

Model description

Basic data

Basic data is an area where data about the product is filled in, some information about what cost of capital the site is using and which currency the user wants in the result of the simulation.

Basic data

Product	RBS2116		
Weight (kg)	330		
Height (mm)	1450		
Width (mm)	890		
Depth (mm)	650		
Volume (m3)	0,839		
Delivery volume, 12 month	1750		
Cost of capital	12%		
Wanted currancy in result	SEK		
	Solution 1	**Solution 2**	
Currancy in each solution	SEK	SEK	

Currency that is possible to use in the calculation model are following:

- Sweden, SEK
- Euro, EUR
- China, RMB
- United States of America, USD
- India, INR

Material

Material/Packing	Solution 1		Solution 2
Packaging solution/material	Plywood		Cor. Board
Purchase price	1068	A	380
Height (mm)	1640		1500
Width (mm)	995		900
Depth (mm)	775		655
Volume (m3)	1,265		0,884
Weight (kg)	40		25,5
Number of products per packaging set	1	B	1
Material cost (SEK)	**1 068**		**380**

With *"Number of products per packaging set" (B)* means how many products there are in each packaging. The products have to be of the same type, which means same weight and dimensions. For multiple products the total packaging cost is distributed per product.

Dimensions and weight for the packaging are not interesting for material cost but is necessary for future calculations.

$$Material\ cost = \frac{A}{B}$$

Handling

Handling

	Solution 1		Solution 2
Time require to pack one set of packaging (min)	4	A	2
Additional time required to other handling, one set of packaging (min)		B	3
Labour cost per minute	7	C	7
Handling cost	**28**		**35**

$$Handling\ cost = (A + B) * C$$

Storage

Basic data		
Delivery volume, 12 month	1750	A
Cost of capital	12%	B

Material/Packing	Solution 1		Solution 2
Purchase price	1068	C	380

Storage	Solution 1		Solution 2
Site storage			
Mean time in storage (days)	5	D	5
Square meter price in production	1800	E	1800
Size at storage area for actual packaging solution (m2)	5	F	5
Inventory carrying cost (SEK)	1,76		0,62
Warehousing cost (SEK)	5,14		5,14
Inventory of finished goods			
Mean time in storage (days)	15		15
Square meter price in production	900		900
Size at storage area for actual packaging solution (m2)	2		1
Inventory carrying cost (SEK)	5,27		1,87
Warehousing cost (SEK)	1,03		0,51
Storage cost (SEK)	**13**		**8**

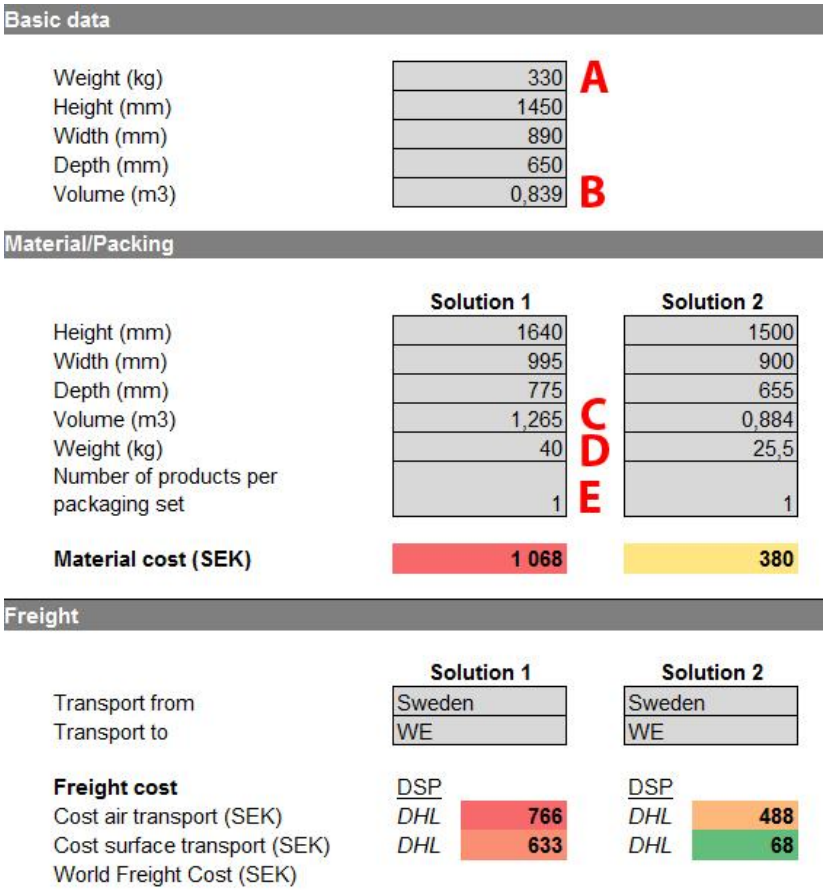
$$Inventory\ carrying\ cost = B * C * \frac{D}{365}$$

$$Warehousing\ cost = \frac{E * F}{A}$$

Same principle to calculate both inventory carrying cost and warehousing cost is used for site storage and inventory of finished goods.

$$Storage\ cost = Inventory\ carring\ cost + Warehouseing\ cost$$

Freight



Basic data		
Weight (kg)	330	A
Height (mm)	1450	
Width (mm)	890	
Depth (mm)	650	
Volume (m3)	0,839	B

Material/Packing	Solution 1		Solution 2
Height (mm)	1640		1500
Width (mm)	995		900
Depth (mm)	775		655
Volume (m3)	1,265	C	0,884
Weight (kg)	40	D	25,5
Number of products per packaging set	1	E	1
Material cost (SEK)	**1 068**		**380**

Freight	Solution 1		Solution 2	
Transport from	Sweden		Sweden	
Transport to	WE		WE	
Freight cost	DSP		DSP	
Cost air transport (SEK)	*DHL*	**766**	*DHL*	**488**
Cost surface transport (SEK)	*DHL*	**633**	*DHL*	**68**
World Freight Cost (SEK)				

Countries and regions that are possible to use in the calculation model are the following:

Transport from:

- Sweden

Transport to:

- Western Europe (WE)
- Central Europe & Middle East (CEMA)
- North America (NA)
- Latin America (LA)
- Asia & Australia (APAC)
- China (CH)
- India (IN)
- World

	Air kg	Company	Air m3	Company	Surface kg	Company	Surface m3	Company
CEMA	7,58	DHL	473	DHL	3,03	DHL	799	DHL
LA	21,58	PA	7 827	PA	2,15	PA	1 648	PA
NA	12,65	DHL	5 364	DHL	2,88	DHL	1 149	PA
WE	19,14	DHL	7 994	DHL	4,31	DHL	1 487	DHL
APAC	7,77	DHL	4 230	DHL	2,03	K & N	984	K & N
CH	3,82	PA	4 220	PA	No Data	No Data	No Data	No Data
IN	17,56	DHL	7 786	DHL	2,15	DHL	581	K & N
WORLD	14,34		4351		3,22		992	

% Air vs Surface	Air	Surface
CEMA	0,61	0,39
LA	0,66	0,34
NA	0,84	0,16
WE	0,02	0,98
APAC	0,77	0,23
CH	1,00	0,00
IN	0,52	0,48
WORLD	0,59	0,41

The image above is a compilation of Ericsson's transports costs and is used to calculate the Freight cost. The columns *"Air kg"* and *"Surface kg"* are both an average transport cost, expressed in SEK/kg. The column *"Surface m^3"* is a volume based average cost, expressed in SEK/m^3. The columns *"Company"* are showing which Distribution Service Provider (DSP) that is cheapest at actual region and transport mode. In the case, when the user choose *"World"* as their destination the calculation model uses the *"% Air vs Surface"*-table to obtain correct World Freight Cost.

Following steps shows how the freight cost is calculated for air transport with actual breakdown value, which is 167 kg/m^3.

$$If\left(\frac{A * E + D}{C} < 167\right)$$

- If it is true then freight cost is:
  $C * 167 * "Air\ kg"$

- If it is false then
  $(D + A * E) * \text{"Air kg"} - If\left(\frac{A * E}{C} < 167\right)$

- If it is true then freight cost is:
  $(D + A * E) * \text{"Air kg"} - A * 167 * \text{"}Air\ kg\text{"}$

- If it is false then freight cost is:
  $(D + A * E) * \text{"Air kg"} - A * E * \text{"}Air\ kg\text{"}$

Following steps shows how the freight cost is calculated for surface transport with actual breakdown value, which is 330 kg/m^3.

$$If\left(\frac{A * E + D}{C} < 330\right)$$

- If it is true then freight cost is:
  $C * \text{"}Surface\ m^3\text{"}$

- If it is false then

$C * \text{"}Surface\ m^3\text{"} - B * \text{"}Surface\ m^3\text{"}$

Damage

Damage				
	Solution 1		Solution 2	
Per cent damaged goods (%)	0,5	A	2	
Cost per damaged goods	5000	B	5000	
Damage cost (SEK)	**25**		**100**	

$$Damage\ cost = A * B$$

Disposal

Material/Packing				
	Solution 1		Solution 2	
Weight (kg)	40	A	25	
Number of products per packaging set	2	B	1	

Disposal				
	Solution 1		Solution 2	
Disposal cost per ton	100	C	500	
Disposal cost per package	40	D	45	
Disposal Cost (SEK)	**24**		**58**	

$$Disposal\ cost = \frac{A}{1000} * C$$

Or

$$Disposal\ cost = \frac{D}{B}$$

Total Cost

Total Cost		Solution 1		Solution 2
Material		1 068		380
Handling		35		42
Storage		13		8
Freight	*Air*	766	*Air*	488
	Surf	633	*Surf*	68
Damage		50		200
Disposal		14		0
Total Cost (SEK)	*Air*	**1 946**	*Air*	**1 118**
	Surf	**1 814**	*Surf*	**698**
Annual packaging cost (SEK)		**3 174 334**		**1 221 002**
Annual cost saving		0		1 953 333

The cost from the six parameters is showed and the total cost per packaging is summed. The annual packaging cost is obtained by multiplying "*Total Cost"* and annual sales volume that was presented in the area "*Basic data"* in the beginning.

Once-for-all cost

Once-for-all cost	Solution 1		Solution 2
New machine cost	40 000	A	600 000
Tool cost (to new fitments etc.)		B	75 000
Verification cost (running test etc.)		C	20 000
Man-hour (h)	20	D	100
Labour cost per hour	250	E	1 000
Other	75 000	F	
Total once-for-all cost (SEK)	**120 000**		**795 000**

$$Total\ once-for-all\ cost = A + B + C + D * E + F$$

Summary

Basic data		
Cost of capital	12%	A

Summary			
	Solution 1		**Solution 2**
Annual packaging cost	2 207 834		2 305 904
Once-for-all cost	120 000	B	795 000
Annual cost saving	98 070	C	0
Pay-back time (year)	1,40		Most expensive solution or no data

Finally a couple of key figures are shown at the summary sheet. Besides earlier calculations like *"Annual packaging cost"*, *"Once-for-all cost"* and *"Annual cost saving"* is a new calculation introduced, *"Pay-back time"*.

$$Pay - back\ time = \frac{-ln\left(1 - \frac{B}{C} * A\right)}{ln(1 + A)}$$