# Contents

# List of Figures

# Preface

This report is the result of a master's project conducted at Plastal AB Simrishamn, in spring 2003 on the initiative of Jan Svedman and Ulrica Larsson. The master's project corresponds to 20 university semester units and is the last element of the Master of Science in Industrial Management and Engineering (180 semester credits) at Lund University.

The target of the report is primarily for people at Lund Uniersity, but also decision-makers at Plastal AB Simrishamn. The basic data for the decision making that this report constitutes, is supposed to be sufficient and holistic for decision-makers at Plastal AB Simrishamn in order to take the appropriate decision on how to solve the packing material problem.

To support this work, a supportive team was established to secure the quality of the project. This team consisted of Nils-Ivar Andersson, Jan Carlsson, Jan Svedman and Magnus Wiege. The team met regularly during the whole project and worked as a forum for discussion and analysis. The authors would like to thank the members of this group and also other people that have been of great help in this project: Jan Hallonsten, Lars Håkansson, Kenth Johansson, Susanne Svarin and Roger Tennevi. Moreover, we would like to thank all the other staff members at Plastal AB Simrishamn that have taken their time to be interviewed and that have contributed with interesting ideas and opinions to this project. Finally, we would like to express our gratitude to out supervisor at Lund University, Ph.D. Ola Alexanderson, who has given us valuable help both on the theoretical as well as on the practical part of the project.

Simrishamn, May 2003

Erik Linde Pierre Winsborn

# Abstract


In the automotive industry, it is common that the customers provide the suppliers with the necessary packing material needed for delivery of the goods. The reason for this is that it makes the handling and unpacking of incoming goods at the customer easy, but it also makes sure that the quality of the packing material is high, and that the transportation damages of the goods are minimised. It should also serve as a support for the supplier, since the supplier would not have to worry about the quality and the distribution of the packing material.

Plastal AB in Simrishamn is one of the bigger suppliers for the Swedish automotive industry, and uses customer owned packing material for the delivery of many of its products. Although the customer owned packing material has many advantages, it also limits the freedom of action for Plastal, since Plastal has to adapt to its customers' procedures when it comes to lead times, ordering procedures, total allowed amount of packing material and other restrictions.

The last years, the customers have become tougher on the packing material, and as a consequence of this together with poor, internal control at Plastal, there has been a lot of problems. An important one is that about 15 unanticipated emergency stops in machines at Plastal occurred during 2002 only, which lead to that machines had to be closed down and production reorganised. Such incidents are serious since they decrease the service reliability, and put the quality of the whole production at risk. The direct cost of this and some other problems amount to more than 1.5 MSEK annually, a figure that will probably increase in the future as the customers become even harder on the packing material.

To minimise the above problems, it is important for Plastal to act as early as possible for an improvement of the packing material process. We believe that the best way to do this is to optimise the use of the packing material by integrating the whole process in Plastal's computer system. This enables automation with increased control as results, which also reduces the risk of having emergency stops. A lot of other problems will also disappear thanks to this change.

The economic impact of this is that Plastal will save more than 1.2 MSEK annually according to our calculations. The payback time for the necessary investment is only 2 months, making it highly prioritised and desirable. Moreover, the disturbances in the production connected to packing material will be diminished, making the whole production process more efficient.

# Chapter 1

# Introduction

*In this chapter a presentation of the background, purpose and limitations as well as a disposition of the report will be made.*

## 1.1 Background

With production plants in most parts of Europe, Plastal Group AB serves the European automotive industry by manufacturing and surface treating interior and exterior system- and function related plastic components. The object of study is the plant in Simrishamn, Sweden (henceforth referred to as Plastal) which is the largest one within the group with more than 400 employees with main customers Volvo Cars, Saab and Scania Trucks. Plastal is using injection moulding and surface treating for the production, and these are technologically advanced processes in which Plastal has very good competence.

It is common in the automotive industry that customers provide the packing material needed by the subcontractors to deliver the produced parts, in order to facilitate their own handling of the goods. This applies first and foremost to smaller standard parts, in this case meaning parts with their longest side less than one meter roughly. For larger parts, other types of packing material are used.

The automotive industry is a mature industry, and competition is getting harder and harder, resulting in cost-saving programs that affect subcontractors like Plastal. One of the consequences is that customers are less willing to provide more packing material than absolutely necessary, thus reducing the possibilities for subcontractors to easily produce large batches. With an endless amount of packing material it would be easier to produce whatever batch was optimal, not being restricted to the fact that the lack of packing material sometimes would inhibit the production. The amount of packing material that Plastal is allowed to hold by the customer is regulated by contracts. Each customer uses different contracts, and therefore has different rules and agreements on lead times, allowed ordering quantities, fees etc.

Plastal uses the customers' packing material through the whole period from when a part is produced until it is delivered, instead of just using packing material owned by Plastal during most of the time and the customer's solely for delivery. The latter would mean that it would be possible to produce a large batch size and store it temporarily in Plastal's packing material, and gradually unpack and repack into the customer's packing material. However, while this pack-and- repack procedure seems reasonable it is also more expensive, because of the extra packing. This extra cost is the reason for why Plastal uses the customer's packing material through the whole period. This results in difficulties when there is not enough packing material, since parts that are not about to be delivered can occupy packing material that really was supposed to be used for other parts. The defective control at Plastal makes it troublesome to know when there is going to be a lack on packing material.

The limitation of the amounts of packing material and the lack of control are problems that Plastal has been facing for a couple of years, but that has become more critical during the last years, along with increasing production volumes and decreasing packing material supplies.

## 1.2 Problem description

The main question for this thesis is how to develop an improved system to control the processes that involve managing the packing material, and to construct guidelines to manage such processes. Expenditures and expected earnings have to be quantified.

The most important problem to be solved is how to automate and enhance the inventory control system of the packing material supplies, and thus increase the control and reliability in the whole chain. The next problem to be solved is how to use this enhanced system, i.e. specify the work organization. If this is accomplished it would result in an optimization of the existing amount of packing material.

## 1.3 Purpose

The purpose of this master's thesis is to map the entire packing material process and thereby get that good insight into the process that a proposal on how it can be improved can be generated. The proposal for improvement should, if it is carried out, ideally solve all or at least most of the problems that can be derived from poor packing material control. The goal with this is to reduce costs for Plastal and to make the packing material process easier for the people working with it. In the end this will make Plastal a more profitable company.

## 1.4 Limitations

Only Plastal's external packing material will be studied, i.e. the packing material exclusively owned and controlled by Plastal's customers. The internal packing material used inside the plant in Simrishamn or within Plastal Group AB or to customers with small-scale orders will not be taken into account. Moreover, we will focus on the three main customers: Volvo Cars, Scania Trucks and Saab Automobile. Finally, the project will not comprise the implementation itself, but only the proposal for improvement and how this should be done.

## 1.5 Overview of the report

**Chapter 2 Methods of Investigation**

In this chapter the working methods used in the master's thesis are presented together with how the research was conceived, designed and executed. The aim of the chapter is to generate an understanding of how the study was conducted, and provide an overview of the working procedure used to fulfill the purpose of the thesis.

**Chapter 3 Empirical Findings**

In this chapter Plastal is more extensively presented as well as the empirical findings acquired during the research. These findings are the direct result of the methodology described in the previous chapter.

**Chapter 4 Literature Review**

In this chapter the most essential theories from the literature study are presented. Since the purpose of this project is to produce a complete and holistic course of action for Plastal to use, the solution has to be derived interdisciplinarily. Critical fields to be concerned are those of supply chain management, process development and inventory control.

**Chapter 5 Discussion and Analysis**

In this chapter we will first of all give the reader a general analysis of the problems connected to packing material at Plastal. The impact of the problems will also be quantified economic terms.

**Chapter 6 Conclusions and Recommendations**

In this chapter we will present the major changes that the implementation of the new packing material system will impose. We will also specify how long time it will take to implement the changes, and give insight into the savings possibilities on this investment as well as on the payback-times.

# Chapter 2

# Methods of Investigation

*In this chapter the working methods used in this master's thesis are presented together with how the research was conceived, designed and executed. The aim of the chapter is to generate an understanding of how the study was conducted, and provide an overview of the working procedure used to fulfill the purpose of the thesis.*

## 2.1 Employed methods

The methodology of this project is built up around a book for project researchers by Denscombe (1999) - The Good Research Guide. Denscombe divides the methodology needed for a research project into three parts: strategy, method and analysis.

First, a strategy for the whole project has to be chosen. Different kinds of strategies can be surveys, experiments, case studies etc. The project behind this master's thesis was conducted as a case study at Plastal. Case studies focus on one instance of a particular phenomenon with a view to providing an in-depth account of events, relationships, experiences or processes occurring in that particular instance. We therefore believed that a case study was the most appropriate sort.

Key decisions about the strategy and methods to be used are usually taken before the research begins, and so it was done in our case.

Apart from deciding on the strategy we also needed to take decisions on appropriate methods. We decided that the most important method was to interview, since there really was no other documentation to be found about the packing material process (PMP) at Plastal. Other possible methods would be to use questionnaires or to carry out observation. To some extent we have used these methods as well, but the main method is the interview.

Finally, when it comes to analysis, it is possible to use both qualitative and quantitative analysis. Ours is mostly qualitative, but some quantitative analysis has also been made, mainly to calculate possible savings from an improved packing material process.

The study was opened by a mapping of activities and costs, identifying causes and effects, in an explanatory way. The first part is thereby explaining. At the end of the study proposals were made for changes, and their possible consequences were analyzed. The last part therefore is more investigating.

### 2.1.1 Theoretical models

The logistic system at Plastal was studied with a systems theory approach. This approach is based on studies of reciprocal action between several projects (or lower level systems) in a system (Bertalanffy, 1968). Material and information pass through the system's boundaries (these boundaries equal the limitations of our project and were reported in the introductory chapter), i.e., the system is considered to be an open system. The system itself consists of smaller sub-systems that all interact. We have intended to map how these sub-systems interact, and to identify possible synergy-effects. We also have tried to identify what these systems indicate to the customers, the subcontractors and to the distributors, i.e. to the actors in the supply chain.

A positivistic approach means that all facts should be proved empirically, and that all estimates should be replaced by exact measurements. The researcher should make unbiased valuations and not be influenced by valuations that are non-academic. This approach is used mainly for analysis of quantitative data, but also for qualitative.

The theories for the PMP are gathered both from technological as well as economic literature. The focus is set on production management and logistics.

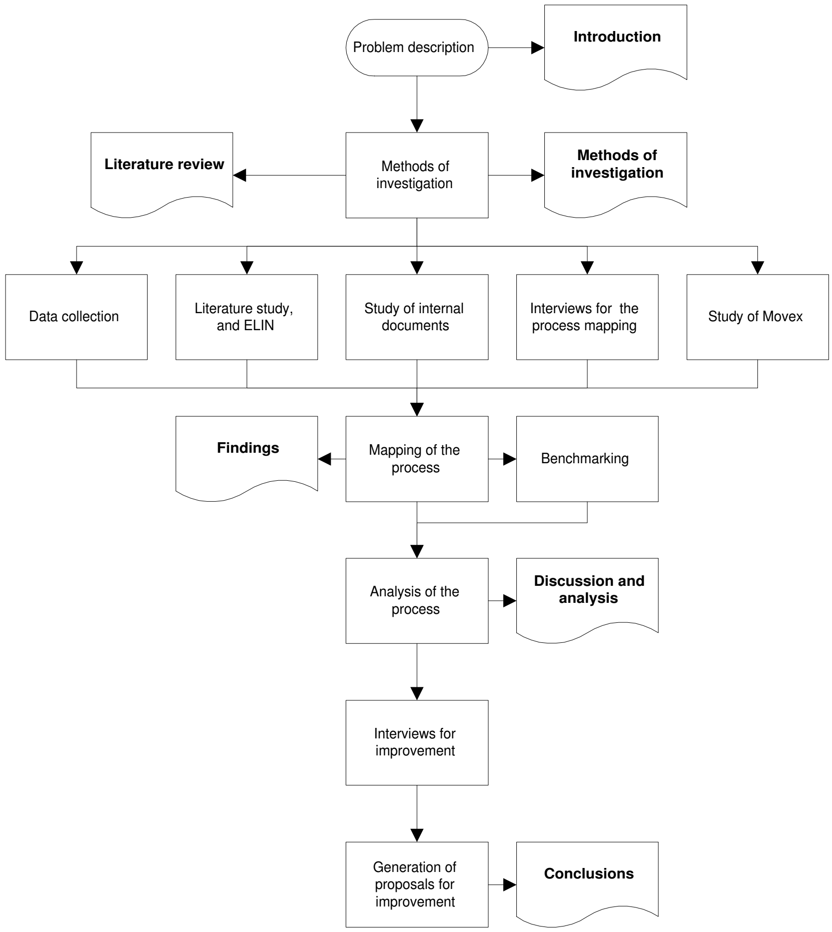
Interdisciplinary projects use knowledge from different sciences and areas, and these different areas interact and thus integrate the knowledge with the project. The biggest obstacle for interdisciplinary research is often the difficulty for people to get into new areas and sciences. On the other hand, the introduction of new methods and models from other sciences could mean that new discoveries are made. (Wallen, 1996: Chapter 6.1)

We have analysed and investigated the PMP from a systems theory approach concerning qualitative data, and from a positivistic approach concerning quantitative data.

## 2.2 Description of how the research was conducted

The project was started by making a clear definition of the goals of the project, as well as the overall purpose of the project. Over the first few weeks this definition changed somewhat but has been the same since. From the beginning it was quite unprecise and big, but it became more focused once we got the know the organisation and the problem better. The limitations of

Figure 2.1: Method map




the project were set clearly though, limiting the project to concern activities connected to customer owned packing material.

Figure 2.1 shows how the different parts of the report was generated.

Once the methodology for the project was settled, books and articles about processes, process mapping and process development were studied, and what theories that had been found previously in the field of study was also investigated. The most essential information from the literature study is presented in chapter 4.

Apart from the literature, internal documents at the company concerning different processes as well as the organization at Plastal were studied in order to get an overview of the present situation. Apart from the PMP, Important other processes were also studied, other than the PMP — e.g. the production process — that in one way or another affected the PMP.

Alltogether this gave a good base for mapping the PMP.

### 2.2.1 Interviews

In order to map the the PMP more in-depth, interviews had to be made with people working with, or responsible for the packing material. The packing material flow through the organisation is handled by different individuals, both directly (physically) and indirectly (administrative work). Depending on where in the flow a person works, this person will not have the same experience of the packing material as another one. This also means that everyone has his or her own picture of the problem and also their own solution concept. This sometimes can lead to a suboptimization of the problem, and it has therefore been important for us to stay as neutral as possible and take all opinions into account. If the suggestion for the improved PMP does not solve all — or at least most — of the problems in the whole chain, it has to be discussed whether additional time should be spent in order to improve the solution or if it should be accepted. If the suggestion is accepted, then it is important to be aware of that there could be resistance somewhere in the chain, which could jeopardise the whole project.

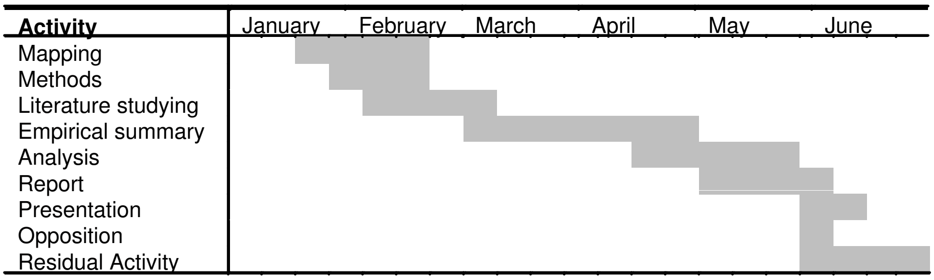
Many interviews were made and important persons were often interviewed more than once or even continuously during the whole project. The interviews were sometimes made with predefined questions, but mostly less formal interviews were made where the interviewee was given more freedom to come up with suggestions for improvement of the PMP. Roughly about 50 persons were interviewed both internally at the plant in Simrishamn but also externally with people from the headquarter in Kungälv, or with staff from Plastal's plants in Arendal and Uddevalla. Even non-Plastal companies were contacted for questions were the information was not to be found within Plastal. All interviews were documented and sent back to the interviwee for comments. The reason for all this was to make sure that we had understood the interviewee right, and that there were no misunderstandings. By interviewing that large an amount of people we guaranteed ourselves almost a "360 degrees overview".

### 2.2.2 Movex

Much time was spent in educating ourselves on Movex, the ERP (Enterprise resource planning) system that Plastal uses for production planning, etc[1]. The reason for this was that a large portion of the PMP would have to make use of this software in order to be improved, and therefore it was necessary for us to gain good knowledge in this area as well. Some of the data used for the calculating was collected from Movex.

[1]More information on Movex in chapter 3.9

Figure 2.2: The initial project plan for the master's thesis




### 2.2.3 Customer study

Finally, to make sure to study the whole chain, we have also visited the customers by travelling to their plants both in Gothenburg and Trollhattan. This gave an even deeper understanding och the PMP.

### 2.2.4 Reducing resistance to change

By spending much time talking to employees we have also reduced the resistance to changes that might turn up when processes are rationalised. Just producing a solutions manual for the problem without integrating the employees in this task, would make it difficult to carry out the implementation. Not only that we have reduced the psychological resistance, we have also taken into account all the valuable experience of the staff which definitely has improved the final result.

### 2.2.5 Project plan

Figure 2.2 is the original project plan, but some minor changes have been made since it was issued. Except from these minor changes the project plan has been followed. One important activity that was omitted in the original project plan was the internal marketing of the project to directors and to the board. Our effort on this woke the interest among the decision-makers at Plastal, and gave the project higher priority. Finally, it raised sufficient funding to drive through the suggested change of the PMP.

## 2.3 Justification of the procedures

Two important concepts to consider when conducting investigations are reliability and validity. These concepts describe to what degree the results correspond with reality, and if they are trustworthy.

Reliability refers to accuracy of the research, and describes the amount of stochastic interference in the investigation. If reliability is high, meaning that the result is not depending on by whom, when, and where the investigation was conducted, the research has a high reliability. The validity of an investigation describes the amount of systematic interference. It is a measure of whether or not the investigation really covered the intended issues.

Reliability is always a big concern when personal interviews are conducted. The respondent might adjust their answers to what they think the interviewer wants to hear, and there is also the aspect of personal opinions being stated as if they were facts.

Validity is also a problem while doing interviews. It is easy to slip into a discussion about something not connected to the subject of discussion. Using questionnaires can be a useful remedy to this. Sometimes though, slipping in to a new subject has widened the interview.

A balance between the quality of the data (i.e. reliability and validity), and the time spent to collect the data is necessary. We believe that the quality is good irrespectively of the time spent. The reliability is high since we have interviewed much people and since the overall opinion of the employees points in the same direction. The validity is also high since we have interviewed people all over and outside the organisation and even at external firms.

It can be argued that only a small portion of the data collected is quantitative, but this is because most of the information to be found at Plastal about the logistic processes was qualitative. This only left one possible alternative - interviews.

## 2.4 Limitations to the methods employed

It is important to stay critical during the entire research process, from the first ideas through the purpose and how one plans and carries out the research to the final results.

Many of the interviews did not, as stated above, follow a predefined pattern. As well as this can be a strength, it might bias the data. Some questions that we asked might have been leading the interviewee to answer what he or she thought we wanted to hear. Specially, when reviewing the employee's working performance on packing material issues, it wouldn't be impossible that the employee would try to give a better picture of how his or her work was performed than was the actual case. This would lead us to believe that the PMP worked better than it actually did. We do believe, when considering the large amount of people interviewed that such effects have balanced out.

The same goes for the data from Movex. It can not be guaranteed that all the figures that were collected are correct, and this may also have biased the data.

# Chapter 3

# Empirical Findings

*In this chapter Plastal is more extensively presented as well as the empirical findings acquired during the research. These findings are the direct result of the methodology described in the previous chapter.*

## 3.1 Plastal Group AB

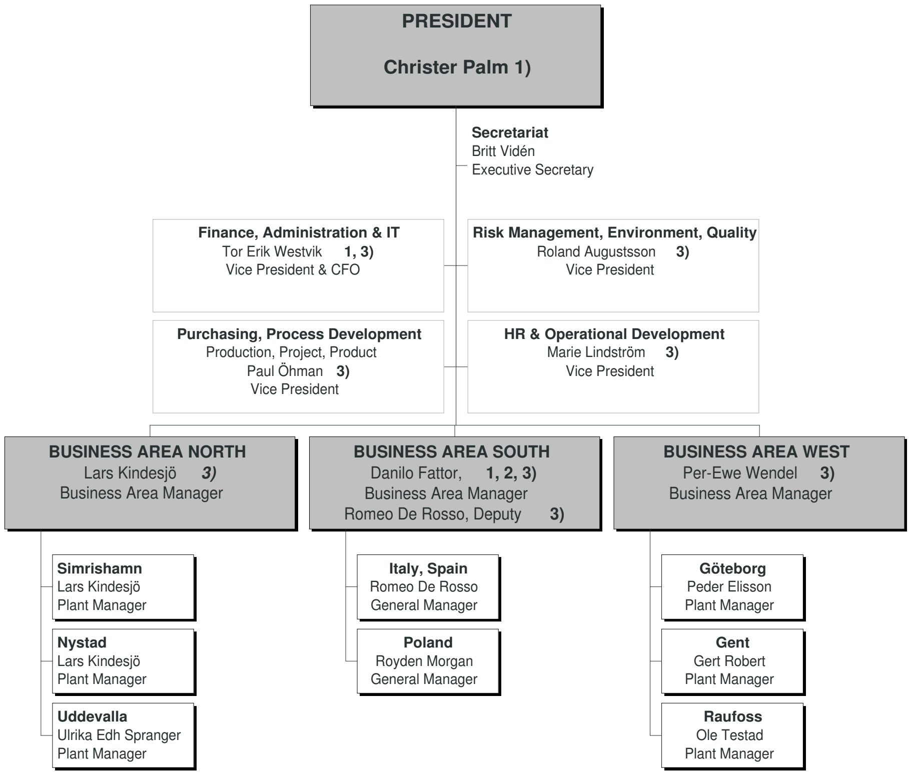
Plastal Group AB (PG) is an important supplier of injection moulded[1] and surface treated plastics for the automotive industry in Europe, serving many of the biggest car manufacturers in Europe, such as BMW, Audi, Alfa Romeo, Volvo, Mercedes, Saab and Scania among others. The company today has plants in Sweden, Finland, Norway, Belgium, Poland, Spain and Italy with more than 2000 employees, with the majority in Sweden and Italy. In Sweden, PG has plants in Gothenburg, Simrishamn and Uddevalla.

Founded in 1934 in Trelleborg, Sweden, the existing PG has been through some mergers and acquisitions and is today owned by the investment company Gilde Investment Management B.V, a Dutch independent investment fund focusing on buyouts in continental Europe.

Total turnover in 2002 for PG was about 3400 MSEK, which shows an increase by more than 150% compared to 1995 year's level. The staff today is roughly twice the size of 1995 and this tremendous growth over the last years has made heavy demands upon all business functions to grow jointly to meet the increased demand.

From figure 3.1 we can see that PG consists of three different business areas — north, south and west. These areas focus on different customers. Business area north for example serves the customers Volvo, Saab and Scania. Business area south serves Alfa Romeo and Audi and business area west mainly serves Volvo.

Figure 3.1: Company organization




## 3.2 Plastal AB in Simrishamn

### 3.2.1 General information

Plastal AB in Simrishamn (Plastal) employed 410 people in 2002 and had a turnover of more than 500 MSEK. We can also see from the organization chart the Plastal AB Simrishamn is a part of business area north. Plastals main customer is Saab, followed by Scania Trucks and Volvo. Plastal produces bumpers, grilles, door panels, dashboards, air ventilation nozzles, instrument panels, SIPS blocks, and much more. The largest product group is the bumpers, and this group also contributes most to the turnover. Figures 3.2, 3.3, 3.4, and 3.5 show examples of products produced at Plastal.

### 3.2.2 Production

Plastal has 27 injection moulding machines with a maximum clamping force of 3200 tonnes. These are technologically advanced machines and quite large. The injection moulder in figure 3.6 is about $10 \cdot 10 \cdot 3$ meters, and is one of the

Figure 3.2: Saab bumper

Figure 3.3: Wheel cover


largest at Plastal. Plastal also has a top modern completely robotized five station painting line to where a great deal of the injection moulded plastics is forwarded. This establishment is one of the most modern in Europe. In addition to this Plastal has another painting line for smaller parts, one UV painting line and facilities for film coating.

The production is automated to great extent using industrial robots, self-transporting trucks, etc. Much of the machinery is fairly new. The plant was originally much smaller than today but has grown during the last 40 years and today consists of several buildings built together. The total size of the plant is 30.500 square meters.

For some articles Plastal uses sequence delivery, requiring high precision and flexibility.

Figure 3.4: SIPS block

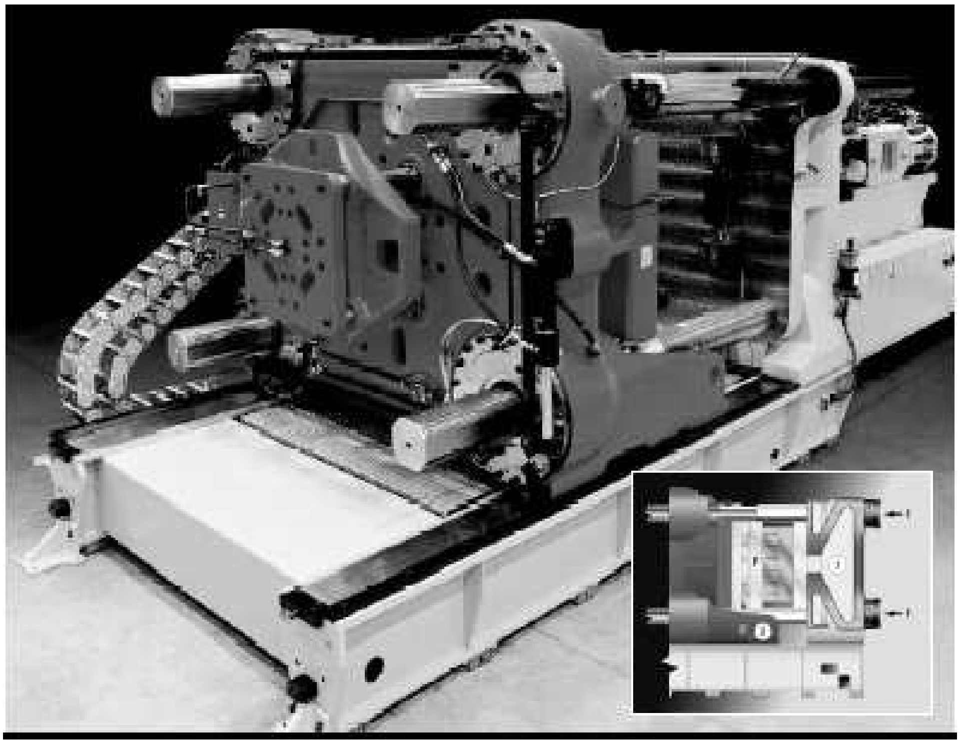
Figure 3.5: Grille

## 3.3 Overview of packing material sorts and prices

Some distinctions on the packing material have to be made. First of all, staff at Plastal divides the kinds of packing material into external and internal. The external refers to the packing material exclusively owned and provided by Plastal's main customers, i.e. Saab, Scania and Volvo. The internal refers to the packing material owned by Plastal. External packing material is used for customer delivery of finished goods, i.e. if Plastal has finished a batch of bumpers for Volvo and wants to deliver it, they have to send it in Volvo's packing material. This is to ease the handling at Volvo when receiving and unpacking the goods but also to secure the quality on the packing material. The internal packing material is used for transportation between plants within PG. For instance, some of the products made at Plastal need additional assembly, which is done at Plastal in Uddevalla. For this matter the internal packing material is used. As mentioned earlier, this project is limited to dealing with the external (customer owned) packing material. We believe that packing material owned by Plastal (internal) and customer owned packing material better than "internal" and "external" explains what packing material we really mean, and we will use these definitions instead. The reason for this is that even though the packing material is called external, it is used internally in the plant, and moreover, it has nothing to do with outer or inner packing material. The inner refers to what is inside of the package such as laminated shims, pads, foam etc. Outer packing material refers to pallets, cases, collars etc.

Most frequent are the pallets together with collars and lids as can be seen

Figure 3.6: Injection moulder



in figure 3.7. Roughly these would represent about 80% of all the customer packing material.

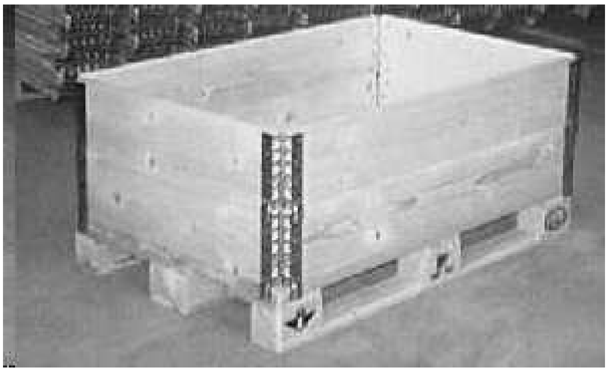
## 3.4 Customers and packing material

Although Saab is Plastal's biggest customer it uses the least customer owned packing material. Instead, most of the products produced for Saab goes with Plastal's own packing material. The customer that uses the most customer packing material is Scania, and Volvo uses almost as much. Usually, it is only smaller parts that are packed in the customer owned packing material. Such parts can be hub-caps, gear knobs, brackets etc. It is difficult to use this standard packing material for larger parts such as Saab bumpers, which is why customer packing material not is used for this.

## 3.5 Production in general at Plastal

Having good knowledge of the flows is important when planning the packing material flow. From the plant map in figure 3.8 on page 33 the characteris-

Figure 3.7: Pallet with collars



tics of the plant in Simrishamn is shown. The production chain at Plastal starts with the delivery of raw material and empty packing material. The outer packing material is stored outside (due to lack of space) and the inner packing material is stored in a tent. The raw material and some packing material are stored inside the plant in the raw material inventory. One reason for some of the packing material to be inside is that it might need to dry before use.

Once the production starts, the raw material (plastic granulate) is transferred via pipes from the raw material inventory to the injection moulding machines. The granulate is then heated up inside the injection moulder, and squeezed together so that it takes the shape of the mould. The moulded products are then stored on racks and then (mostly) transferred to be masked. The next step is the painting line, where the product is painted a few times, with the masking prohibiting painting at some areas.

Different products demand different flows, and not all products follow the example flow of above. The above one is typically true for bumpers, and other large products. The smaller product usually do not need to pass through the painting line, but are instead directly passed to the stock of finished goods.

The articles that are interesting for this thesis usually pass the ID-point before coming to the final storage in the storage of finished goods. The ID-point works as a registration point so that the internal computer system can keep track on what has been produced and what there is left to produce. Everything that is produced is marked with a bar code, which is scanned at the ID-point and thereby registered electronically. What passes through the ID-point is exclusively packed in customer's packing material. Products that do not pass the ID-point are usually not packed in customer's material (e.g. bumpers). This category instead is passed directly to another storage of finished goods.

When goods are delivered, this is registered in the ERP (Enterprise resource planning) system, meaning that it is possible to keep exact track on what is inside the storage of finished goods.

From here the goods are either transported to another plant within PG for additional treatment, or directly to the customer.

There are, however some exceptions to this. Some Saab products are directly passed on to a next-door company called Samhall-Lavi, where it is possible to repack goods that was packed in Plastal's packing material into the customers' packing material (more on this later). Samhall-Lavi is also used for some minor assembly work that Plastal not has the resources to do.

## 3.6 Packing material

The packing material is delivered by the customer and unloaded at Plastal by forklift trucks and then stored outside in the packing material inventory. Much of the packing material comes folded and has to be erected or assembled by production staff at Plastal before use. This is done manually in the raw materials inventory. After the assembly, the packing material is delivered to their respective stations in the production, and, when filled by production workers, transferred to the finished goods inventory by forklift trucks. This description is a simplification, but more or less captures the process.

## 3.7 Limiting factors

As for any manufacturing company, the need of identifying and eliminating bottlenecks in the production is of great interest. Roughly, there are three factors that inhibit production today at Plastal (assumed that Plastal is offered more orders than it can accept): Machine capacity, available storage space and lack of packing material. This project aims to reduce the impact of the lack of packing material as a bottleneck in the production, assuming that all other factors are constant. It is a fact, that with more packing material and more space, it would be possible to work with larger batches and thus reduce the number of setups and start-up costs, scrap costs etc. One problem to be solved is how to get more packing material.

## 3.8 Packing material administration

### 3.8.1 Ordering procedures for packing material

The Saab packing material is ordered by fax once a week. The Scania packing material is also ordered by fax every three weeks. Volvo packing material is ordered every four weeks but is ordered online on a packing material portal provided by Volvo Logistics. Today, one person administrates both Saab and Scania packing material, and one person administrates the Volvo packing material.

The quantity ordered is determined on the basis of three factors: what is currently stored in the packing material stock, the production orders in Movex for the period that the packing material is expected to cover, and adjustments made by the procurer based on experience.

To find out what packing material that is currently stored in the raw materials inventory, i.e. the first factor, the procurer has to physically count every pallet, box, collar etc, which is time consuming and not really informative since the stock could be half the following day of what was there when counted.

The packing material that corresponds to the production orders in Movex, i.e. the second factor, is for each time period retrieved by a separate database program at the time of the ordering of packing material. This is possible since Movex has information on what is going to be produced in the future.

The third factor is the personal opinion of the procurer based on what his or hers experience is.

### 3.8.2 Arrival of packing material

For Saab and Scania all packing material arrives on two specific days every week, but for Volvo the packing material is not limited to arriving on certain predefined days, but instead exactly on the day Plastal wants it to arrive. Irrespective of this, it is up to Plastal to make sure that the ordered packing material is delivered on the right day and that the right quantity and sort is delivered. Sometimes it happens that the order not agrees with the delivery and in these cases Plastal naturally has to inform the customer on this to retrieve the remaining packing material.

To secure that the right quantity and sort is delivered, the Plastal staff at arrivals checks most of the incoming packing material. Even though the staff knows exactly what has arrived, it is not reported into Movex since Movex today would not have any use of that information. Instead it is used in Microsoft Excel. It is important to note, however, that the information is at least available even though it is not used in Movex today.

## 3.9 Movex

Plastal has been using Intentia's text based ERP system Movex for a couple of years. The version Plastal uses is tailored for the automotive industry. The system is used for production planning, customer orders, stock reports, invoicing, article series, etc. Plastal employs two consultants just for Movex issues, in order to maintain full usability. It is a large system and it is difficult to get a good overview of all the functions and data that are stored inside. The documentation that exists is specific help guides within the program, but only for specific issues. Therefore it is difficult to get into how the program works. Most of the people at Plastal are using the text based version of Movex, and the reason for using this, despite its tedious appearance in comparison with the graphical interface (also available to every user), is that it is much faster once you have learned how to use it, than the graphical version.

In order to familiarize the reader with how this system works, we will spend some time explaining that. Such insight is necessary in order to understand the possibilities that Movex offers for packing material, possibilities that are not used today. Figure 3.9 shows the main menu for the standard user. Movex is built up around several different modules. One module might for instance handle all the articles, another one might keep track of the customers and a third one might plan the whole production. Some of the modules in Movex that are interesting for this thesis are the ones that deal with customer orders, production planning, stock balances, procurement orders and basically everything that involves packing material. From the main menu every module can be accessed, either via a shortcut or by typing the complete name of the module. Every user can adapt this menu so that it meets the needs of every individual user.

### 3.9.1 Production orders and customer orders

The following part intends to make the reader familiar with how Movex plans the production.

To understand this we need to separate the ideas of production orders and customer orders. The production order is the internal order at Plastal of how much should be produced during a certain period and of a certain product. It is based on the customer order, but does not necessarily need to have any stronger similarities with it. Basically, as long as the customer orders are fulfilled, i.e., the goods are delivered on time, the production orders can fluctuate a lot from the customer orders. The production order states what article and what quantity that will be produced, what machine that will be used, how long it will be needed, when the production will commence, when it will terminate, etc., that is, basically everything that has to do with the specific batch. The customer order only states what should be delivered and when this should be done. The customer order is mostly issued by the customer itself, but is sometimes issued in collaboration with Plastal.

By using customer orders as a starting point, it is roughly possible to tell as early as six months beforehand what the production will be, i.e. how much that will be produced of each article within a certain (larger) period of time. To be more accurate, as early as six months before delivery, there does not exist a specific and fixed customer order, but instead an indication made by the customer of how much it is likely to need. Such long-term needs might however be changed by the customer, and thus limiting the reliability of these figures other than to be used for rough planning. Roughly six weeks before delivery most of Plastal's customer orders are more or less fixed. This means that it is possible each day to see Movex's production plans during the forthcoming six weeks. Of course not even these figures are fixed, mainly due to two reasons. The first one is that the production plan proposed by Movex might not (and usually is not) be optimal and is most certain to be changed by a production planner. These changes can take place a few weeks before the production, but they can also take place only a few days before or sometimes even during production. This means that there are great fluctuations in the production plans even on a few days' basis. The reasons for this can be many; staff vacation, periods of sickness, machine maintenance, machine breakdowns, lack of material, lack of packing material, holidays etc.The second reason is that the customer orders also can fluctuate on short notice, however, normally not as much as the production orders.

As stated before, Movex automatically generates production orders up to as long as there are customer orders, in this case up to one year ahead. This means that, as soon as a customer order is entered in the system, Movex generates production orders enough to secure that the customer order can be delivered. If there should be any problem, such as that there are no available machines at the time, Movex will notify the user on this. These production orders are then reviewed a few times before the production takes place. When fixed, they are separated by the system and Movex is not allowed to make any changes to them. Automatically orders are fixed 24 hours before production, but normally the user fixes (or freezes) the orders before. All the planning is made by the system once a day during the night. For Plastal this is an appropriate time interval, but of course it can be changed to whatever interval.

It is possible to set up lots of parameters for each article or machine in Movex. Planning methods (such as the Wilson formula), lead times and order quantities are possible parameters for any article. Movex is thereby very flexible, but we will not go through all the possible settings here, since that would occupy a lot of space, and since most of it would be out of interest for the packing material purpose. Later though, we will present some of them that can be used with packing material.

### 3.9.2 Stock balance

It is important to know how stock balance is defined in Movex. Since the stock balance is used primarily for production planning it is important only to consider material that is not already allocated to a production process.

For instance, there might physically be 100 kg of a certain granulate in the raw material stock, but on a closer look this has already been allocated to production later the same day and should therefore not be considered as available. With not available it is meant that it is not possible to use this material to any other process than the one specified in Movex. Therefore, when speaking of stock balance in Movex we do not speak of what is physically available at every point of time but instead of what is disposable. So even though we have 100 kg of granulate, the balance in Movex could show 0. This shows the main use for stock balances, but there are also other ways of using it. It might for example be interesting to find out how much is currently stored in the finished goods stock. What is showed is contingent upon how the user has set Movex to work. This is normally referred to as inventory position or available stock.

In other words, this depends on the parameters in Movex. The user can set the stock balance to be measured as what is physically inside the plant (i.e. the on-hand stock), not considering that the material measured could be allocated to processes or used up. For planning reasons, it is most convenient to work with an inventory method that measures what is disposable at every point of time, but in some special cases it can be necessary to work with what is physically available. Of course the user can specify different locations inside the plant for the stock balance to be measured (such as the raw materials inventory or stock of finished goods) depending on the information he wants to have.

At every point of time in the future it is possible to check the balance of for instance granulate, which is a raw material used in most of the products. The balance would then take into account all planned deliveries of new granulate, as well as all planned production orders that would consume granulate and thus decrease the balance. It is important to remember that the stock balance does not show what is physically available.

### 3.9.3 Packing material in Movex

So, technically there seems to be possibilities in Movex to handle packing material in an excellent way. However, at Plastal, these possibilities are not yet used. The usage today is limited to keeping track of what packing material goes with each article and the weights and measures of different kinds of packing materials, where the latter is used for shipping purposes. What is striking is that packing material not at all is involved in any kind of inventory control system. This means that Movex not at all keeps track of current packing material balances or in/out flows, resulting in a poor overview of the available packing material. Moreover, since there is no packing material balance, it is not possible to let Movex plan packing material demand (to acquire empty packing material from its customers), suggest ordering quantities etc. The reason for this poor support is that packing material has not had the same status - and thereby priority - as for example raw material (that is highly integrated into Movex) until now.

The whole automotive industry is constantly hunting down unnecessary costs in order to be as efficient and profitable as possible, and lately many have been restricting the allowed amount of packing material. It is essential for production that there are sufficient amounts of raw material available for production. Packing material, however, has always been material that just was supposed to be there, and also was. The reductions mean that the suppliers only get as much packing material as is needed in order to manage to deliver what the customer ordered. In turn, this is demanding the same control and precision from the suppliers that their customers use. In practice this means that Plastal has to increase the control of packing material and give it higher internal priority in order to do this.

## 3.10 Customer regulation of packing material

Every project at Plastal regulates the packing material by a contract. A project is connected to every new article, for instance, there was recently a new project for the bumpers for the Saab 9-3. In the project contract, basically everything that can be controlled is controlled. This of course also includes the packing material. This regulation is, of course, formalised and it us usual that every customer has the same rules for all projects. Since there is one project for every new part of a car, it is possible for the customers to regulate the packing material for every article. However, the customers usually have more or less the same packing material contracts for all articles. The contract specifies how often the packing material is delivered, how long the lead-times are, how much packing material Plastal is allowed to have at every point of time with respect to the customer orders, etc.

By Saab Plastal is allowed to hold up to one week's packing material at the time. This means, for example, starting on Friday week 01 with customer orders for week 02 that requires 100 pallets, Plastal is allowed to have no more than 100 pallets in stock on Friday week 01. On Monday week 02 Plastal is allowed to have packing material corresponding to the customer orders for Tuesday week 02 until Monday week 03. The orders for new packing material have to be made one week in advance. One week's packing material in practice means that the possibility of larger batches of, say 3 weeks, is basically impossible. The opportunity remains of course to produce a large batch, pack it in other packing material than Saab's and the repack in Saab's packing material. This is expensive however, and the one that takes the decision to do this has to be aware of the costs of repacking compared with the savings made by running a larger batch. People at Plastal believe that 3 or 4 weeks of packing material is the optimal amount considering the available space and machine time.

Although Saab's short lead-times are appealing, one week's packing material is most often not sufficient. When it comes to Volvo and Scania they offer more packing material but on longer lead-times. Figure 3.10 explains the details on all three customers.

A non-profit firm within the Volvo Group that is called Volvo Logistics AB handles Volvo's packing material. It is not a requirement for any Volvo division to use Volvo Logistics as a supplier on packing material but convenient. Volvo Logistics buys, maintains and transports the packing material and internally debits other Volvo companies. By having basically the whole Volvo Cars corporation as a customer (and even some Ford companies) it makes Volvo Logistics a cost effective solution for many Volvo companies. Volvo Logistics delivers precisely but also requires the same control from the customer. If the customer destroys or somehow looses packing material the customer has to replace it. Neither Saab nor Scania uses such an advanced system for the packing material as Volvo does. Neither do they force the supplier to pay for lost or destroyed packing material — yet.

The three customers' willingness in temporarily allowing more packing material varies. Saab is the strictest, rarely allowing more than just one week's packing material. With Volvo it is mostly possible to order extra packing material, but on the other hand Plastal has to pay a lot of money for that. Scania is usually willing to supply Plastal with more packing material than contracted and does not charge anything for this. However, since the packing material for Scania is very bulky the space at Plastal is instead the limiting factor.

## 3.11 Experienced problems

Depending on where in the packing material chain we have asked, we have got different answers on what problems that are the most critical. Asking the truck drivers at the very beginning of the chain, they say that it sometimes can be very stressful to wait while Plastal unloads the packing material. On the other hand, they agree that this stress is present at almost every client. Asking the forklift truck drivers, they argue that the biggest problem is the lack of space in the outdoor packing material stock. This makes it difficult to maintain effective handling, since the trucks are having difficulties in turning around, or meeting side by side. They believe that what causes this is that Plastal holds too much packing material at the same time. Their wish is either to extend the area for the packing material or to hold less of it.

The next step is in the production. The machine operators complain that sometimes the service staff (that assembles the folded packing material) not manages to deliver enough packing material, so that the machine operators either have to go and do it themselves or stop the machine and wait until the service staff can do it. This could mean that production is slowed down and delayed.

The packing material administrators say that one problem is that they are having difficulties in ordering the needed amount of packing material, since the customer refuses to send what was ordered. This in turn has implications on the production and on the production planning. Sometimes the production has to be changed beforehand since it is obvious that the packing material not will be sufficient. What is much is worse, is if the production goes on until somebody suddenly realizes that there is no more packing material. Then the production has to be stopped for quite a while waiting for more packing material from the customer or until somebody decides to stop the batch and change to a new one that uses different packing material. One common problem for the packing material administrators as well is that when they leave work on Friday afternoon and come back in Monday morning, ususally most of the packing material that was there has been used up by the staff that has been working weekends. This means that sometimes Mondays can be a difficult day to find packing material on.

The problem for the production planner is that he can not see how much packing material that is available. Therefore, he sometimes makes production orders that can not be fulfilled.

Figure 3.8: Overview of the plant

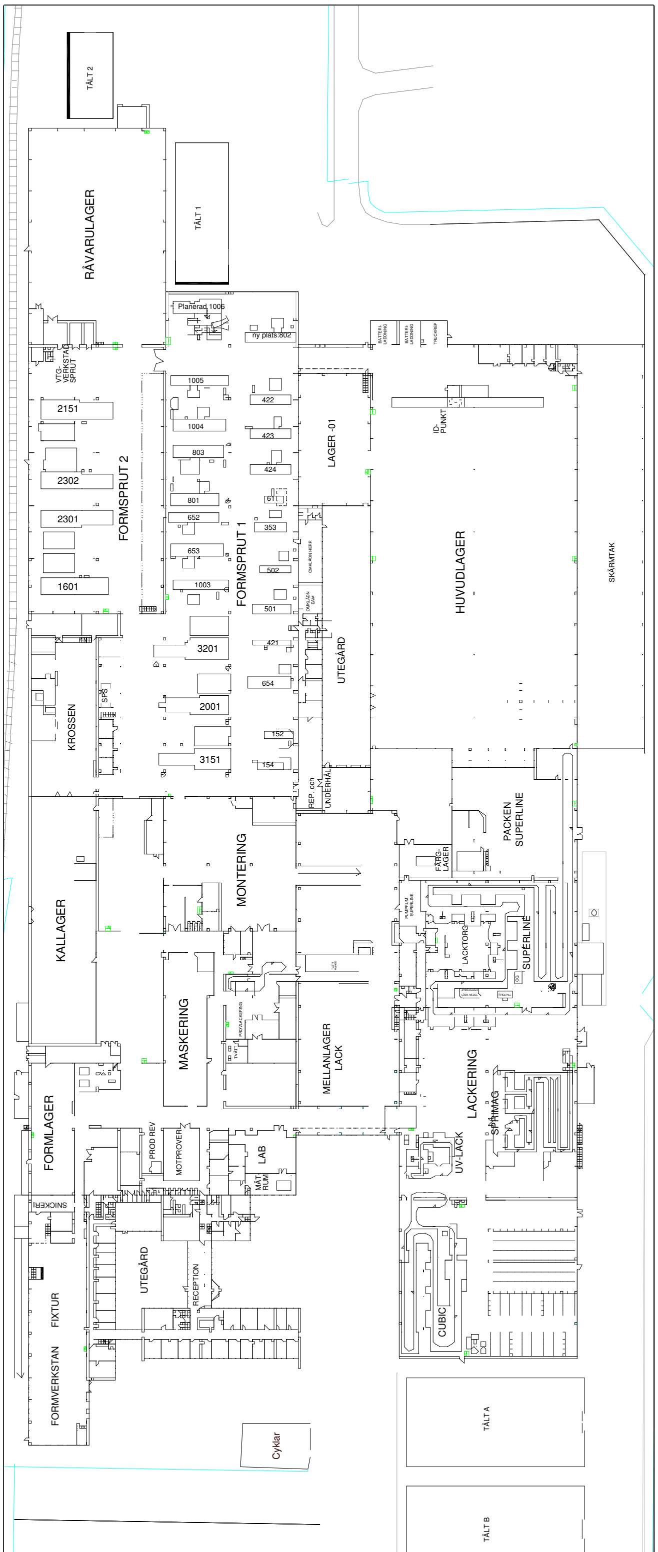


Figure 3.9: The main window in text based Movex

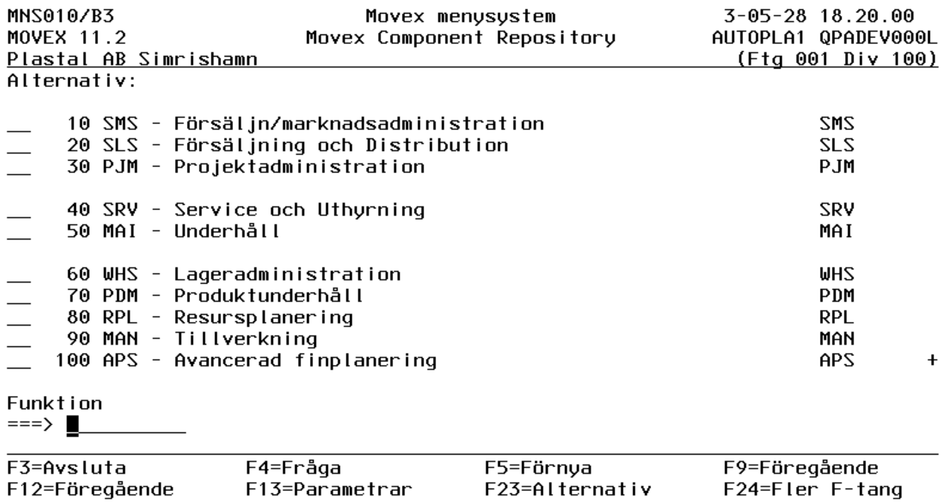
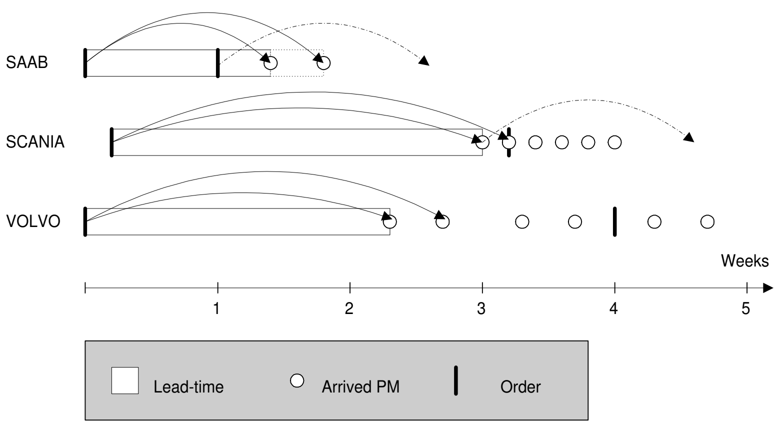



Figure 3.10: The ordering process for the tree main customers.



# Chapter 4

# Literature Review

*In this chapter the most essential theories from the literature study are presented. These incorporate literature on supply chain management, process development, inventory control and investment analysis.*

## 4.1 Packing material process

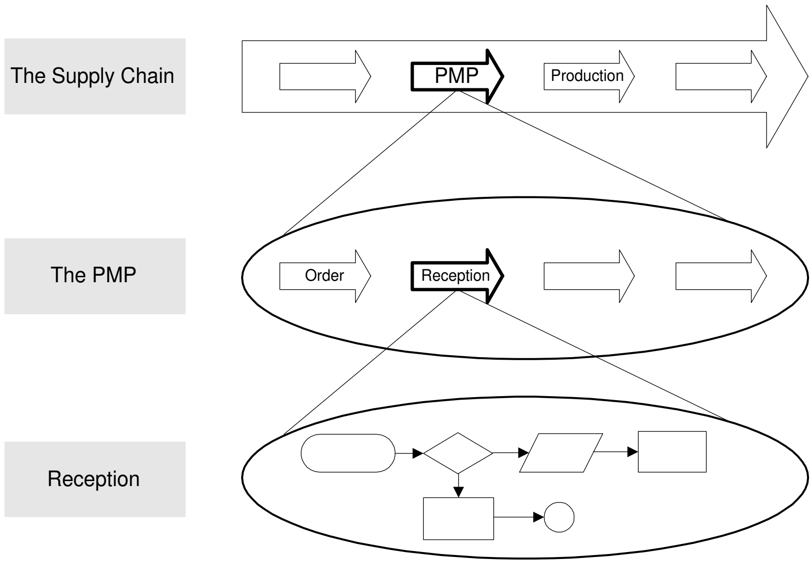
The packing material process (PMP) at Plastal can be analyzed from different perspectives. It is possible to analyze it from an inventory control point of view or why not as an organizational problem? Depending on the approach and on what theories that are used, different solutions concepts can be derived. Since the purpose of this project is to produce a complete and holistic course of action for Plastal to use, the solution has to be derived interdisciplinarily. The relation between the PMP and other process levels can be seen in figure

## 4.2 Supply chain management

This section is based on (Hill, 2000:190-231). A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers. Supply chains exist in both service and manufacturing organizations, although the complexity of the chain may vary greatly from industry to industry and firm to firm. The PMP is a part of this chain.

Traditionally, marketing, distribution, planning, manufacturing, and the purchasing organizations along the supply chain operated independently. These organizations had their own objectives and these were often conflicting. Marketing's objective of high customer service and maximum sales conflicted with manufacturing and distribution goals. Many manufacturing operations were designed to maximize throughput and lower costs with little

Figure 4.1: Different process levels




consideration for the impact on inventory levels and distribution capabilities. Purchasing contracts were often negotiated with very little information beyond historical buying patterns. The result of these factors was that there was not a single, integrated plan for the organization - there were as many plans as businesses. Clearly, there was a need for a mechanism through which these different functions could be integrated together. Supply chain management is a strategy through which such integration can be achieved.

### 4.2.1 Supply chain decisions

We classify the decisions for supply chain management into two broad categories — strategic and operational. As the term implies, strategic decisions are made typically over a longer time horizon. These are closely linked to the corporate strategy (they sometimes *are* the corporate strategy), and guide supply chain policies from a design perspective. On the other hand, operational decisions are short term, and focus on activities over a day–to–day basis. The effort in these types of decisions is to effectively and efficiently manage the product flow in the "strategically" planned supply chain.

There are four major decision areas in supply chain management: location, production, inventory, and transportation (distribution), and there are both strategic and operational elements in each of these decision areas. Because of the limitations of this project, we have focused on the processes directly associated with the packing material and the inventory control of the packing material. In the following passages we will therefore focus on process development and inventory control.

## 4.3 Process development

This chapter is based on Harrington (1991), Kock (1999), Hunt (1996) and Rentzhog (1998). When working with processes it is important to define and understand what a process is. The abstract nature of a process makes defining tricky and with these difficulties in mind argued that processes, as most abstract entities, need to be modeled in some way to be understood. And more importantly, two or more persons must understand the process in roughly the same way. However, since processes are mental abstractions of abstract entities, models always give an incomplete picture of a process.

Despite the difficulties in describing a process numerous researchers have contributed with their definitions. One description of a process is "a set of interrelated activities". In this sense processes are seen as activity flows (e.g. workflows) composed of activities which bear some sort of relationship with each other. This means that if activities are not perceived as interrelated then they are not part of the same process. As can be seen from the argumentation above the definition of a process can be very complex and abstract.

### 4.3.1 Importance of processes

Regardless of the exact definition used for describing a process there is no doubt that the process within a company often makes the difference between failure and success. Processes are true differentiators between companies. This is due to the fact that a competitor can buy a physical product, dismount it and study it in detail. The cause, for example of short lead-times, flexibility and responsiveness can be impossible to explain only by looking at the end product. This can be exemplified in the automobile industry where the knowledge of the competitor's products generally is very large but there still are major differences in profitability. Part of the differences in profitability can probably be explained by differences in business processes.

### 4.3.2 Process improvement

Process improvement can be defined as the analysis and further development of organizational processes to achieve performance and competitiveness gains. On the basis of the existing process an analysis of improvement possibilities is made and suitable adjustments are implemented.

The advantage of this approach is that it builds on further development of existing knowledge about the process. This is important for making development of the process to continuos activity. Every time teams or groups of individuals analyze their process, implement changes and observe the effects, they learn more about the processes, which can be used for further improvements. Another advantage of the process improvement approach is that it is not limited to only cover large projects. Every loop through the PDSA-cycle[1] can contain everything from a large improvement project to small adjustments. To build on the existing process also implies less extensive and dramatic projects. Parts that already work well do not need to be re-invented, which also decrease the risk for unwanted side effects.

On the other hand there are not only the risks and costs that are decreased by the process improvement approach but also the improvement potential. Researchers who recommend process re-design argue that it is not uncommon where processes are so badly suited to the situation that the only way to make them competitive is through re-design. They often argue that the processes are built on obsolete principles, which makes process improvement insufficient. Process re-design will be discussed more down below.

Before the analytical work with problem solving can commence the problems or improvement possibilities have to be identified. Harrington (1999:122) and Rentzhog (1998) suggest following steps:

1. Eliminate Bureaucracy

   Remove unnecessary administrative routines and paper work.

2. Duplication Elimination

   Remove identical activities that are performed in different parts of the process.

3. Value Adding Assessment

   Evaluate every activity in the business process to determine its contribution to meeting customer requirements. Real-value-added activities are the ones that the customer would pay you to do.

4. Simplification

   Strive to make the process as simple as possible. This implies to question and try to remove unnecessary decision occasions, unnecessary hand over, unnecessary documentation and other unnecessary activities.

5. Cycle Time Reduction

   Cycle time reduction does not only save time, but is also a well-known approach for generating improvements in a number of different areas.

[1] A theory from Japan that says Plan — Do — Study — Act.

6. Error Proofing

   Error proofing implies making it difficult to do the activities incorrectly. To decrease or eliminate the possibility to make errors is a powerful but surprisingly uncommonly used approach.

7. Simple Language

   Reducing the complexity of the way we write and talk, making our documents easy to comprehend for all that use them.

8. Supplier Partnership

   The output of the process is highly dependent on the quality of the inputs the process receives. The overall performance of any process improves when its suppliers' input improves.

9. Standardize

   Make everyone in the process perform the work in the same way. As long as there are variations in the way the job is performed there will also be variations in the result.

### 4.3.3 Process re-design

Re-design means that on basis of the aim and the customers of the process a whole new process is designed. Literature about process re-design often stress that one should not be satisfied with marginal changes but instead strive to create radical and fundamental changes.

As for process improvement there are also a number of principles that are valuable to consider when working with process re-design. Willoch (1994) suggest following steps:

1. Organize on basis of the result, not the task.

   Borders are preferably removed from the process to make possible that one person or a team manages to perform all steps in the process.

2. Let the persons who use the result perform the work in the process.

   In many cases process simplification, can be made by letting the customers perform parts of the process themselves.

3. Integrate information management in the operative work where the information is collected.

   Data should be collected and gathered at the department that is affected by the data.

4. Make the decisions where the work is performed

   In many organizations the decisions are made separated from the actual performance of a job. This has negative effects on organizations where the co-workers take their own initiatives and make important decisions necessary to satisfy the customer.

5. Link parallel activities instead of integrating their end-result.

   Processes with parallel activities, such as development of complex products have to be coordinated in some way. Modern technology makes it possible to know what other persons in the development team does independently of if they are situated in the same building or at the other end of the world.

6. Treat geographic spread resources as if they where centralized.

   The classical border between centralized and decentralized has changed. Nowadays IT solutions create a possibility to simultaneously enjoy scale benefits from centralization and positive decentralizations effects such as flexibility and vicinity to customers.

### 4.3.4 Process improvement or re-design

Process improvement and process re-design is usually considered to be two distinct separated approaches towards process development.

### 4.3.5 Process mapping

Process mapping is a tool for accomplishing process development. Relevant basic data is needed for making the right decisions. As the complexity increases it is getting harder to get an overview without a structured working procedure. Process mapping offers a structured way of working by describing a process with symbols. The result is a picture of the activities that are performed every time the process is carried out. The picture also provides information concerning the different activities. Such a map generates an understanding for complex processes that is difficult to achieve in the daily work.

The aim of the mapping has to be clear before the mapping begins. The first step is thus to make clear why the mapping should be done and what purpose it should serve. (Hunt, 1996)

### 4.3.6 Efficient changes

An efficient change requires that the personnel realizes the connection between the wealth of the company (and thereby indirectly of themselves) and the necessary actions that need to be taken. The personnel also has to realize that a change is necessary. It is therefore necessary to make sure that they understand why the change is necessary, by making it very clear what the problems are today. When a change has been proposed, the staff has to be prepared to work with the change, and not against it, i.e. they have to accept the change. Such acceptance is only accomplished when the staff is a part of the work that leads to the change. It is absolutely necessary that the staff feels that they are an important part of the change.

In order to have an efficient change, the solutions of course also need to have good quality. By working together with the staff, this helps to get a good overview of the current situation, and thus increasing the quality of the final solution.

### 4.3.7 Measurements

Being able to improve performance demands measurements. It is important to start measuring early both within the process and in its interface to verify that the improvement work has an effect.

### 4.3.8 The customer

The customer is the most important parameter in the process. Customers give processes their right to exist and answer the question what the result of the process should be. The customer also influences the way things get done in processes. Taking a process approach implies the customer's point of view.

## 4.4 Inventory control

The basic function of inventory control for packing material is to insulate the production process from changes in the environment. Inventory control basically means deciding on three principal choices. The first one is for the review of the stock to be continuous or periodic. Continuous review means high control but is also very costly, periodic review is usually cheaper but does not give the same control. The second choice is the type of inventory control method to be used, i.e. what rules that shall be used for planning, ordering etc. Finally the order quantity method has to be specified, often as a function of the inventory costs where the chosen quantity minimizes the inventory costs.

Inventory costs are often divided into inventory holding cost (the cost of holding the manufactured or purchased material in stock) and the cost of obtaining that material. In the case of purchased material it is the order placement and processing cost which includes purchasing, goods receiving, incoming inspection and accounts payable. For manufactured items it is the cost of setting up the machines and processing the works order. It does not include the direct cost of obtaining or manufacturing the part as this would be incurred irrespective of the batch size.

Material control can in principal be executed in two ways. The first one is material resource planing (MRP) with a dependent and deterministic demand. In the second one, the future demands are seen as stochastic, and, since they cannot be derived from other demands, they are seen as independent. The core of the latter is the economic order quantity (EOQ), which will be presented in the next passage together with relevant material control methods for the packing material. (Michelsen, 1995: Chapter 1)

### 4.4.1 Economic order quantity

In the literature the best batch size is most often determined by the EOQ formula. From a pure financial point of view this is correct, and the EOQ is defined as

$$EOQ = \sqrt{\frac{2US}{I}}$$

where U = annual usage, S = ordering or set-up cost and I = inventory holding cost.
Unfortunately there are a few assumptions made for this to be true. For example, the demand should be equal and regular, the physical size of the part is not considered, there should be sufficient capacity, there should be sufficient storage space and facilities. In the real world these may be a problem.

The concept is that one should build or purchase parts in such a manner so as to incur the least total cost to the company over a period of time. The more that is put into stock at a time the more it will cost to store it from an inventory holding point of view. From this point of view, the inventories should be as small as possible. However, the more that is produced at a time the more the cost of setting up the machines and processing the order can be spread. From this point of view it should be more profitable to have large inventories. Obviously the correct batch size is one that is somewhere in between these two opposing points of view. What is established is that the most economical batch size is when the holding cost equals the set-up cost. All the fancy methods of determining the batch size are based on this fact, but some take other considerations into account as well. (Michelsen, 1995: Chapter 2)

### 4.4.2 MRP ordering rules

Most MRP modules allow choosing between several ordering rule options. Typically they offer; Fixed order quantity, lot for lot or discrete ordering and period order quantity. Some also offer periodic ordering, least total cost and part period balancing. In addition there are order modifiers to make the order quantity generated practical. We have briefly outlined the principle of each of these methods in appendix D.

# Chapter 5

# Discussion and Analysis

*In this chapter we will first of all give the reader a general analysis of the problems connected to packing material at Plastal. The impact of the problems will also be quantified in economic terms. We will give information on what the desired results should be, i.e. what qualities an improved packing material system should have. After that we will use the theories of process mapping, process improvement and process re-design mentioned in chapter 4 to analyze how the PMP best can be improved to achieve the desired goals. We will apply inventory control theory to the PMP and use trains of thought from supply chain management theory. When this is done, we will present the main ideas of what the improvement will look like. These ideas will be presented more thoroughly and also concretized in the conclusions and recommendations chapter.*

## 5.1 Problem and cost analysis

The task of the customer owned packing material is to serve as a support for the production, both for the customer and the supplier. The customer gets handling easy when the delivered products arrive in the customers own packing material, and the supplier is supposed to benefit from not having to worry about the packing material, since this is supplied and handled by the customer solely. However, as written before, this packing material does not always serve as a support for Plastal's production but instead as an impediment. This depends partly on the customer, which sometimes lets Plastal hold very small volumes of packing material in addition to what is absolutely necessary to secure delivery, but mainly on Plastal which has insufficient control and administration of the packing material. Also the advance planning at Plastal is poor as well as the internal communication. In the following passages we intend to give the reader an overview of each of the main problems and how much each and one of the costs today.

### 5.1.1 Emergency stops

We have mentioned the emergency stops in the empirical findings chapter, but not given the reader a hint on how serious these are. Only during 2002 15 unexpected emergency stops in the five largest injection moulders occurred that were directly caused by lack of packing material. This figure does not include similar incidents in smaller injection moulders. Such stops can jeopardize the production and reduce Plastal's ability to deliver on time. Just failing once to deliver on time would cause Plastal tremendous costs in terms of being liable for damages because of production stops at the customers' plants. This has to be avoided! The incidents occur when production workers suddenly realize that there is no more packing material. What is usually the procedure after that is that the production in that machine is stopped for one to two hours while staff members look for more packing material or figure out what to do. As there is usually no more packing material to be found, the machine either has to wait as long as 24 hours until new packing material can be sent via express delivery, sometimes from abroad, or the group leader of that machine decides to change the mould (which takes a few hours, delaying the production further), and a new product batch should be run.

By using Plastal's ABC-calculus, we have been able to calculate this impact in economic terms. Unfortunately we can not present how we did this since this would expose information that is highly confidential for Plastal. However, we are allowed to present the final figure, which is an estimated 250[1] KSEK. Remember that this figure only takes into account the major emergency stops and thus is larger in the real world. In addition the above figure, we have not taken into account the loss of possible income that occurs when such events happen. This would increase it even more.

### 5.1.2 Alternative costs due to restricted amounts of packing material

Speaking to the people at the planning department, they argue that the optimal batch size, with respect to available storage space and machine capacity, would correspond to about 4 weeks of packing material. This cannot be verified by the economic order quantity formula (also known as the Wilson formula), since this says a much higher figure. The Wilson formula is of course theoretically correct, but in practice it can be difficult to strictly act upon this formula. The main reason for this is that Plastal suffers from lack of space, and that following the advice of the Wilson formula would require additional storage space be built, which is not prioritized for

[1]As for the reliability of this figure, numerous persons have checked and approved it at Plastal, both at the planning department but also at the board of directors. Therefore we believe that the figure is reliable.

the moment. Therefore we will assume that 4 weeks of packing material is the optimal amount. As we stated in the empirical findings chapter, Scania Trucks allows Plastal to have 3 to 4 weeks of packing material, Volvo Cars also allows Plastal to have 3 to 4 weeks of packing material, but Saab Automobile allows Plastal to have merely 1 week of packing material. This means that, in this respect, Scania and Volvo seem to be giving Plastal the packing material that is optimal, as when for Saab it is a bit tighter.

But there are ways to circumvent the small amounts of packing material. Sometimes, Plastal packs the parts into its own packing material and then sends this to be repacked at Samhall-Lavi in the customer's packing material. This is especially true for the small Saab Automobile articles. This enables Plastal to run 3 or 4 weeks batches and continuously let Samhall-Lavi repack the finished products into the customer's packing material, but on the other hand it costs a lot of money to do this. This money could be compared with what Plastal saves in setups and scrap costs[2], but, in the end, all the money that this costs could have been avoided if Saab would supply Plastal with 3 or 4 weeks of packing material from the beginning instead. Again, we cannot present the exact calculations, but this ends up to about 500 KSEK annually for Plastal. By making the customer realize that the price of the products could have been 500 KSEK less expensive if there was more packing material, that would be a big step in an understanding of the packing material dilemma.

### 5.1.3 Administration

We have mentioned before that the administration for the packing material is very expensive. The main reason for this is that the computer support for packing material at Plastal today is unsatisfactory.

Today, Movex is only partly involved in making prognoses for the packing material. Administration would be a lot easier if Movex was set to perform these tasks. By having the packing material totally integrated in Movex, this would make planning very much easier, and it would reduce the risks of having emergency stops. The planner could easily see if there was going to be sufficient packing material or not, and never setup a batch that would use more packing material than available.

There is however a downside with integrating the whole chain of packing material. The downside is that not all parts of packing material is suitable for this integration, or even possible to integrate. The reason for this is that there are some alternative flows of packing material (concerning a few products and a few types of packing material) that cannot easily be integrated into Movex. All such alternative flows have to be fed manually into Movex and this requires a lot of time. If one flow of packing material is excluded

[2] In conjunction with every production start, the scrap costs are high, but decrease with time as the process goes on

from Movex, then this could influence the whole chain. The final result will, although the packing material flows in Movex system may not be completely automatic, be that the total time spent administrating packing material will be less in the future than it is now, but that there has to be some regular work in order to manage the alternative flows.

Assuming that our interviews show the reality correctly, about 8 hours per person every week is spent just for administrating the packing material. Since there are two persons doing this together, this costs totals about 200 KSEK annually. This amount could be reduced significantly if the packing material was easier to administrate.

### 5.1.4 Lost packing material and rent

Since Plastal has inadequate control of the packing material, or more precisely, since Plastal has not integrated the packing material into Movex, it becomes easy for the customers to claim their right in missing packing material, or for rental of packing material that was used in addition to what was allowed in the contract. We mentioned earlier that only Volvo practices this currently, but that it is not impossible that Saab and Scania in the future also will become harder on costs. We can not give any details on these figures, but simply conclude that it sums up to somewhere between 500 to 600 KSEK every year, also this figure acknowledged by Plastal. A more efficient and more reliable PMP would give Plastal more control to identify (and thereby have a chance to avoid) the periods when Plastal has too much packing material, according to the contract, but also to minimize the risks of losing packing material.

### 5.1.5 Cost summary

The problems that we have dealt with above, and also quantified in terms of annual costs, are not the only problems caused by packing material. However, we believe that these are the most important ones, and the ones that most urgently need to be solved. Summing up these costs yields, at least 1.5 MSEK. Implementing a better PMP can spare a great part of this. It is the opinion of people at Plastal that this figure is a minimum of the costs today, and that the costs probably are even bigger in reality.

## 5.2 Extended problem view

When analyzing the above problems, we have come to the conclusion that much of them can be derived from one single problem, namely lack of control. It is lack of control that causes the emergency stops, it is lack of control that causes the administration costs to be much higher than necessary and it is lack of control that most likely forces Plastal to pay large amounts of money to Volvo Cars every year for lost/rented packing material. Lack of control also reduces the possibility of the person that plans production to see if there is enough packing material or not. If he could easily see that, then a lot of the problems could be avoided. For example, it would be possible for the production planner to setup another batch before starting the original batch if it was found not to have enough packing material available.

Thereby this problem will be our first priority to solve. We believe that it is necessary that the problem is solved now, since it might become worse in the future. One scenario is that both Scania Trucks and Saab Automobile start using the same methods as Volvo Cars does, or that Volvo and Scania reduces the allowed amount of packing material. There is only one method to solve the problem, and that is to computerize the administration of the packing material. There are plenty of choices for software systems to do this, but since Movex already is up and running, and since Plastal has good competence on how to use it, integrating the packing material into Movex seems to be the most reasonable choice.

## 5.3 Process mapping

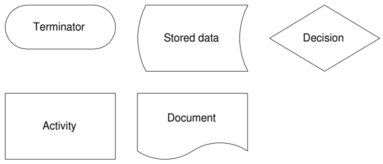
In order to understand how to change processes (and thereby to solve the above problems), it is essential to map them to get a full insight into what they look like and how they work. Once they are correctly mapped, it is possible to decide whether to improve or to re-design them, and how to do this. Improvement or re-design are two possible ways of process development. Which approach that is suitable for each process will be discussed below.

Another reason for the importance of mapping the processes, is that if some part of a process is changed as a consequence of any of the proposals of this thesis, that might not only influence the part itself, but also other parts or sub-processes, in the original process. This might lead to unwanted effects that could have been avoided.

It is said in the literature review that it is often the processes that explain a company's profitability. The end product might be the same, but the costs for producing it might be higher at one company and lower at another. The packing material is not one of the major processes at Plastal, but Plastal seems to have quite good control on the bigger processes, which is the reason for why packing material now is being prioritized. When the PMP has been made more efficient, then the next problem will prioritized and solved, and so on. In the end, this kind of constantly working for improvement can explain how Plastal has managed to keep its profitability over the years. It is important to keep in mind that the goal with all this work is to make Plastal a more profitable company.

We have identified three main processes that could be developed. These

Figure 5.1: Explanation to figures used in process maps




are the administration process, the physical process and the computational process. Each and one of them will be analyzed below, and it will be decided what kind of process development that is suitable for them.

Figure 5.1 will show explain the figures used in the maps.

## 5.4 Administration process

As stated below, mapping the process is the starting point for any process development. What is mapped here is the administration process, which is a mapping that almost entirely is built up around the interviews that we have made with the packing material administrators.

From figure 5.2 we can see that there are three sub-processes connected to the administration process.

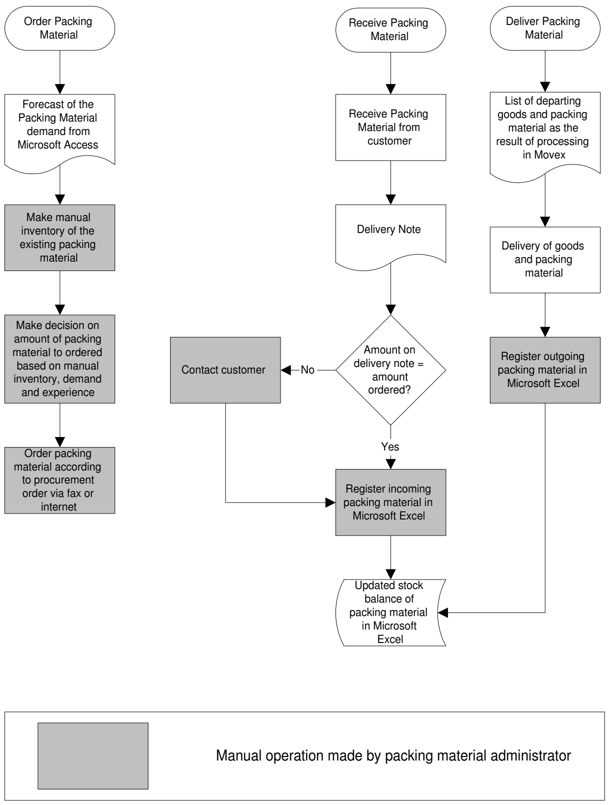
### 5.4.1 Ordering

The first one is the ordering of packing material. We can see that a big part of this process is done manually. The first step is to get a forecast of the packing material. The packing material administrator has a sub-program in Microsoft Access which helps to sort out the appropriate data from Movex. The next activity, that is done manually, is making the inventory in order to see how much packing material that is currently stored at Plastal. This means that the packing material administrator is doing something that a computer would do much faster, much better and much easier. This is the most time-consuming process, and it might take at least an hour to count all the packing material. Sometimes this is done several times a week. Here is room for development. The next step is to decide how much packing material to order. This is based on the current stock level, the future packing material demand and on experience.

At the end of the process, the packing material administrator orders the packing material. This step has to be done manually because of the customers' routines. It thus leaves two parts to be automated in Movex: Making inventories and taking decisions on how much to order.

Only two activities have to be revised or improved and therefore there is no reason the re-design the whole process from the beginning. Doing this

Figure 5.2: The administration process before the change




completely is quite impossible; it would require the customer to change his behavior as well, and that is not very likely. It is enough to merely improve the two mentioned parts of the process.

Process improvements build on further development of existing knowledge. It is also the fact that for things that work well, it might be enough with just an improvement and not re-design, which is more radical. Although the PMP today is not very efficient, at least it works most of the times. An improvement would make it more efficient and more reliable.

In the next section we will analyze the improvement possibilities and the possible problems for the packing material administration process by using the methods of Harrington (1999:122) and Rentzhog (1998), but next we will deal with the other two sub-processes in packing material administration.

### 5.4.2 Reception

The next sub-process is the reception of the ordered packing material. We can see here that what is manually done is the checking of whether the correct amount of packing material was sent. This can not be automated with today's technology at Plastal. Packing material still has to be unloaded, checked and stored and the investments for automating this, would - if not impossible - at least be very expensive. This is not economically motivated, and we will base the process development on this sub-process upon process improvement as well, since there is no need (and no room) to completely re-design the process.

We see that, after the packing material has been checked, the information is entered into Microsoft Excel in order to update the stock balance that is held in this program. We believe that this information is valuable, but the way it is used should be different. Instead of typing it into Excel it should be typed directly into Movex.

### 5.4.3 Delivery

Finally, the third sub-process deals with when products are sent away to the customer. We can here see that the manual step in here is that the departed packing material is entered into Microsoft Excel. Again we believe that this information is necessary, but using it in Movex could make the process a lot easier and eliminate some of the manual work. An advantage of using Movex at this step, is that the manual input becomes obsolete. Movex already "knows" what products that are being delivered, and can automatically use this information for the packing material as well. With the same argument as for the last sub-process, we will develop this process by using process improvement as well.

This means that the whole packing material administration, i.e. all the three sub-processes, will be improved, and not re-designed.

## 5.5 Physical process

When it comes to the physical process of the packing material, i.e. from the arrival through the production to the final storage, there is no need (or at least no possibilities) for improvement or re-design. This is not only our own opinion but also the opinion of many people at the planning department. The physical process of the packing material can be seen in figure 5.3. The change of the physical process would require more investments (for instance restructuring of storage etc.) than restructuring of the work organization or improvements of Movex. Development of the physical process is neither prioritized nor needed for the moment. If there were resources for this, some of the flows could be shortened and made more efficient, but doing this would require an extensive analysis and a larger budget. The result would probably be that the storage space for the packing material would be moved or rebuilt, and such changes are too radical and expensive for the

Figure 5.3: The physical process of the packing material

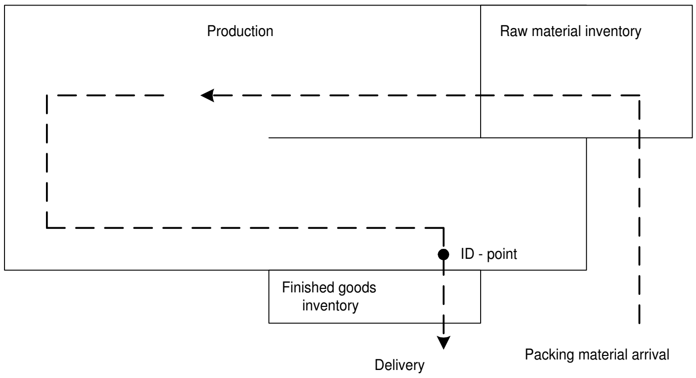
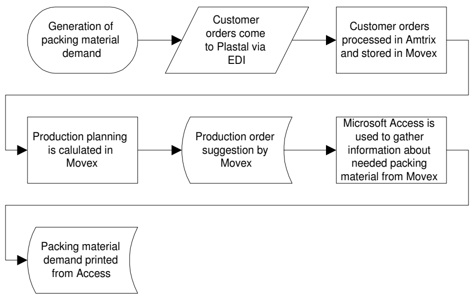



Figure 5.4: The computational process before the change




purpose of this project. Therefore we conclude that developing this process is beyond the scope of the thesis.

## 5.6 Computational process

This process is a bit harder to describe since it is not visible to the same extent as the previous two processes. The computational process today is however not very extensive, as mentioned earlier, since the packing material today makes very little use of computers. The process can be seen in figure 5.4. From the square ”Production order suggestion by Movex”, the process no longer makes use of Movex. As our opinion says, as well as the general opinion at Plastal, that this process has to be integrated in Movex, this means that the process has to be completely re-designed. To achieve the breakthrough that is wanted for packing material, it would not be sufficient with just an improvement. A total re-design would give more than marginal changes, it would give a totally new fundament to work from and make the process much more efficient.

## 5.7 Conclusion on the processes today

The three main processes have been identified, and the need of change has been defined. The administration process and the computational process need to be developed, but the physical process does not need any development today. Furthermore, the administration process needs improvement and the computational process needs complete re-design. In the next section we will use theory from process improvement and process re-design to identify possibilities and problems that we have not yet considered.

## 5.8 Improvement of the PMP

Harrington and Rhentzog (as referenced in the literatur review) argue that there are 9 valuable principles that need to be considered when working with process improvement. These were explained in the literature review and should help to identify the problems and improvement possibilities. We will discuss every principle below and then sum everything up at the end.

1. Eliminate Bureaucracy

   A lot of the administration today is paper based. This means, that every year literally kilos of papers have to be filed and stored. This means that there is a lot of possibilities for improvement if the process could be more computerized and stored electronically. Also many routines that today take up a lot of time could be eliminated. This includes making daily inventories of the packing material, or making manual prognoses of the packing material demand.

2. Duplication Elimination

   One important process, which can be made more efficient by an improved packing material administration, is the arrival of packing material. Today the packing material is unloaded by the forklift truck drivers, checked, and noted on a paper, which is transferred to the packing material administrator. The packing material administrator thereafter uses this information to update his packing material stock in Microsoft Excel, and finally files a copy of this. When the packing material administration is integrated in Movex, all this can be done directly by the forklift truck drivers (the trucks are equipped with Movex terminals). This means that no papers have to be transferred, and that no documents have to be stored. This saves time and resources.

3. Value Adding Assessment

   Today, the customers accept that Plastal often come in with last-minute orders of packing material, and that Plastal often asks for more packing material than what is allowed. This behavior is not forbidden, but it makes it more difficult than necessary for the customer. By planning more in advance at Plastal such behavior can be reduced. This would improve the relation between Plastal and its customers, and also make it easier for the customer to meet with Plastal's demands. A more efficient administration would reduce the need of last-minute orders of packing material, and could also provide the customer with better long-term forecasts on Plastal's packing material demands.

4. Simplification

   As mentioned above, some or even much of the documentation can be removed when the administration is made more efficient, i.e. when it is integrated into Movex. When it comes to removing unnecessary decision occasions, Movex will help to remove the choice of how much should be ordered, by presenting more reliable figures of the packing material demand than today's system is able to present.

5. Cycle Time Reduction

   The total cycle time for the packing material chain will not be reduced, since the customer sets this. However, parts of it will be reduced thanks to computational power and the simplification mentioned above. An example of this is the total time spent administrating the packing material.

6. Error Proofing

   The most important error proofing is that the human interactivity and the data transferring between sub-systems (that today occupy a lot of time) will be reduced. Instead, Movex will be taking over many of these tasks. As long as Movex is a reliable software system, the result will also be reliable. There will still be room for errors, of course. It is not sure that the implementation is error proof for example. Errors might show up after some time, that were not anticipated from the beginning. Such errors might be concerning packing material that not behaves as "normal" packing material, and that might need special treatment, both physically and electronically. Therefore it is necessary to expect that there will have to elapse a few weeks (or months) after the system is introduced, until it can be considered error proof.

   As soon as a problem occurs, there will be resources to fix this problem. The main packing material flow together with all other packing material flows or possible exceptions will be documented.

Also, there is some human interaction that cannot be avoided. When making the order, the administrator has to transfer the figures from Movex onto the customer's ordering form. This cannot be avoided. It is important to realize that the system cannot be made completely error proof.

7. Simple Language

   As to every job, there are words and phrases that are used among the employees that might be difficult to understand if you are not used to them. These, we believe, are difficult for us to change, and they will probably continue living on. Although tiny, we have managed to change the phrase "external packing material" into "customer owned packing material", and managed to get the employees to use this phrase instead. The reason for this is that external can mean a lot of things. In the same way we have also changed the phrase "internal packing material" into "packing material owned by Plastal". This makes it easier for people not normally involved with packing material to follow discussions.

8. Supplier Partnership

   In this case, supplier means the same thing as customer, since it is the customers that supply Plastal with packing material. The output of the process is of course dependant on this input, and we have mentioned before that there are possibilities both for the customers and also for Plastal to improve here. For instance, the shorter lead times that the customer uses for delivery of packing material, the easier it becomes for Plastal. A packing material order that was made 3 weeks ago has probably become a little out-of-date when the packing material actually arrives. We have also stressed that it is difficult to get on with just one week's packing material. This and the fact that the lead-times are long, make improvement possible. Unfortunately, it is very difficult for suppliers (Plastal) to demand changes from the customers. It is often the other way around, that the customer demands changes of the supplier. We are aware of that the above is a problem, and what Plastal can do is merely to inform the customers of the problematic situation, not to specify any specific demands.

9. Standardize

   Today, two persons administrate the packing material. In the future, it is possible that it is enough with one person doing this, but if there still will be two persons doing it, then it is necessary that they work in the same way. Differences here might deteriorate the final result. Therefore it is important that we educate the administrators together on the new system, which will reduce this risk. Also the forklift truck drivers are two persons (and will most certainly remain two persons), and the same goes for them. They have to be working in the same way in order to get the best result. We wrote earlier that will we will produce a manual for the whole packing material administration. This will help the process to be standardized.

## 5.9 Re-design of the computational process

As discussed before, it is not enough with just an improvement of the computational process. It has to be completely re-designed. Willoch (1994) has listed six principles that are valuable to consider when working with process re-design. These principles could help to identify the problems and improvement possibilities, i.e., we will use them for the same reason as with the principles for process improvement.

1. Organize on basis of the result, not the task.

   To be able to do this, it is necessary that the goals are present and clear before the work begins. In our case, the first step was to find out what we wanted the result to be. We therefore asked the administrators what characteristics they wanted a completely new packing material system to have. We compared this with the ideas of similar areas (such as raw material administration, which is similar to packing material administration) together with our own expectations, and set out a goal for the new packing material system.

   - The system should be easy to use and only present the information that was necessary for the packing material.
   - The system should use conventional interface and modules in Movex, and should be easy to learn for people with knowledge of Movex.
   - The system should be reliable and present correct data.
   - The system should replace much of the manual work that was done before, such as making inventories and prognoses.
   - The system should NOT be completely self-administrating, even though this could be possible. A person should always be required to operate the system.

2. Let the persons who use the result perform the work in the process.

   The last point in 1. makes this not only possible, but also necessary. The connection between the person (the administrator) who uses the system and the final result is very strong. If the administrator is doing a good job, this will directly result in a good PMP. The feedback (positive or negative) from the planning department will reach the packing material administrator quickly.

3. Integrate information management in the operative work where the information is collected.

   This is actually a problem, since much of the data that will be needed for a well functioning system will not be collected from the department of planning or from the packing material administrators. It will instead be collected from the production technology department. The data will consist of what packing material that goes with each product. This data is quite important, since if it is not correct, then the system will systematically show the wrong values. It cannot be guaranteed that the data is correct for all 2000 products that will need to be integrated into Movex, but the people at the production technology department are the only ones that have this information and we trust that this information is more or less up-to-date. The planning department is the department that will be most affected by the result of the new packing material system, so the ideal situation would have been if they also administrated this data, in order to assure the quality.

4. Make the decisions where the work is performed

   This will also be the case, since most of the decisions are and will be taken by the packing material administrators, or sometimes, by the packing material administrators together with the production planning department.

5. Link parallel activities instead of integrating their end-result.

   We can not see that there are any parallel activities. The PMP is more like a sequential chain, and it is not very complex, for instance when compared to the development of advanced products. Also very few persons are involved, and even fewer will probably be involved in the future. We believe that this principle is of less importance for this project.

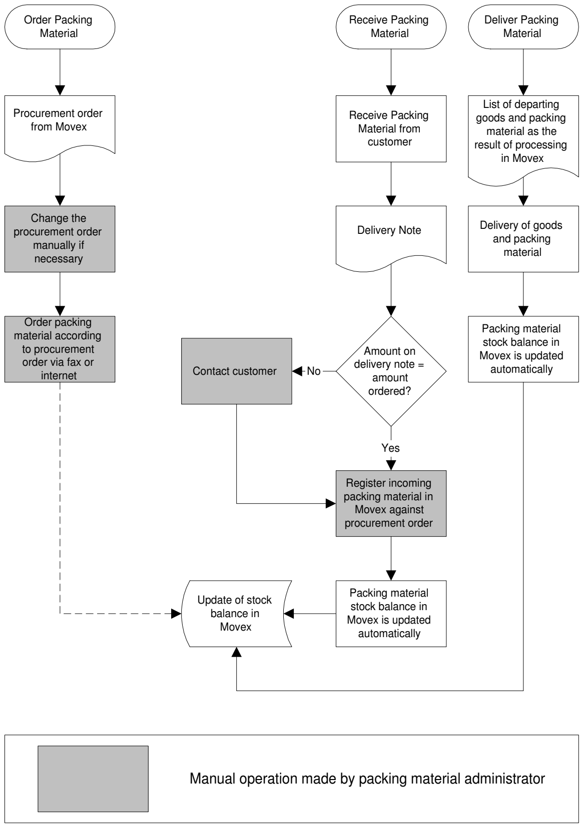
6. Treat geographically spread resources as if they where centralized.

   This is very much the situation today. Volvo Car's packing material administration is completely IT-based, and Saab Automobile and Scania Trucks are probably getting there soon.

## 5.10 Process Mapping after the Change

After the improvement of the PMP has been made, the processes will look different, in particular the computational process. This section will help the reader to understand what the changes will look like.

Figure 5.5: The administration process after the change




### 5.10.1 Administration Process

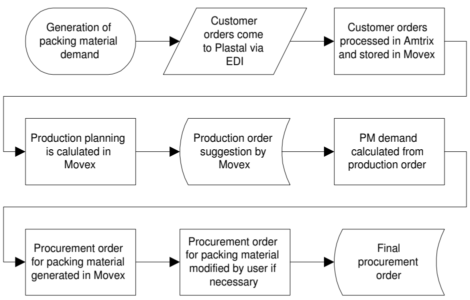
This process will be improved, and the final result can be seen in figure 5.5. As before, the administration process will be split up in three sub-processes: Ordering, delivery and reception.

#### Ordering

What was processed in Microsoft Access will instead be processed directly in Movex. Movex will generate a procurement order [3] automatically, and the user will be able to study this and have the chance to change it. Procurement orders will be generated for as long as the planning horizon is set in Movex, i.e. up to six months. The procurement order generator will take into account that packing material sometimes only can be ordered for example

[3]A detailed plan on what material that needs to be ordered every day in order to be enough to cover the demand

Figure 5.6: The computational process after the change




every 3rd week, or whatever the specific restrictions may be. More details about this can be found in the inventory control analysis.

**Reception**

The manual input into Microsoft Excel will no longer be needed, and the same goes for the stock balance in Microsoft Excel. Instead Movex will keep track of the stock balance. The procurement orders generated will serve as the list in which the forklift truck drivers put in the information about the checked incoming packing material. For every day, the procurement order contains information on how much and what sort of packing material that will arrive. The forklift truck drivers confirm with Movex that the correct amount has arrived, or, if there is a difference, they enter this directly and Movex adjusts all future stock balances by using this information.

**Delivery**

Before, when goods were delivered, the stock balance in Microsoft Excel was updated manuallt. Now, this will be done automatically in Movex. Movex knows exactly when goods are being delivered and can instantly adjust the stock balance on basis of this information. The stock balance in Microsoft Excel will thereby not be used anymore.

### 5.10.2 Computational process

This process will be re-designed, and the final result can be seen in figure 5.6.

We can see that the differences to the original process will be quite many. First, a customer order is registered, whereafter Movex automatically generates production orders to cover the customer order. Then the procurement orders are generated, and there are some different ways to do this. The simplest is just to set the procurement orders to cover the production orders.

In some cases though, this might lead to procurement orders that are not possible. This can be when the procurement order states a higher volume than what is allowed by the contracts. Then the result might be that the customer is unable to send the requested amount, which gives the implication that the production order has to be changed. An alternative way would be to let Movex calculate procurement orders so that they never exceeded the allowed amount. There are plans on getting a more refined system like this last one in the future, but we will settle with the most basic method and make sure that it works. The next step is to, if necessary, adjust the procurement order, which results in a final procurement order that cannot (easily) be changed once it is transferred to the customer.

## 5.11 Inventory control analysis

Here we will discuss the main methods of the inventory control of the packing material. This section will not go into further detail into the inventory control methods than what is written below. The reason for this is that the methods can be differing depending on the type of packing material, and that this would require special treatment for every type of packing material in this thesis.

Material planning can be based on two principal methods: Fixed order quantity (using the EOQ) or material requirements planning (MRP).

Since Plastal has information about future customer orders, and future demand and since Movex is using the MRP methods, it is appropriate to use MRP. The next decision is if to have periodic or continuous ordering. What emulates the reality best is the periodic ordering, since packing material only can be ordered once a week or every third week. Next it has to be decided whether fixed or variable order quantity should be used. Here as well, variable order quantity best matches with the reality. The variable order quantity can be restricted by only allowing certain multiples of packing material to be ordered, for example 100, 150, 200 etc.

Every packing material order's purpose is to cover the packing material demand some period ahead in time. This makes a manually set cover time an appropriate choice. In this method, the ordering quantity is calculated in accordance with the theory of MRP to cover the manually set period. More details about the methods can be found in appendix D.

## 5.12 Efficiency of the solution

In figure 5.7 on page 65 we have tried to list the problems and arranged them by their seriousness. We have mentioned the most important problems either in this chapter or in the empirical findings, but some problems might be new for the reader.

We have tried to make critical estimates on how well each problem will be solved. The higher up the bar is, the better the problem is solved. We will now comment each and one of the problems, and how well they are solved by our solution.

1. Stressful for truck drivers: This is the work of the truck drivers that deliver empty packing material to Plastal, and that bring the finished goods to the customer. From our interviews we have got the impression that this can be very stressful. We believe that this is true, but that it is the same for every company. A solution to this would be to enlarge the area for the trucks and speed up loading and unloading. This is however out of the scope for this thesis.

2. Difficulties in finding the right packing material: The storage of empty packing material is huge, and there are only two persons who know where to find everything. These persons unfortunately cannot be at work every day, and other people have to find the packing material, which sometimes takes some time to find. It is not a very big problem, but to solve it would require the forklift truck drivers to specify exactly where they have put all the packing material and this would slow down the handling considerably. Our solution does not improve this problem.

3. Difficulty in setting up the right parameters in Movex: Time will show if for instance the safety stock is correctly specified, and if the right inventory control parameters are used. There are resources though at Plastal that can be of good help on this. We don't expect this problem to be very big, at least not after the system has been up and running for a few weeks.

4. Inefficient administration: This is not one of the most serious problems, since the situation does work today (making inventories, using Microsoft Excel etc.), but there is much room for improvement. We believe that our solution will improve the administration considerably, and that this improvement also will have effects not only on the administration, but also on other problems.

5. Lack of space for forklift trucks: The drivers have argued that the Plastal holds so much packing material that it sometimes is impossible to drive the truck. There are actually two possibilities to solve this problem: either to increase the space, or to make sure that only the packing material that is being used the next days are stored. We believe that our solution will solve the problem with the latter method, namely by optimizing the use instead of increasing the area. This can be done since the administrators will have better control on what packing material that is obsolete.

6. Inefficient assembly of packing material: Sometimes the production workers complain that they have to wait for the service staff to assemble the packing material. This should never happen, since the whole machine then temporarily would have to be shut down. Our solution does not solve this problem, however we have discussed it with the service staff and made them more aware of the consequences of not having the needed packing material ready for use. We hope that the situation will improve in the future.

7. Production orders do not equal customer orders: The long term demands are based on customer orders, and the automatically generated production orders are also based on these. The long term packing material demand is therefore also based on customer orders. However, this long-term demand is not very reliable since the production orders tend to fluctuate a lot on a short-term basis. This means that the packing material that was ordered 6 weeks ago not corresponds to the real demand. The only solution for this is to hope the customers will shorten their lead-times. The shorter the lead-time, the more reliable the production orders will be. Our solution does not improve this problem.

8. Routines following an emergency stop: Today there are no fixed rules on what to do on an emergency stop that was caused by lack of packing material. We have not set out any such rules, but instead we hope the emergency stop itself never will occur, since Movex always will warn the user before.

9. Lost packing material: The risks of "displacing" or losing packing material (and thereby be forced to replace the customer for it) will be much smaller with a system that has much better control than today's system. If it would happen though, and if it is not certain whom of the customer or Plastal that has the correct figures, it will be easier for Plastal to uphold its rights towards the customer and claim that it has not done anything wrong.

10. Rental costs: These are the costs that occur when Plastal holds more packing material than allowed by the contract. The solution itself does not solve this problem, but with the whole packing material process (PMP) inside Movex, it is easy to construct a query in Microsoft Access that works out this information and tells Plastal of the cases when this might occur.

11. Limiting contracts: This is mainly a subject of Saab Automobile, since both Volvo Cars and Scania Trucks are more "generous" with their packing material supplies. We earlier presented a figure on how much the lack of packing material costs Plastal annually, and it is up to the

market department to use this figure in order to convince the customer that it should be more generous with the packing material. It is also possible to be more specific and exactly tell the customer how much the price of the product goes up with just one week's of packing material, compared to 3 or 4 weeks' of packing material. This can be done directly by modifying the spreadsheets that the market department uses for their product calculation.

12. Lack of space for empty packing material leading to reduced possibilities to hold packing material buffers: When compared to 5. this problem has the same cause. The problem is however at another level, and it is a big problem today. We believe though, that the problem will be reduced by using the existing space more efficiently.

13. Lack of space in the stock of finished goods: It would be possible to run larger batches if there was more space here. However, space is expensive, and Plastal does not prioritize this for the moment. Our solution can not do anything about this problem, but it could be subject to change in the future.

14. Uncertain production orders: The whole computational process above builds on the fact that the production orders should correspond to what is really produced, and that the production orders not last for more than around 24 hours. If more is produced than what the production order originally stated (which is sometimes the case), then the predicted packing material demand will be lower than the actual demand. This means that although Movex planned the packing material correctly, there may still be a risk where Plastal could run out of packing material, since one batch might have used more than what was designated. It cannot be avoided that the real amount produced sometimes differs from the production order, but in the cases that the planning department knows beforehand that the production order is not correct, then the production order should be updated to the correct amount. By doing this, Movex will notify the user if the updated production order will have any negative effects on future production orders. That will give the user the option to act before the packing material actually is finished up. Another thing with production orders, is that the longer it lasts[4], the more biased the packing material demand will be. For example, a production order that needs one week to go through, would deduct all the raw material and the packing material from the stock balance already the first day. This would mean, that although Movex would present a stock balance, the actual stock balance would be much better, since the demand in the real world is

[4] The time from when the first product in the batch is produced until the last is produced

split up on seven days, but in Movex's world, it all comes the first day. By using production orders that are no longer than one day, such biases can be avoided.

15. Emergency stops: These have been discussed a lot in this thesis, and we believe that an improved PMP has a good chance of reducing the risk of having an emergency stop.

16. Lack of control on packing material demand: This problem results in several other serious problems, of which the most important one is 15. We are convinced that this problem will be solved completely by integrating the PMP into Movex, and by using our suggestions for work organization that will be presented later.

To sum up the efficiency of our solution, we can see that many of the problems remain unsolved. However, the most serious ones are — if not completely solved — at least greatly improved. We believe that we have focused on the problems that were in the scope of this thesis, and that many of the unsolved problems would have been more or less impossible to solve with our resources.

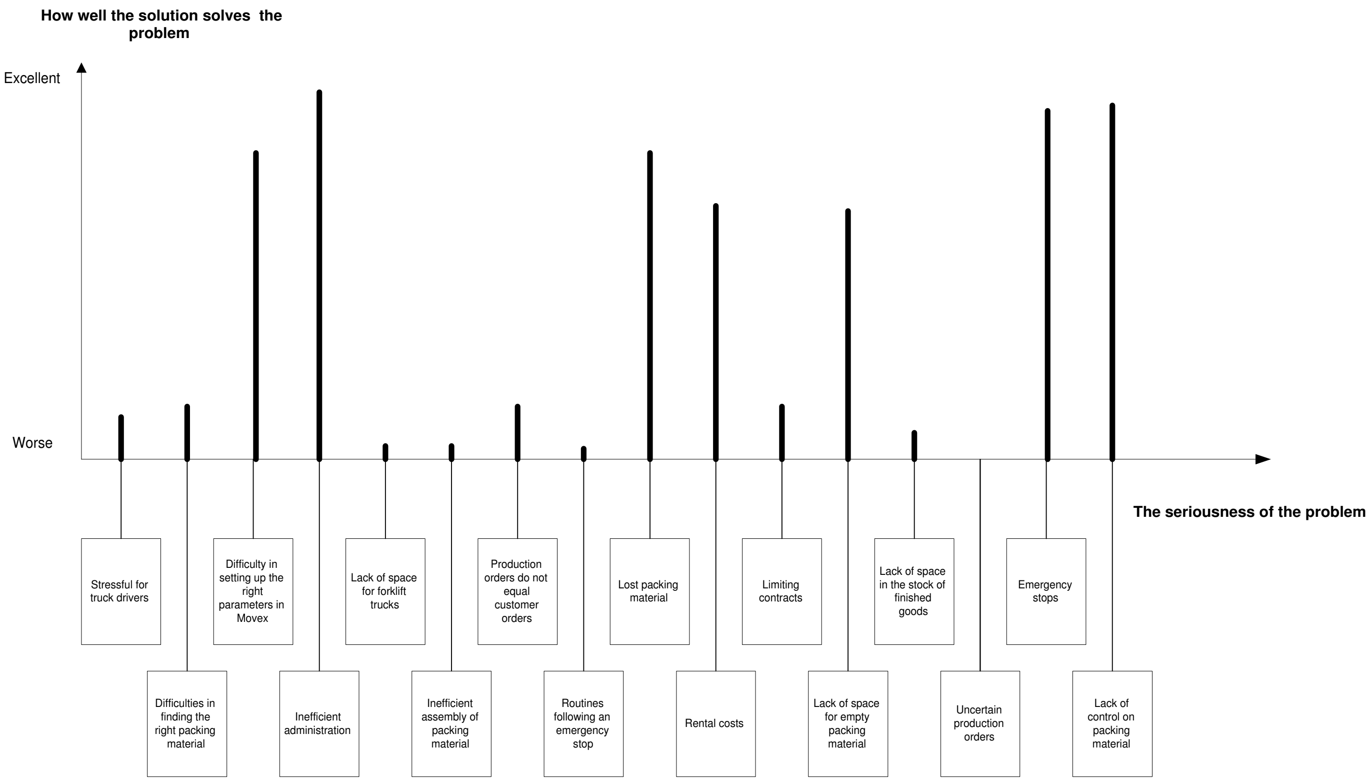



Figure 5.7: Solution efficiency

# Chapter 6

# Conclusions and Recommendations

*In this chapter we will present the major changes that the implementation of the new packing material system will impose. We will also specify how long time it will take to implement the changes, and give insight into the savings possibilities on this investment as well as on the payback-times.*

## 6.1 Summary

In order to survive in a highly competitive environment, Plastal has to systematically improve its competitiveness, and logistics is an appropriate area in which to do this.

The changes in the packing material process will lead to a lot of desired effects. The correct packing material and the correct amount of packing material at the right time will make use of the limited space more efficiently. Rental costs, costs for missing packing material or other costs that can be connected to packing material will be minimized or eliminated. It is also important to note that the risk of having an emergency stop will be greatly reduced. This will also mean that the total number of production starts and setups will be reduced, as well as the scrap costs. The savings are large in comparison to the effort required to implement the change needed.

## 6.2 Changes

The necessary changes to undertake for the implementation of the new packing material process have been divided into three areas: Movex and inventory control, work organization and project contracts. The changes will be described briefly. For more detailed information, please see the company report that was written primarily for Plastal. This report is available through Plastal.

### 6.2.1 Movex

Each article in Movex will have its packing material specified. This new feature makes it possible to let Movex administrate the packing material. Information about what packing material that should be used for each article will be found at the production technology department.

The outside storage of packing material has to be defined and in Movex as an inventory for packing material.

### 6.2.2 Work organization

Only one person will be needed in the future to administrate the packing material, instead of two. The main implications for the forklift truck drivers will be that they use Movex to report on incoming packing material instead of papers. Other than these, no other changes are necessary.

### 6.2.3 Project contracts

The staff responsible for new projects will in the future be more aware of how a limited amount of customer owned packing material can limit the production. The reason for this is that they will see clearer in their spread sheet analyses how the cost to make the product the product will vary with the number of weeks of allowed packing material.

## 6.3 Implementation

The implementation will need about 11 weeks. The first seven weeks are only used for the changes in Movex. Practically, this means the integration of the packing material for more than 2000 articles, where each article needs between 10 and 25 minutes. The main part of this phase will be done during the vacation when the plant is closed down. That gives the possibility to interfere with Movex without disturbing any production process. The following two weeks will be needed to launch the project and to educate the people that are going to use it. The last two weeks will be used to discover — and to correct — bugs or errors. After this 11 weeks we expect the system to work decently, but still this system needs to run side by side with the old system for a few months before it is possible to completely rely on the new system.

## 6.4 Savings

In the previous chapter we calculated all the costs connected to the packing material process. We have here tried to estimate the possible savings that can be made, and how much the implementation would cost. It is our opinion

Table 6.1: Summary of the costs of the packing material administration today

| Cause | Cost | Sav. potential % | Sav. potential |
|---|---|---|---|
| Lost packing material | 400 KSEK | 100% | 400 KSEK |
| Rental costs | 200 KSEK | 100% | 200 KSEK |
| Emergency Stops | 250 KSEK | 100% | 250 KSEK |
| Administration | 200 KSEK | 80% | 160 KSEK |
| Alternative costs | 500 KSEK | 50% | 250 KSEK |
| Total sav. potential | | | **1260 KSEK** |

as well as the opinion among staff at Plastal that the figures presented are not overestimates. It is also likely that the costs will increase when the customers are regulating the packing material even harder. Table 6.1 shows the possible savings today.

We can see that the savings possibility ends up to around 1.2 MSEK. This has to be compared to the cost of implementation, which amounts to about 150 KSEK. This is mainly costs for salary but also includes costs for unexpected events. This gives a total payback-time of around 2 months. This is obviously acceptable from a payback point of view. Further information about Pay-back can be found in appendix C

# Chapter 7

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Årsredovisning för Plastal Group AB 2002, 2001, 2000.

## Interviewees

Nils-Ivar Andersson, Jan Carlsson, Lars Håkansson, Anders Isaksson, Kenth Johansson, Johan Larsson, Jörgen Ljunggren, Nada Mikacic, Jan Svedman, Roger Tennevi, Magnus Wiege, Stefan Wikenhed, Paul Öhman, Leif Åkesson, Mattias Westberg, Karen Togander, Susanne Svarin, Ragnar Strandh, Agne Sjögren, Nils-Inge Persson, Daniel Olsson, Karl-Göran Nilsson, Lars Kindesjö, Katarina Hartmann, Jan Hallonsten, Per Eriksson, Eva-Karin Eriksson, Per Berlin, Majvor Berg, Mikael B Andersson and Lage Vinberg

# Appendix A

# Planning Methods in Movex

Basically, there are two methods to use for planning in Movex: Material Resource Planing (MRP) or the Economic Ordering Quantity (EOQ) method. A theoretical description of these methods was made in chapter 4. Basically, the MRP method looks at future orders to plan the production, while the EOQ method uses historical data to plan the production by making prognoses.

Common for the two methods is that two main parameters have to be specified. The first one is the time span of which a planned order is fixed and thus not changed by the system, and the second parameter is the number of days before the planned production actually starts that the production is supposed to be planned manually for that very article. There are also other common parameters needed by Movex from an administrative point of view, but these are of minor interest when choosing a planning method.

When using MRP it is possible to set a time security marginal for every order that corresponds to the number of days that the order has to be produced before it is supposed to be delivered. The same goes for any raw material, that it is convenient to have the raw material arrived at least a few days before the production start in case there would be any kind of delays.

On the other hand, when using the ordering level method it is possible to set a safety stock, i.e. a minimum stock quantity that is only planned to be used for unpredictable occurrences. This is to minimise the impact of fluctuations in the supply chain or in the production. The safety stock can, for instance, be proportional either to the number of days the stock will last when an unexpected incident occurs. The ordering level can be specified manually or as the safety stock plus the consumption during the lead-time.

When the stock balance reaches (or is below) the ordering level the system creates an order for more of that article, which can be raw material for instance.

The quantity that is ordered can be either fixed or variable. For instance, it might be possible only to order 100 pieces at every order (fixed order quantity), or 97, 98, 99 etc. pieced if order quantity is variable. Usually, for packing material at Plastal, the orders are variable within some multiples depending on the packing material.

Moreover, the time interval between orders can also be fixed or variable. For packing material at Plastal the time interval is fixed and the size of the interval varies between 1 and 4 weeks depending on the customer.

### Overview of available material planning options in Movex

#### Fixed order quantity/variable period

- Manual registered quantity
- Fixed quantity to cover a fixed time period
- Economic Order Quantity (EOQ)
- EOQ with discount

#### Variable order quantity/fixed period

- Order against discrete demands
- Manual registered cover time
- Period Order Quantity (POQ)

#### Variable order quantity/variable period

- Least Unit Cost (LUC)
- LUC with discount
- Up to the maximum inventory level

# Appendix B

# Packing Material Codes

We will now show to what extent the packing material today is supported by Movex by studying an example material. This example will show that packing material exists in two worlds in Movex; one is for production planning and one is for shipping. We note before we start that when it comes to production planning, this is not currently used for packing material, but with this example we show the possibilities of using it.

First, we want to take a look into the article index to see the product structure of every article and thereby find out what packing material is included in it. By having an article index and a product structure for every article, it is possible to let Movex automatically plan the production on a longer term. We therefore type MMS001 in the main menu to get to the article index.

In the article index we will study one article arbitrarily chosen, namely 65442-0001, and we search for this article and find that it exists (figure B.1).

Depending on what number we type on the row next to the article, Movex performs different actions. For instance, by typing 5 we can see some details about the product, for example which customer it belongs to, who is responsible for the product, etc.

From here we can find out what methods to be used for inventory control, responsibilities for every article, where the article is produced etc. Further into this module, we can specify the methods more exactly, for instance the parameters of the Wilson formula (figure B.2).

To find out what parts that are included in the 65442-0001 we use the "consists-of-analysis" module PDS100. For each article it is possible to look up what semi-manufactured products, raw material or packing material that are included in it by using this function (figure B.3).

We search for article 65442-0001 and see that several parts form this product, for instance 2 kg polyfill, 5 clips etc. We also notice that it consists of 1 VOC011.

The code VOC011 is what is referred to in Movex as a packing material

Figure B.1: MMS001/B1

```
MMS001/B1                   Artikel. Öppna              3-02-25 09.25.48
31=Artikel/lst      32=Saldo-IDn        33=Disp samtl lst   34=Materialplan
35=Lager trns hist  36=Artikelstat      37=Prod kalkyl                    +
    Sts __ - __                                                 EFGHIJ----
_1  Artikelnummer    Namn                                              Sts
__  65442-0001_____
__  65442-0001       PLENUMTÄCKN VÄ STYRD P28                           20
__  65442-0002       PLENUMTÄCKN HÖSTYRD P28                            20
__  65442-0003       PLENUMTÄCKN VÄ STYRD P28 PARTS                     20
__  65442-0004       PLENUMTÄCKN HÖSTYRD P28 PARTS                      20
__  65443-0100       SKÄRMBREDDARE FR KPL VÄ P28                        20
__  65443-0103       SKÄRMBREDD FR KPL VÄ P28 PARTS                     20
__  65443-0200       SKÄRMBREDDARE FR KPL HÖ P28                        20
__  65443-0203       SKÄRMBREDD FR KPL HÖ P28 PARTS                     20
__  65443-9100       SKÄRMBREDDARE FR YT VÄ P28 -P                      20
__  65443-9200       SKÄRMBREDDARE FR YT HÖ P28 -P                      20
__  65444-9100       BOTTENSVÄLLARE FR VÄ P28 -P                        20
__  65444-9200       BOTTENSVÄLLARE FR HÖ P28   -P                      20
__  65445-0100       BOTTENSVÄLLARE KPL VÄ P28                          20
__  65445-0103       BOTTENSVÄLLARE KPL VÄ P28 PART                      +
--------------------------------------------------------------------------
F3=Avsluta          F4=Fråga            F5=Förnya           F12=Föregående
F13=Parametrar                          F23=Alternativ      F24=Fler F-tang
```

Figure B.2: MMS001/E

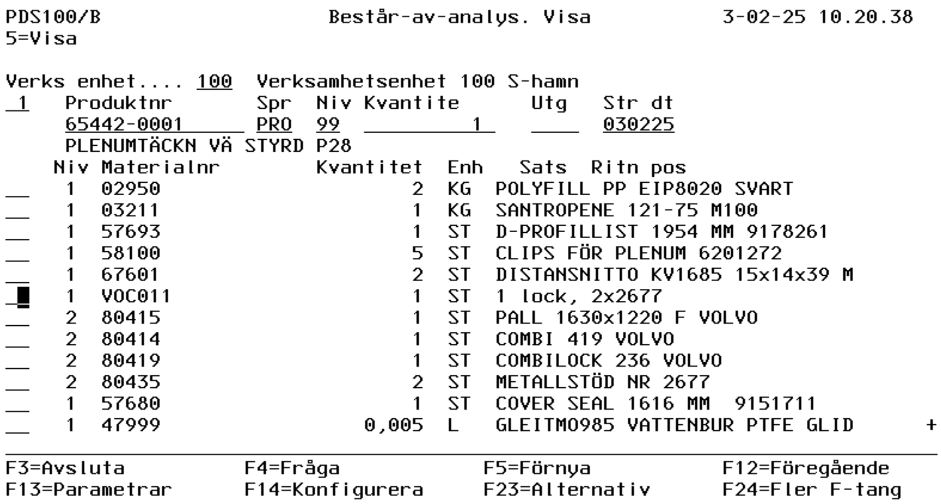
```
MMS001/E                    Artikel. Öppna              3-03-03 14.36.37
MOVEX 11.2                                            AUTOPLA1 QPADEV000W
Plastal AB Simrishamn                                   (Ftg 001 Div 100)
Artikelnr...... 65442-0001_____
Namn........... PLENUMTÄCKN VÄ STYRD P28
Beskrivning.... PLENUMTÄCKNING VÄNSTER P28
Ritn nr........

Status......... 20                  Artikelansv.... SIACA
Artikeltyp..... F        Färdigproduk   Köpa/tillv kod. 1

Artikelgrupp... 420      Volvo P28 Pr   Anskaffn grupp. EJ       Ej definiera
Produktgrupp... 420      Volvo P28 Pr   Konter ktrl obj PLASTAL  PLASTAL
Affärsområde... 2        EJ LACKADE D
Utgåva.........                     KÄO-administr.. 0
Lagerbokföring. 1                   Batchredov met. 0
Lag kont metod. 1                   Batchnumrer met 0
Grundenhet..... ST                  Alt enh används 0

                                         01-05-29 / 02-12-06 / SISSV
--------------------------------------------------------------------------
F3=Avsluta          F4=Fråga            F5=Förnya           F6=Text
F12=Föregående      F13=Fältval                             F24=Fler F-tang
```

Figure B.3: PDS100/B

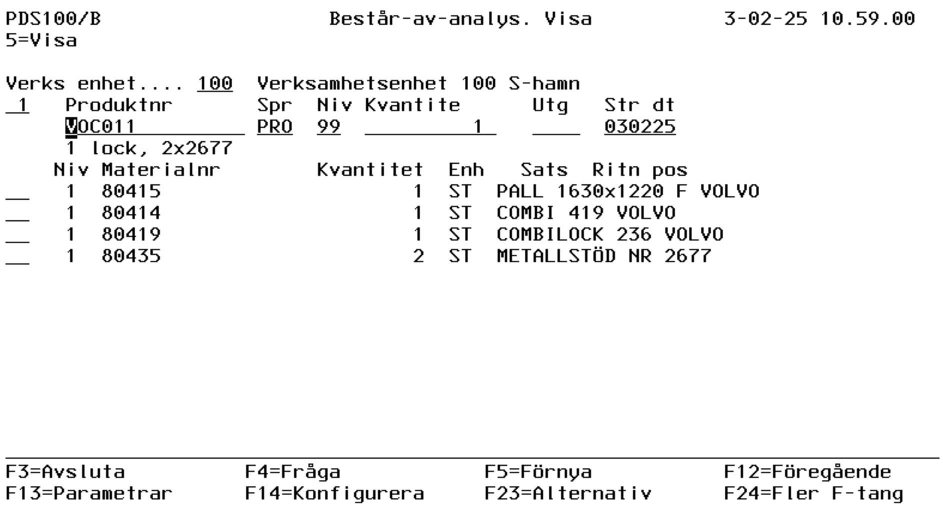


```
PDS100/B                    Består-av-analys. Visa          3-02-25 10.20.38
5=Visa

Verks enhet.... 100  Verksamhetsenhet 100 S-hamn
_1   Produktnr          Spr  Niv Kvantite        Utg    Str dt
     65442-0001_______  PRO  99  __________1_    ____   030225
     PLENUMTÄCKN VÄ STYRD P28
    Niv Materialnr           Kvantitet  Enh   Sats  Ritn pos
__   1  02950                        2  KG  POLYFILL PP EIP8020 SVART
__   1  03211                        1  KG  SANTROPENE 121-75 M100
__   1  57693                        1  ST  D-PROFILLIST 1954 MM 9178261
__   1  58100                        5  ST  CLIPS FÖR PLENUM 6201272
__   1  67601                        2  ST  DISTANSNITTO KV1685 15x14x39 M
_    1  VOC011                       1  ST  1 lock, 2x2677
__   2  80415                        1  ST  PALL 1630x1220 F VOLVO
__   2  80414                        1  ST  COMBI 419 VOLVO
__   2  80419                        1  ST  COMBILOCK 236 VOLVO
__   2  80435                        2  ST  METALLSTÖD NR 2677
__   1  57680                        1  ST  COVER SEAL 1616 MM  9151711
__   1  47999                    0,005  L   GLEITMO985 VATTENBUR PTFE GLID      +

F3=Avsluta          F4=Fråga            F5=Förnya           F12=Föregående
F13=Parametrar      F14=Konfigurera     F23=Alternativ      F24=Fler F-tang
```

Figure B.4: PDS100/B



```
PDS100/B                    Består-av-analys. Visa          3-02-25 10.59.00
5=Visa

Verks enhet.... 100  Verksamhetsenhet 100 S-hamn
_1   Produktnr          Spr  Niv Kvantite        Utg    Str dt
     VOC011___________  PRO  99  __________1_    ____   030225
     1 lock, 2x2677
    Niv Materialnr           Kvantitet  Enh   Sats  Ritn pos
__   1  80415                        1  ST  PALL 1630x1220 F VOLVO
__   1  80414                        1  ST  COMBI 419 VOLVO
__   1  80419                        1  ST  COMBILOCK 236 VOLVO
__   1  80435                        2  ST  METALLSTÖD NR 2677

F3=Avsluta          F4=Fråga            F5=Förnya           F12=Föregående
F13=Parametrar      F14=Konfigurera     F23=Alternativ      F24=Fler F-tang
```

Figure B.5: MMS053/B1

```
MMS053/B1             Kundartikel. Koppla emballage        3-03-03 14.48.58
MOVEX 11.2                                               AUTOPLA1 QPADEV000W
Plastal AB Simrishamn                                      (Ftg 001 Div 100)

Emballagenivå.. 1                      Emballagvillkor ___
                                       Kundnr......... __________
                                       Adressnr....... ______
    Vlk Artikelnummer    Kundnummer  Adr nr  Kvantitet   Emb
_5  ___ 65442-0001______ __________  ______ ___________
__      65442-0001                              999999   VOC004
__      65442-0002                              999999   VOC004
__      65442-0003                              999999   VOH403
__      65442-0004                              999999   VOH403
__      65443-0100                              999999   VOL301
__      65443-0103                              999999   VOL401
__      65443-0200                              999999   VOL301
__      65443-0203                              999999   VOL401
__      65445-0100                              999999   VOP004
__      65445-0103                              999999   VOS402
__      65445-0200                              999999   VOP004            +

F3=Avsluta           F4=Fråga             F5=Förnya            F12=Föregående
F13=Parametrar                            F23=Alternativ       F24=Fler F-tang
```

Figure B.6: MMS050/E

```
MMS050/E                     Emballage. Öppna              3-03-03 14.50.39
MOVEX 11.2                                               AUTOPLA1 QPADEV000W
Plastal AB Simrishamn                                      (Ftg 001 Div 100)

Emballage...... VOC004

Benämning...... 1 lock
Lagerplatstyp.. 02   Stuv
Artikelnr......
Kollislag...... PAL  Pall
Viktkapacitet..
Volymkapacitet.
Bruttovolym....      2,778
Vikt...........    116,500
Kollilängd.....  1,630
Kollibredd.....  1,220
Kollihöjd......  1,397

Norm faktor....
                                            99-07-09 / 99-07-09 / SMKI

F3=Avsluta           F4=Fråga             F5=Förnya            F6=Text
F12=Föregående                                                 F24=Fler F-tang
```

code. Each Movex implementation might have different structure on their packing material codes. At Plastal, the first two letters signify the customer, in this case Volvo, indicating that this packing material belongs to Volvo. The following letter usually indicates the size of the pallet. The fourth letter most often indicates the height of the package counted in numbers of collars. The last two numbers are used in increasing sequence starting with 00, with 00 meaning that one kind of packing material, 01 and 02 another. VOC011 accordingly refers to a pallet (in this case a combitainer, i.e. a big wooden box) with 0 collars, plus additional covers, sentinels, foam etc. according to what the specification of 11 says. We can make a further "consists-of-analysis" of VOC011 to find all the components constituting it (figure B.4).

We see that VOC011 is a conception of four parts, together forming the packing material VOC011. This code would (if it was in use - we will get back to that later) be used for inventory control of the packing material. As an example, to produce 10 units of 65442-0001 next week, we would need to have 110 units of 80415, 110 units of 80414 etc. in stock.

So far it is not complicated, but Plastal's implementation of Movex is confusing at one point: namely that this very code is also used in the packing material modules but with another purpose and with another significance. The same article can therefore have two different packing material codes that really should have been the same, or, contrarily, two identical codes that signify different structures. In order not to confuse the user it should be clear what these codes means, but today it is not.

To study this conflict we enter the packing material module MMS053 and search for 65442-0001 here as well. Notice that this is not the article index, but instead an index of what packing material that is "connected" to every article which is for shipping purposes and not for planning purposes (figure B.5).

We can see that the packing material needed for 65442-0001 has the code VOC004. This is also referred to as a packing material code, but differs from the one that we found when using article index MMS001. Now we have two very similar (and therefore confusing) packing material codes connected to 65442-0001. In this case the codes are easy to separate since they have different names, but in many cases they even have the same name but with different meanings.

If we study the code VOC004 we find that it not at all corresponds to VOC011. The use of these latter modules is instead if we want to find out the size and weight of the packing material. We therefore study the code VOC004 in the next packing material module MMS050. This module is for shipping purpose for keeping track of the above variables in order to calculate how many pieces of goods that go into every truck (figure B.6).

Here we find that each VOC004 weighs 116.5 kg, has a length of 1.62 meters, etc. Summing this up, we note that for article 65442-0001 there are two packing material codes connected; the first one is found in the article index module, the second one in the packing material module.

This system with two different packing material codes (one for inventory control and one for a logistic purpose) is a very unfortunate implementation and probably no Intentia's idea with packing material codes. The packing material codes can be of great use in the packing material modules where they actually serve a specific logistic purpose. However, the other use does not really fill a function in Movex today, since the packing material is not planned by Movex. However, Plastal uses another program to make prognoses of the packing material demand, and this program collects information on packing material from the article index.

Originally, both codes signified the same packing material, but since they were two different systems, they have grown apart. This has caused great confusion at Plastal, and it seems to us that no one really was aware of that the packing material codes really could have to different meanings.

To give a final example on how this system can form a dangerous trap is when checking what packing material is used for 65442-0001 in the "consists-of-analysis" (PDS100) and to find out that it is VOC011 and then to check the weight of VOC011 in the packing material module (MMS050). This would incorrectly present the weight and space of the packing material for the article 65442-0001 resulting in problems when trucks are to be loaded.

The final note is that these two codes are separable, i.e., one of them can be changed without interfering with the other one. This can be useful if we decide to change either one of them.

# Appendix C

# The Discounted Payback Period

The discounted payback period (DPP) is the length of time until the sum of an investment's discounted cash flows equals its cost. The discounted payback period rule is to take an investment if the discounted payback is less than some pre-specified cut-off.

At Plastal most project are initially valued by the payback method. A reason for this is the quick changes in the automotive industry, making long term investments less reliable than in many other industries. For a normal project to be approved, it should have a payback time between 8-12 months. The discount rate for these kinds of projects is also very high, 15% annually.

By calculating the disclunted accumulated net income value the discounted payback period time can be derived by the following formula (Persson, Nilsson 1999: 80):

$$\sum_{k=1}^{DPP} \frac{a_k}{(1+i)^k} - G = 0$$

If a is constant for all a's, then the payback time can be derived as

$$DPP = -\frac{\ln(1 - \frac{G}{a}i)}{\ln(1+i)}$$

The limitation of the discounted payback period is that it does not measure the return on investment over the entire life of the project, but rather looks only at the time horizon needed to "pay" for the project with the discounted cash flows. The weighted average cost of capital of the firm should be used as the discount rate in calculating the cash flows of the project (Brealey, Myers 2000: 97).

# Appendix D

# MRP-methods

## D.1 Fixed order quantity

When a net requirement is found MRP will create an order for this predetermined order quantity. This is usually fixed by the manufacturing process or equipment used to manufacture the part. MRP will consume any surplus in future periods before ordering again.

## D.2 Lot for lot (L4L)

MRP will generate a planned order equal to the net requirement for each period. One must be careful when using this method as if you have requirements for each day, MRP will plan an order for each day. It is common practice to use order modifiers with this method or to use the Period Order Quantity rule if orders are not wanted on a daily basis.

## D.3 Period order quantity (POQ)

Using this method, the order quantity will be equal to the net requirement for a given number of periods. This method is often used in conjunction with the ABC classification. Blanket rules are determined for A's, B's, and C's. For example, A items order 4 weeks supply, B items order 10 weeks supply etc.

When MRP finds a net requirement it then adds that periods requirement to the following periods requirement as per the number of periods specified. For example if 3 periods were stated for a part then MRP would add the net requirement for three consecutive periods together and plan an order for that quantity. To obtain the best results with this method, the EOQ should be calculated for the item and that quantity divided into the annual demand to determine the number of orders to be placed a year. That time period requirement is then entered into the system as the period order quantity requirement. This will result in the correct number of set-ups or order placements to be placed during the year but the holding costs will be reduced to a minimum as the actual quantity required during that period of time will be the quantity ordered.

## D.4 Periodic ordering

Periodic ordering is very similar to Period Order Quantity, except that POQ only starts counting the periods from a requirement whereas Periodic Ordering orders at the fixed frequency irrespective whether there is a requirement or not. This is extremely useful when a number of parts are bought from one supplier and you want them shipping together to reduce the transport cost.

## D.5 Least total cost (LTC)

This dynamic lot sizing technique calculates the order quantity by comparing the inventory holding cost to the ordering/set-up cost for various lot sizes and selects the lot where these costs are nearly equal. One method of doing this is to add consecutive periods discrete quantities together and calculate the carrying cost. This is then repeated after adding the next periods requirement into the order quantity until the holding cost exceeds the ordering/set-up cost. The holding cost either side of the ordering/set-up cost is examined and whichever is the closest determines which order quantity is the one to use.

## D.6 Part period balancing

This method which is also defined as a dynamic lot sizing technique, uses the same logic as the least total cost method, but adds a routine called look ahead/look back. In simple terms it first calculates the order quantity using the LTC method but then goes further forward combining periods together and regrouping the earlier periods to see if the overall result is less costly. This method tends to be extremely sensitive to minor changes and requires a very stable requirement else it recalculates all the order quantities and triggers further changes down to the lower level MRP items.

## D.7 Order modifiers

Order Modifiers, often referred to as batching rules, enable the system to modify the order quantity determined by one of the ordering methods into a practical usable quantity. For example, if the order method calculated the order quantity as 5 751, but the supplier sold his product in boxes of 1 000, the order needs modifying to 6 000.

The modifiers available are; minimum order quantity which increases the order quantity to a minimum of the stated quantity, maximum order quantity which limits an order to this quantity and then MRP will plan a second order for the remainder, multiple order quantity where the order quantity is increased to a multiple of the stated quantity.

(Persson, Virum 1996: 159-171) (Michelsen, 1995: Chapter 3).