Supply Chain Evaluation

- A case study at Scania Production Angers S.A.S

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Executive Summary

Title Supply Chain Evaluation at Scania Production Angers

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Problem Increased competition requires enterprises to understand factors of success in their industry. The systems approach is a good tool when identifying opportunities and to create an understanding of what is behind problems in the supply chain. The use of different material control methods offers several combinations of for example order quantity and delivery frequency. Scania Production Angers (SPA) has made several improvements regarding material flows, but savings due to lower stock levels compared to increased transport costs have not been evaluated. What is important to consider when evaluating the supply chain and what parameters are of most vital importance for costs? What should be included in a method for investigating, evaluating and deciding on material flows?

Purpose The purpose is to create a model for evaluation of the supply chain, from suppliers to the assembly line, and to apply this model on Scania Production Angers.

Method We performed a case study where we investigated how the supply chain works, through three mappings, with the aim to identify what parameters that influence activities and costs. Our empirical findings are structured according to the elements in the system and the focus is on the element *transformation process* since we consider that it includes the supply chain in our case. By using *systems approach*, for structuring our empirical findings, in a combination with relevant theories of logistics, our intention was to identify essential parameters that affect the material flow and costs in the supply chain. The parameters regarding what is important for a well functioning system are collected in an *evaluation model*. The results from our evaluation together with our empirical findings are collected in a proposal for a work method on how to investigate, evaluate and deciding on material flows.

Conclusions SPA should increase the communication between departments and also between SPA and its suppliers and transporters, since an increased understanding of what affects costs could then be achieved. Several problems regarding costs are due to lack of knowledge about how transporters in particular, but also suppliers work. High transport costs often depend on lack of knowledge regarding praxis in the transport industry and therefore SPA should spread its knowledge about how it works within the enterprise. There is too much focus on stock levels and the present measure should therefore be complemented with parameters that consider the total cost chain. The stock levels are lowered through smaller order quantities and more frequent deliveries, but much more can be gained by instead lowering the safety stock.

The material flows to SPA, regardless of material control method, vary both regarding frequency of deliveries and order quantity and more even flows could be worth striving for. The transport costs can be lowered and when doing this the whole consignment should be considered. An evaluation regarding the present weight range is one way to find a better set of material flows. SPA also has to work with further transport coordination between suppliers located near each other since there is a lot to gain by coordination of these flows.

Keywords Material control methods, Scania Production Angers, systems approach, evaluation, supply chain, transformation process, transport, work method.

Résumé

Titre Evaluation de la Supply Chain chez Scania Production Angers

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Problème La compétition de plus en plus vive demande aux entreprises de comprendre les facteurs clés du succès dans leur secteur. L'approche des systèmes est un bon outil quand on identifie les opportunités et que l'on permet de comprendre ce qui se cache derrière les problèmes de la Supply Chain. L'utilisation des différentes méthodes de contrôle de matériel offre plusieurs combinaisons, par exemple, la quantité de commande et la fréquence de livraison. Scania Production Angers (SPA) a réalisé plusieurs améliorations quant aux flux matériel, mais les économies dues à la baisse du niveau des stocks par rapport à l'augmentation des coûts de transport n'ont pas été évaluées. Qu'est-il important de prendre en compte quand on évalue la Supply Chain et quels paramètres sont d'une importance vitale pour les coûts ? Que doit-on inclure dans une méthode d'investigation, d'évaluation et de décision sur les flux matériel ?

But Le but est de créer un modèle d'évaluation de la Supply Chain, allant des fournisseurs jusqu'à la ligne d'assemblage, et d'appliquer ce modèle à Scania Production Angers.

Méthode Nous avons pris un cas d'étude dans lequel nous avons recherché comment fonctionne la Supply Chain, grâce à 3 cartographies, avec pour but d'identifier quels paramètres influencent les activités et les coûts. Nos découvertes empiriques sont organisées selon les éléments du système et le projecteur est mis sur l'élément *processus de transformation* puisque nous considérons que cela inclut la Supply Chain dans notre cas. En utilisant *l'approche Systèmes*, pour structurer nos découvertes empiriques, dans une combinaison de théories pertinentes de logistique, notre intention était d'identifier les paramètres essentiels qui influent sur le flux matériel et les coûts dans la Supply Chain. Les paramètres jouant un rôle important dans un système qui fonctionne bien sont collectés dans un *modèle d'évaluation.* Les résultats combinés de notre évaluation et de nos découvertes empiriques sont regroupés dans une proposition de méthode de travail sur l'investigation, l'évaluation et la décision sur les flux matériel.

Conclusions SPA devrait augmenter la communication entre les services et également entre ses fournisseurs et transporteurs, depuis qu'une meilleure compréhension de ce qui influe sur les coûts a pu alors être réalisée. Plusieurs problèmes concernant les coûts sont dus à un manque de connaissance des méhodes de travail des transporteurs en particulier mais aussi des fournisseurs. Les coûts de transport élévés dépendent également d'un manque de connaissance en ce qui concerne les pratiques dans l'industie du tranport et donc SPA devrait étendre ses connaissances dans ce domaine dans toute l'entreprise. On met trop en lumière les niveaux de stock et la mesure en question devrait donc être complétée par des paramètres qui prennent en compte la chaîne totale des coûts. Les niveaux de stock sont minorés grâce à de petites quantités de commande et des livraisons plus fréquentes, mais beaucoup pourrait être gagné en minorant le stock de sécurité.

Les flux matériel vers SPA, sans prendre en compte la méthode de contrôle de matériel, varient à la fois par la fréquence des livraisons et par les quantités de commande et les flux pourraient être encore meilleurs. Les coûts de transport peuvent être réduits et pour ce faire, l'expédition dans sa totalité doit être prise en compte. Une évaluation de l'actuelle répartition des poids est un moyen de trouver une meilleure combinaison de flux matériel. SPA doit aussi travailler avec une coordination transport supplémentaire entre les fournisseurs situés les uns près des autres car il y a beaucoup à gagner en coordonnant ces flux.

Mots clés Méthodes de contrôle matériel, Scania Production Angers, approche des systèmes, évaluation, supply chain, processus de transformation, transport, méthode de travail.

Preface

After four months of hard work and of course some wine and cheese tasting, we have finally finished our master thesis. We have learnt a lot and it is hard to imagine how fast four months can pass by. There are many persons who have made this master thesis possible which we would like to thank.

First we would like to thank Martin Lundstedt and Lars-Henrik Jörnving at Scania Production Angers for initiating this master thesis. It has really been an interesting and challenging time in France and we are very grateful for getting this opportunity. We also want to thank our steering group, the persons at the Logistics and Finance departments and our family and friends for support and encouragement.

Further we would like to thank our tutors for giving us feedback on our work. According to us it was not a bad idea to have supervision by mail even though it sometimes was a bit difficult both for you and us to explain what we meant.

Finally we are especially grateful for all the material planners and Nathalie Beaussier at the Logistics department for taking care of us, answering all our questions and of course for arranging the go carting.

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1 Introduction

1.1 Background

Global competition is increasing the pressure on enterprises to accelerate in abilities necessary to be able to respond to customers' needs at a low cost. New technologies and new organizational forms in transports and logistics have opened new possibilities and enables enterprises to reach beyond their own organizational and national boundaries to coordinate operations and management through the entire supply chain.[1] The theories regarding logistics however have their roots in the sixties. During the first twenty years it was the big industries that showed interest in these theories, but today both medium and small enterprises have interest in the logistics development. The development of logistics has, amongst others, concluded in the JIT philosophy where new ideas about how production and stock should be managed have arisen.[2] This development has concluded in changes in the process of purchasing in the enterprises and since enterprises focus on providing products to their customers when it is needed, the purchasing will focus on providing material when it is required by the production. The aim is thus to lower stock levels and to have a continuous flow of materials to the production with a minimal time of unpacking and checking received material. For this kind of flow and for the supply chain to work, the enterprise must work closely together with suppliers and a mutual trust must reside.[3]

The concept of supply chain is a direct and extended coordination of operations across the entire supply process and the key, in a strategic view, is coordination among enterprises. Operations of both internal and external suppliers must therefore be integrated and for the network of separate operations to work, it is important to achieve common objectives in material- and product flows. A characteristic of a well working supply chain is that member enterprises achieve their individual objectives through the performance of the supply chain as a whole. The major challenge of the supply chain is with this background to manage the integration across boundaries.[4]

The importance of managing the supply chain becomes even more necessary as supplier networks become larger and multi tiered, as suppliers as a result of specialization also feed other suppliers. This places more stress on external coordination. Due to competition for customers, there is also an increased pressure for efficiency within the chain, that is internal coordination. Since customers' demands more and more affect decisions in the supply chain, this also influences the choice of supply chain members.[5] Another thing affecting the structure of the supply chain is that an enterprise's supply chain may also share members with other supply chains. This can result in competition between members if resources of individual

[1] Schary, P.B., Skjott-Larsen, T., (2001), Managing the global supply chain, Copenhagen Business School Press, Handelshojskolens forlag, p. 22
[2] Tarkowski, J., Ireståhl, B., Lumsden, K., (1995), Transportlogistik, Studentlitteratur, p. 72
[3] Gadde, L-E, Håkansson, H., (1998), Professionellt inköp, Studentlitteratur, pp. 78
[4] Schary, P.B. et al, (2001), p. 25-29
[5] Schary, P.B. et al, (2001), pp. 26 and p. 38

members are demanded by more than one supply chain. Often the enterprise with monopolistic demand for its products directs the development of the chain.[6] This is also the case if there is one customer in the chain that is of most importance for several of the suppliers in the supply chain. How well an enterprise succeeds is, based on this discussion, dependent of how good knowledge it has regarding both its own position in the network and the structure of its network as a whole. This knowledge is also important to have when the enterprise cannot work in close relation with all of its suppliers as this takes up too much time and resources and therefore the enterprise must make choices regarding which suppliers to initiate a closer relation to.[7]

As the discussion above suggests, it is important for an enterprise to know its position in the network and in the supply chain, to be able to plan its activities. This is also important since many industries face increased competition, which is the case in for instance the truck industry. The global production of heavy trucks has shown a steady growth during the last decade but has recently faded.[8] Under these circumstances manufacturers have searched for ways to cut costs, protect market shares and reduce the industry excess capacity.[9] One result of the increased competition is that the truck industry, during the last decades, also has gone towards a pull strategy where every produced truck is dedicated to a customer order. The competition has also led to a higher level of customization and enterprises in the truck industry must therefore also be able to produce trucks with for instance variation in engine size, type of breaks, number of axles and cabin size. This type of customization requires deliveries in sequence while there are other parts on the truck that experience irregular consumption and should be managed by other material control methods (MCM). These characteristics makes the truck industry interesting to study from a logistics point of view since there are many ways to optimize flows through the elaboration of different MCMs, which in turn affect for instance stock levels and frequency of deliveries.

In the automobile industry Toyota is the leading enterprise regarding lean production and its production philosophies have been studied and copied by numerous of enterprises where the philosophy can be applied and there is no question that truck makers are amongst these enterprises.[10] The truck industry is also moving towards an increased use of modular assembly and design, which is commonly used in the automobile industry. This requires that when all parts and components are to be put together at the assembly plant, it is important that they have the demanded quality and are delivered on time. There are several examples of enterprises were this evolution could be found. Volvo is currently working on a joint platform with Renault V.I for its new generation of trucks. DaimlerChrysler, which historically has had quite differentiated products, is trying to standardize about 60 to 70 percent of its truck

[6] Schary P. B. et al, (2001), p. 30
[7] Gadde, L-E et al, (1998), pp. 66
[8] http://www.scania.se/ir/archive/acrobat/sca01EN.pdf, 2003-01-06
[9]http://www.standardandpoors.com/europe/francais/Fr_forum/articles_sectoriels_et_commentaires/European-Truck-Makers_09-05-02.html, 2003-01-06
[10] Gadde, L-E et al, (1998), pp. 79

components. Scania, which is one of the most profitable truck manufacturers, is the truck manufacturer that has the most modularized products.[11]

One outcome of the competition in the truck industry is, as mentioned above, that enterprises are striving for adjustment to customers in order to keep and win the confidence of the customers. This in turn means increased requirements for flexibility and dependence on its suppliers. When adjusting the enterprise's activities to the customers' demands, there is a risk that possible consequences on the enterprise are not taken into consideration. An example of this is if costs for more frequent transports, as a result of an enterprise striving for increased flexibility, are not evaluated in relation to savings due to for example decreased stock levels. This is one reason why it is important to also take suppliers and different sets of material flows into consideration when the supply chain is to be designed and managed. Since there are many factors affecting how well an enterprise succeeds it can often be difficult to see what potential for improvement that is possible. Working with improvements is also difficult since it is not always obvious what the effects of the improvements are in a broader context.

1.2 Problem Discussion

The supply chain can be viewed as a network that involves the sequence of connections among organizational units. The supply chain can also be viewed as a system where the systemic properties are the interdependencies of activities, organizations and processes. For instance the transport transit time influence the amount of inventory held within the system. This means that actions taken in one part of the system affect other parts and therefore the objectives of supply chain management pertain to the system as a whole rather than to individual members.[12] In order for enterprises to be able to compete in the conditions of today, it is important to enable an understanding of which factors of success that are present in their industry and therefore in their supply chain. As described above, one important task for enterprises, in for example the truck industry, is to be able to produce in accordance with customer demands and even exceed these. This means increased requirements for flexibility in the organization and to enable this flexibility, enterprises often try to find other solutions of how to organize their functions and activities.

A solution that seems to be good for one or some actors in the supply chain does not have to be a solution that is good for the supply chain as a whole. Therefore it is important to get an understanding of how the different actors in the supply chain affect each other. The systems approach is a critical component in the identification of opportunities of the system and to create an understanding of what factors are behind problems in the supply chain. The fundamental idea behind the systems approach is that the system consists of a group of objects and that the system as a

[11] http://www.standardandpoors.com/europe/francais/Fr_forum/articles_sectoriels_et_commentaires/European-Truck-Makers_09-05-02.html, 2003-01-06

[12] Schary, P.B. et al, (2001), p. 33

whole has different characteristics than those present in each object.[13] Since enterprises, in for instance the truck industry, often constitute a very complex context with several parameters affecting their performance, perhaps ideas of systems can be helpful to use. Maybe the systems approach cannot be fully applied on an enterprise, but hopefully it can at least encourage involved people to think about how their organization and their supply chain really works. A first step to be able to manage the supply chain is however to understand it. For this it can be helpful to view the supply chain at a single point of time and consider what might change in strive for adaptation to a changing environment. A reason to consider what might change, when evaluating a system, is that it might work as a help to recognize opportunities regarding for instance possibilities to achieve competitive advantage in the market.[14]

For an enterprise that plans its manufacturing only, or at least mostly, based on the needs of its customers, it is also important to work with its suppliers to create good relationships and hopefully achieve a win-win situation. Since an enterprise often has to deal with a large amount of suppliers, it is not easy to handle all flows and find the optimal set of flows. The use of a number of different methods for placement of orders offers several combinations of for example the frequency of deliveries to the factory and order quantity. Several enterprises in the truck industry today try new MCMs, for example Kanban[15] or sequence. Often those methods are not new for the industry, but new for the country or enterprise that intends to apply them. Since there might be essential differences in the conditions enterprises face in different parts of the world, an interesting question is if those ways to control material flows, are appropriate for enterprises everywhere in the world. Several of the methods have their roots in Japan, where the distance to the enterprises' suppliers is much shorter than for most enterprises around Europe.[16] Maybe it is not appropriate with those methods where the distance to the majority of the enterprise's suppliers is long. The question regarding whether to use methods of this kind or not must be evaluated with respect to for example increased costs for transports and the dependence of the suppliers to secure quality and time of delivery.

For an enterprise to be able to decide about what solution that is most optimal for the current situation regarding material flows, it can be helpful to make an evaluation of different control methods used with the aim to create an understanding of what parameters affect them and how. Scania is interesting to study regarding for instance its different MCMs, type of packaging and frequencies of transports. Scania also has assembly plants strategically placed over the world and this together with the fact that Scania has the highest proportion of modularization in the truck industry, implies interesting material flows of components and parts from both internal and external suppliers.

[13] Lambert D. M., Stock J. R., Ellram L. M., (1998), Fundamentals of logistics management, Irwin McGraw-Hill, USA, p. 7-10

[14] Schary P.B. et al, (2001), p. 30-34

[15] Kanban is a signaling system where cards are used to indicate a need to replenish inventory at a user's station in a production system. Schary, P. B. et al, (2001), p. 155

[16] Gadde, L-E et al, (1998), pp. 78

1.3 Problem Formulation

Scania Production Angers (SPA) is one of Scania's three assembly plants in Europe and is located in France. A big proportion of the suppliers is the same for the three plants and since Scania is an enterprise with its roots in Sweden, several of the suppliers are located there. According to this many of SPA's suppliers are located far off and about 50 % of them in Sweden. SPA, as many other enterprises, is striving for adjustments to customers and therefore its requirements for flexibility and dependence on its suppliers have increased. On a number of occasions improvements regarding material flows have been carried out at SPA, but since SPA does not have any method to evaluate how different parameters influence the total flow, it does not know whether the present set of flows is optimal for its supply chain.

In the light of this situation, it would be helpful for SPA to have some kind of work method that could be used to get an overall picture of consequences raised by different changes regarding material flows. For SPA a large part of its transporters are also its customers, which places further requirements on how the total supply chain works. The work method should therefore also enable an appraisal of whether the present set of material flows is the most favorable or not for SPA, its transporters and its suppliers.

As a result of the discussion above many questions arise both regarding the special case of SPA and for other enterprises facing similar conditions and difficulties. How can an overall understanding of the total supply chain and parameters affecting it be achieved? What is important to consider when evaluating the supply chain? What parameters are most vital when the aim is to find cost effective solutions in the supply chain? Can the use of systems approach enable an understanding and at the same time give rise to ideas? How can found parameters be used in order to come to decisions regarding stock levels, order quantities, coordination of incoming goods and so on? What should be included in a work method for investigating, evaluating and deciding on material flows? Is there a difference in the outcome when using different MCMs?

1.4 Goals

In this thesis we have three concrete goals that we want to fulfill. The goals are:

- To generate three mappings, on a country, supplier and part level, with the aim to identify interesting flows and to collect enough and appropriate information to use as a basis for our analysis of parameters influencing the supply chain.
- To identify parameters, influencing the supply chain, which can be used as a basis for evaluation of different material flows.
- The parameters we found to be of most vital importance, regarding costs in the supply chain, will be presented in a proposal for a work method on how to evaluate and decide on material flows.

1.5 Purpose

The purpose is to create a model for evaluation of the supply chain, from suppliers to the assembly line, and to apply this model on Scania Production Angers.

1.6 Delimitations

This thesis only considers material flows between suppliers and stock and between stock and assembly line, thus we will not study flows between assembly and end customer. Therefore, when we refer to the supply chain in our case study we only mean from SPA's suppliers to the assembly line (Figure 1.1). Since there might be a difference in which parameters that influences the supply chain of an enterprise, we will mainly concentrate on those that have impact on our case study. The mappings done to reveal these parameters will be concentrated to the different categories of material flows present in our case study. To obtain a good understanding of the flows and parameters in the supply chain, we will only perform a more thoroughly study of 5-10 different flows.

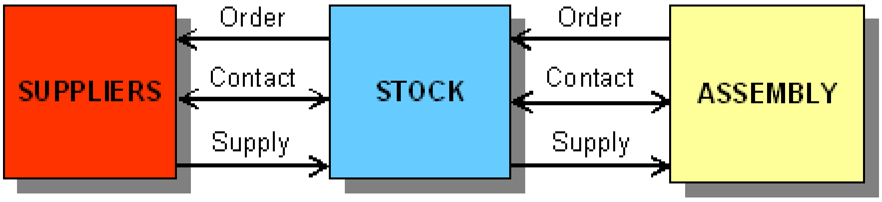

Figure 1.1, Logistics flow.

The simplifications we have done during the mapping process will not be described here but in the research strategy and research process (Chapter 2.2). In those sections we will also give comments on possible consequences for our choice of flows for respective mapping. In our mappings we will only present data regarding European countries even though SPA also has suppliers in for example Brazil, Luxembourg and Tunisia. The reason for this is the availability of information and that there are some other circumstances regarding the excluded countries. For example the transport cost from Tunisia is a part of the price of the delivered goods since the suppliers in Tunisia are responsible for the transports. For different reasons we have chosen only to handle SPA's external suppliers. For instance the structure of the collaboration with internal suppliers is difficult to affect and those flows also most often work very well. For internal suppliers the transport costs are most often low since full truckload (FTL) is used. Another delimitation is that we only will investigate material flows *to* SPA and therefore not flows of for instance packaging *from* SPA. We will also mainly focus on the total supply chain from suppliers to assembly line and will thus not have the intention to give proposals on improvements for any individual flow if time does not allow it.

The assignor to this thesis is SPA and the purpose is that the results from our study should be possible to use when evaluating and deciding about both new and existing material flows. SPA has given us free hands regarding how to work with the assignment and has mostly given us guidance on different occasions. A wish from SPA has however been for us to come up with some kind of guidance for how to work with material flows with regard to different MCMs. In our thesis we will only present this work method and not to do further tests of how it really works.

Since our thesis is based on a case study at SPA our results perhaps is most useful for SPA, but since the MCMs used are common for several enterprises, we hope that our results should be possible to use also for other enterprises. If not directly, so perhaps for benchmarking between two or more enterprises. As our thesis mainly is intended for people with fundamental knowledge in the area, we do not present any theories or models in depth. The purpose with the theory chapter is to give us ideas on what is interesting to study regarding the supply chain and also to give SPA an overall picture and understanding of the whole supply chain.

1.7 Scania Production Angers

SPA is one of Scania's final assembly plants. Apart from SPA Scania has two other final assembly plants in Europe, one in Zwolle in the Netherlands and one in Södertälje in Sweden. Scania's components are prerequisites for Scania's decentralized final assembly. Most of the components used in the trucks are produced in Sweden.

SPA produces 44 trucks per day and has 500 employees. To be able to produce the trucks SPA has about 250 suppliers who deliver about 3400 different parts and components. The suppliers are either internal or external. There are five internal suppliers, which supply the main parts of the truck, the so-called components, which are the gearbox, truck frame, axles and drive shaft, engine, and cabs. The external suppliers supply everything from screws to fuel tanks and these supplies are called parts. SPA works continually with improvements of their material flows, both from supplier to stock and from stock to assembly line. One example of this is that SPA has shifted to have more daily deliveries and placing orders founded on the real supply demand.

1.8 Glossary and Definitions

Abbreviations and words that are used several of times in our thesis will be explained here. For some of the words it is our perception that is behind the explanation.

FTL — Full truckload

LTL — Less-than-truckload

MCM — Material control method

Optimization — Improvements in one part of the supply chain that are good for the result of the total supply chain.

Pay weight — The weight that a buying enterprise pays for a consignment.

Real weight — What the consignment really weighs.

SPA — Scania Production Angers

Sub-optimization A solution proposed by one actor in the supply chain means a worse case for another actor and an optimization where the gains in one part do not exceed the benefits of the total supply chain.

Supply Chain From suppliers to assembly line.

Systems approach A method for how to structure a certain problem formulation based on elements in the system theory.

Weight range A minimum and maximum weight defines a range, in which a pre-defined transport cost per 100 kg is used. The ranges vary with transporters and distance.

1.9 Outline

Chapter 1, Introduction In this chapter we present the background and problem discussion to our subject area in this thesis and also present the specific problem formulation regarding the situation at Scania Production Angers. Then our goals, our purpose and finally the delimitations that we have done in our thesis are presented.

Chapter 2, Method In this chapter we present the method we have used in our thesis. We also give some comments on how we intend to use system theory and systems approach in a combination with other methods and as a base for our case study. Except for methodological reflections, we also present our research strategy and process for our thesis. Finally we discuss and evaluate our choice of method.

Chapter 3, System Theory In this chapter we present how we have used system theory and in particular systems approach in our thesis. First we have a short discussion regarding the development and link between system theory, systems approach and logistics. Then we continue with a discussion regarding system theory and systems approach.

Chapter 4, Theory In this chapter we present the different theories that we have used in our thesis. We start with overall theories regarding the supply chain and then we continue with theories for different parts of the supply chain. We have divided it in three parts where the first is from supplier to stock, the second is stock at enterprise and the third is from stock to assembly line.

Chapter 5, The Logistics System	This is the first of our two chapters where we describe empirical findings. Here our empirical findings are presented using the seven parameters defined for how we use the systems approach. The parameter transformation process is divided in the same three parts as the theory chapter.
Chapter 6, Mappings	This is also a chapter where we present empirical findings, but here the findings are based on the three mappings we have carried out. Here we also have complemented with information and observations from visits at both a supplier and a transporter.
Chapter 7, Evaluation Model	In this chapter we present our evaluation model. The model is designed based on both empirical and theoretical studies and is used for evaluation of the system.
Chapter 8, Analysis and Application of Model	In this chapter we give comments on our findings and the analysis will follow the system structure as we have defined it. The main part of the analysis regards the transformation process. The results from our analysis regarding handling of material flows will be presented in a proposed work method for how to evaluate and decide on material flows.
Chapter 9, Conclusions	In this chapter we present our conclusions from our analysis and application of model. The conclusions will be presented based on our evaluation model, which consists of the elements in the system.
Chapter 10, Work Method	In this chapter we present our proposal for a work method on how to evaluate and decide on material flows.
Chapter 11, Future Research	In this chapter we give some ideas for areas that could be interesting for future research.

2 Method

In this chapter we describe the method we will use in this thesis. First we present what method thoughts that our work is based on and give some reflections on them. Then our research strategy and research process is presented where we explain how we have planned our work with this thesis and also describe our work along the way. Finally we discuss and criticize our choice of method.

2.1 Methodological Reflections

The aim with our thesis is to evaluate the supply chain, from suppliers to assembly line, with regard to resources, activities and costs. The evaluation model will be constructed based on both empirical and theoretical studies and will contain parameters of vital importance for the costs in the supply chain. We will perform a case study at Scania Production Angers (SPA) to be able to collect information regarding different activities in the supply chain. The model will be used when evaluating the case of SPA. Our goals with the evaluation are to come to conclusions regarding how well SPA corresponds to our evaluation model and to find parameters to base a work method, regarding how to investigate and evaluate material flows, on. We will now describe how we will collect data in our study and how we intend to structure and use it.

2.1.1 Method for Collection of Data

In the *deductive* perspective, that is the *traditional* research process, the starting point is theories, questionings or hypotheses and the results shall be possible to test.[17] Often there is a need for the deductive approach when there for instance is conflicting knowledge in a field or when there is a need to prove gaps in the knowledge regarding a certain area. However, regarding the *inductive* perspective, that is the *qualitative* research process, the starting point is often taken in empirical material and data is collected to create concept formulation in the form of hypotheses and theories. In the inductive perspective it is common to use case studies and a case can for example be an enterprise. The aim of using this perspective is often to explain, understand or describe certain systems or organizations.[18]

We will both have an *inductive* and a *deductive* approach in our thesis. What we know from the start is that SPA is not pleased with its present situation regarding how to evaluate different material flows and that SPA does not really know what has to be done to improve the situation. Since SPA has many parameters influencing its flows and results, we will therefore dedicate lots of time to study different flows within and outside the enterprise. We will thus perform a case study at SPA with the aim of creating an understanding of how its supply chain works today and to identify parameters that influence activities and costs in it in different ways. This is our

[17] Backman, J., (1998), Rapporter och uppsatser, Studentlitteratur, Lund, p. 20 and pp. 23
[18] Backman, J., (1998), p. 48-53 and pp. 66

inductive part of the thesis. We will use our empirical findings together with theories with the intention to identify in what areas there is a potential to do things better and what is important to consider when evaluating the supply chain. We attempt to present theories that concern the different parts in the supply chain respectively, as well as theories regarding the total supply chain. Our intention is that our theoretical studies shall provide us with further ideas regarding what can be interesting to investigate in the supply chain and also to give us a picture of what parameters can be interesting to include in an evaluation model. This is our deductive part of the thesis.

The most common methods for collecting data when performing a case study are interviews, different kinds of participation and studies of documents and to enable an increased understanding of the situation how- and why questions are often asked. As time pass by, the researcher will hopefully get a better view of the problem and further information from different sources can then be collected to enable increased understanding.[19] What we first will do is to collect overall information regarding how the supply chain at SPA works to get some ideas of what can be interesting to study more in depth. We will also study different literature to be able to find additional areas that can be interesting to investigate. When we have a picture of what can be interesting to study in the supply chain, we will also perform mappings, to find additional data of interest regarding material flows. With mappings we mean defined procedures for what material to gather and how to decide about what data to study further. Some of the ideas for these mappings come from a proposal of what to regard when analyzing an enterprise's distribution structure. The proposal is a checklist with six parameters, which we will present in the theory chapter (Chapter 4.1.5)[20]. We will perform three mappings on different levels:

- country level
- supplier level
- part level

We actually have several intentions with the mappings. The first is that we will use them to collect appropriate information, that is as a structure for how and what information to collect. The second is that we will use them to get an understanding of how the activities regarding material flows really work. The third intention is that we will base our proposal, on how to work with and evaluate material flows, on the knowledge both from the mapping process and collected data. When performing the mappings we will increase our understanding and knowledge regarding material flows and other activities in the supply chain and this will be considered when deciding on what level of investigation that will be appropriate in our proposal. The objective and process for each mapping are described in the chapters regarding research strategy and research process (Chapter 2.2). The reason to why we present this is that we think that our mapping process can work as a base for future research

[19] Backman, J., (1998), p. 48-53
[20] Segerstedt, A., (1995), Kompendium i material och produktionsstyrning/MA/Logistik, Västerås, pp. 68

regarding material flows and at the same time give ideas on what could have been done different. We have defined three goals for our thesis and those are chosen with the mappings in mind. We think that the goals capture important fields of our case study and at the same time clarify the structure of our empirical study.

During our process of information collection we will get a better picture of what kind of theories that can be interesting to use in our thesis and we will therefore add theories along the way. As mentioned, our aim with the theory chapter is both to present theories regarding different areas in the supply chain to get ideas on what to investigate and to create an overall understanding, of how the supply chain works, among the people at SPA.

2.1.2 Structure through Systems Approach

When the researcher finds it appropriate with a result that gives a good description of the whole, it is appropriate to choose the qualitative method. The aim with the collected data is to give an overall picture of the situation, which enables an increased understanding of contexts, as the system theory and systems approach.[21] The systems approach has been used in different areas of logistics before, for instance where the aim has been to optimize parts of or the total supply chain. For us this approach seems to be a good way to create an understanding of what parameters affect the supply chain and how. As we have a problem formulation as a starting point for our thesis, we will however only describe those parts of system theory that we find are of particular interest to enable an understanding of the use of systems approach to give structure to a certain problem. In the next chapter we will give a short description of system theory and systems approach on the basis of what we find appropriate for our thesis (Chapter 3.2). As we thought that it would give us a better base for our case study, we have chosen to combine different authors' proposals on what elements to include in the system[22]. We will however focus on the element *transformation process* since we consider that it includes the supply chain in our case study, that is from suppliers to stock, stock at enterprise and finally from stock to assembly line. Both in our empirical findings and analysis we will discuss the element transformation process at the end of the chapters since we think that the other six elements are a base for the transformation process. Except for more general theories regarding supply chain management, also our theory chapter is divided in these three parts. The more general sections of the theory will be used where we think it is most suited. We have chosen to have this, to some extent, open way of applying the theory and also empirical findings from our mappings (Chapter 6) since we think that it can give us ideas about what is important to consider in a supply chain.

Through our case study we will collect a lot of different information and by describing the empirical findings from our case study based on proposed elements in a system, we think that we will get a good structure of our study. Since the thoughts

[21] Holme, I. M., Solvang, B., (1997), Forskningsmetodik- Om kvalitativa och kvantitativa metoder, Second edition, Studentlitteratur Lund, p. 77-80

[22] The parameters we will use are owner, Weltanschauung, customer, actors, environment, performance measurements and transformation process.

behind *system theory* points out the importance of understanding the different parts of the system, we think that there is a potential in using these thoughts in structuring and enabling an understanding of an enterprise with numerous parameters affecting. In the qualitative method the analysis is a continuing process and can be made easier by preparing some structure for the analysis before the actual observation starts.[23] We think that this idea agrees with how we attempt to work with our thesis since we want to build some kind of structure or work method for how to evaluate SPA's supply chain from our knowledge gained from both empirical and theoretical studies. By using systems approach, for structuring our empirical findings, in a combination with relevant theories of logistics, our intention is to identify essential parameters that affect the material flow and costs in the supply chain in different ways. We will then collect these parameters for what is important for a well functioning system in an evaluation model. The model will be divided according to the elements in the system and will be presented in chapter 7. Our intention is to evaluate the case of SPA based on this best-case model to be able to come to conclusions regarding where to find areas of improvements and also what is important when investigating and evaluating material flows. Based on both the results from the evaluation and our empirical findings from our mappings, we will design a work method that foremost suits SPA's need of a method for evaluating and deciding on material flows.

2.1.3 Generalization

The foremost advantage of case studies is that one can study what happens under real circumstances and that one can retrieve in depth information about the course of events in a process. The disadvantages of case studies are that one does not know if the studied process is common or if prerequisites for similar situations are present in other organization. It is therefore often difficult to come to generalized conclusions from case studies. However the result can instead be a methodology or an approach that can work as a good representation in other situations as well.[24] Our intention is to create an understanding of what is important when evaluating and deciding on material flows and therefore we will collect our findings from our analysis in a work method for how to handle material flows. Since SPA is an enterprise within the traditional industry, we think that our results can work as a good example even in other situations, at least as a proposal on what to consider when evaluating material flows. We thus think that the structure that we will use for our thesis, that is using systems approach when describing the situation and the division of the transformation process in parts considering different sections of the supply chain, can also be good to use in other situations for instance when evaluating what affects an enterprise's costs. As mentioned earlier, we also think that our description of research strategy and research process can work as a good base for future research.

[23] Backman, J., (1998), p. 54
[24] Wallén, G., (1996), Vetenskapsteori och forskningsmetodik, Studentlitteratur Lund, p. 115-118

2.2 Research Strategy and Research Process

In this section we will present how we intend to work with our case study and also how our work actually proceeded. With the aim at structuring our work we have chosen to divide it in five phases with respective objectives. The five phases will not be separated from each other, instead they will be integrated and will overlap. Common for the first four phases is to get an overview of why and where costs occur in the supply chain and to enable an understanding about parameters affecting these costs. This is a way for us to avoid the trap of investigating attempts of improvements that are not for the benefit of all the enterprises in the supply chain. In the descriptions of our first four phases we mainly focus on our empirical part of our work and in the fifth phase we gather all information both regarding empirical and theoretical findings. For each phase we first present the objective and then we continue with a description of how the work proceeded along the way. The five phases are:

- Phase one – Overall view
- Phase two – Selection of countries
- Phase three – Selection of suppliers
- Phase four – Selection of specific flows
- Phase five – Final gathering of material

2.2.1 Phase one – Overall View

Objective

To see what potential there is for improvements for an enterprise with many factors affecting the performance, it could be interesting to first enable an overall understanding of the enterprise's situation with respect to for instance suppliers. During this phase we will therefore study relevant literature and collect background information on SPA and its logistics function. The goal with the first phase is to get an understanding of SPA's supply chain to be able to find out what focus we should have in our further work. During this phase we will also consider the definition of our system.

Process

When we had collected material about for instance different material control methods (MCM) and various types of stock, we decided to divide our work in three mappings. By working with mappings on different detail levels, we thought that it would be easier to find the flows of real interest as excluding flows along the way. Another reason to this way of working was that we had got the perception that there were many different parameters and cost drivers that were hidden behind a certain material flow and therefore it was very difficult to choose some flows for further research without this knowledge. For instance the transport cost for different flows and countries seemed to be a parameter that could be interesting to receive more information about before picking the flows for final research.

We also got the perception that there were almost like two different goals for the production, one for the line supply and one for how the flows to SPA should be handled. As we understood it the most important matter regarding the line supply is that there never is a shortage on the line and that the JIT thinking is present. For the procurement however we understood it as the most important matter is to keep low stock levels, which results in a large amount of deliveries from the different suppliers. With this in mind we firstly thought it would be appropriate to divide our description of the case in two systems, one from suppliers to stock and one from stock to assembly line. However, since we thought that it was important for SPA to get an overall understanding of how its functions and activities influence each other, we decided to describe our case as one system.

2.2.2 Phase two – Selection of Countries

Objective

In this phase we will perform our first mapping to be able to choose flows of interest for a more thorough investigation in mapping two. We will cluster the suppliers by country and collect data regarding frequency of deliveries and cost for material and transport. The purpose of this first mapping is for us to get an overall picture of the situation to be able to choose some countries to examine further and we will also as far as possible identify general cost drivers in the supply chain.

Process

A problem we encountered when doing this mapping was a lack of data on a sufficient detailed level regarding transport costs, which resulted in that we decided only to look at transport- and material costs for January. The smaller set of data should however not give us a distorted view of the flows since the average time in stock of parts at SPA is about four to ten days and this decision was also approved in discussion with key personnel at SPA. Another problem we faced was the difficulty to decide what transport costs that were related to January since the invoices from the transporters only arrive few times a month. Finally we used the following criterions to choose what countries to examine further in mapping two:

- The countries that represent the largest material cost and transport cost.
- There should be a high frequency of deliveries from the country to SPA.
- There should be information regarding the transport costs.
- The suppliers in the country should represent different MCMs.

We chose these criterions since we wanted countries with steady flows and different MCMs. Also, we wanted to avoid countries with flows from which no conclusions could be drawn since they might be too unique. Since the information regarding transport costs were difficult to retrieve for all countries, the other criterions were of crucial importance. This resulted in the selection of four countries to use in our further work and in the next phase we will describe our choices of suppliers for the selected countries.

2.2.3 Phase three – Selection of Suppliers

Objective

In this phase we will collect information about the suppliers in the chosen countries with regard to for instance number of deliveries and which kinds of MCMs that are used in the relation to the supplier. The goal with this phase is to be able to choose two to five suppliers per country to examine further in the final mapping. From this mapping we also intend to identify additional parameters that affect the total cost of the supply chain.

Process

The material collected in this mapping was done on a supplier level and were information on material- and transport costs, type of MCMs used, number of deliveries both per MCM and in total. As for the preceding mapping we chose to only investigate data of deliveries regarding January. The following criterions were used as a base in the selection of suppliers:

- It should be an external supplier.
- Delivery at least two times a month per each part.
- Suppliers with two or more of the different MCMs were mainly chosen, but of most importance were that the chosen suppliers for each country represented each of the MCMs.

From this we chose a set of suppliers who we discussed with the responsible material planner to get his or hers view of our choice of respective supplier. This resulted in that we discarded some flows that were similar on a country basis or that were inappropriate in other ways, for instance if they delivered their goods through another supplier. We then had to choose some new suppliers to enable a good base for mapping three. After the selection of suppliers we continued our data collection for these suppliers and since the information collected in this mapping should be used for the choice of what flows to investigate in depth in the final mapping, we thought it was important with different kind of information (Appendix 1). To achieve further understanding regarding how the relation between SPA and its suppliers and transporters work, we also visited one supplier and one transporter.

During this phase we had a discussion regarding how to select the specific flows in the next phase because we were not sure of what was most interesting to investigate further. We saw two possible alternatives:

- We could select flows from the same country that have the same MCMs to enable a comparison of this method within the country.
- We could select flows with different MCMs from a country to enable a comparison of the usefulness for different methods for a specific country.

We realized that since most of the flows are more or less unique, it is probably difficult to come to some general conclusions regarding the different methods.

However, we decided that we should select flows with different MCMs in a country with the aim at finding some general parameters for each method used irrespective of the country.

2.2.4 Phase four – Selection of Specific Flows

Objective

In this phase we will first select one or two suppliers per country based on the information from the preceding mapping and then we will choose some specific flows of parts within each supplier. Our goal is then to choose about eight to ten flows to examine in depth to be able to find parameters that can be related to a specific MCM. We will in this mapping investigate, for the specific parts, how the MCMs both between the suppliers and the stock (sequence, Kanban, re-order point and batch) and between the stock and the assembly line (line feeding, two-bin and sequence) affect the costs of the system/supply chain.

Process

When we chose the flows for this mapping we decided that it was enough to start with two flows per country. This resulted in that we for some countries chose two different suppliers that represented different MCMs and for some countries the flows were to be found at the same supplier (Appendix 2). Since we mainly intended to examine how different MCMs work independent of country and only partly what similarities there are within a country, the flows were chosen on a bit different ways. We tried however to chose flows of the same kind and with some obvious similarities, regarding for example number of call-offs and delivered quantity, for several countries with the aim at as far as possible enable a comparison.

The criterions that we found most important for the selection of specific flows for final investigation were:

- What kind of MCM.
- Number of call-offs.
- Cost for transport and material.
- What quantity that is delivered.
- If a specific flow or supplier were interesting because of some other reason.

The information regarding the ratio between transport costs and material costs in our material is on a supplier basis and might therefore not be representative for all the individual flows, but we thought that this was an important criterion for the selection of flows anyway. Our choice of specific flows resulted in nine flows for investigation in depth. For these we collected information regarding for instance way of packaging, transport cost per part and what kind of supply to the assembly line that is used (Appendix 3-11). During this mapping we used the CMRs[25] to be able to identify

[25] Documents with information from the supplier regarding what have been delivered and from the transporter regarding for instance what the consignments weigh and their volume.

which parts were received and the invoices to be able to calculate the transport cost for our studied flows.

2.2.5 Phase five – Final Gathering of Material

Objective

In this phase we will gather all information and material that we have collected during the preceding phases. Parameters of importance for a well functioning system will be gathered in an evaluation model to be used when evaluating our findings from our case study. The outcome of this step will both be conclusions regarding how well SPA corresponds to our evaluation model and a proposal on a work method for how to evaluate and decide on material flows. The results shall also be analyzed with the aim to find out what knowledge from the case study at SPA that can be applied in other situations as well. There will also be some comments due to our use of the systems approach in our study. The outcome of this phase is described in the analysis and conclusion chapters.

Process

First we structured our empirical findings after the time line in the supply chain, that is we started our description in the need of the assembly line and ended the description when this need was satisfied. When constructing our evaluation model, based on ideas both from our case study and our theoretical studies, we saw no point in dividing the transformation process in the three parts a before. The reason to this was that we thought it would be better to consider the supply chain as a whole when doing the final evaluation, since what happens in one part of the supply chain often affects another. When deciding on what to include in the evaluation model, we tried to see a connection between what we had found important in different theories and during our case study. Since we thought that the elements in the system provided a clear structure, we chose to use these elements in our evaluation model. Our first idea was that we only should use this model, and thus the system structure, to summarize our analysis, but with this approach we had a hard time describing our analysis. Therefore we decided to structure the whole analysis according to the system elements. This enabled us to describe and discuss topics that concerned different parts of the supply chain in the same context. The structure from the systems approach also helped out in pointing out important aspects of the supply chain.

During our mappings we got several ideas regarding both parameters and methods that could be important when investigating material flows. Those ideas together with knowledge about material flows resulted in a proposal for a work method, aimed to be a support when analyzing material flows (Chapter 10). When constructing the work method we had a primary goal that it would be useful for the material planners at SPA, but we think that many of the thoughts, especially the objectives, can also be useful in other cases.

2.3 Critics and evaluation of choice of method

In this section we will give some comments on our choice of method for this thesis and also on how the work has proceeded. The aim with critics of sources is among others to decide whether the source measures what it should, that is *validity*, and to be sure that there are no systematic faults, that is *reliability*.[26]

We think that the systems approach was a very good tool for describing our case study. The reason to this is that the activities and parties in the supply chain are linked in different ways and affect each other. The result of the use of systems approach is however to a great part dependent on how the system and the different elements are defined. For instance if the customer in our system had been defined as SPA instead of the assembly line, the outcome and the discussion had been different than the present, as SPA actually has the possibility to make demands on the system. As discussed, it was hard to both describe and discuss our case study without the structure proposed in systems approach (Chapter 2.2.5). We, however, think that it could have been even more appropriate if we had more theory regarding systems in our theory chapter. We consider our choice of the other theories as appropriate when analyzing the system and mainly the transformation process, which we divided in the same three parts as the theory chapter.

When using the systems approach in the analysis and application of model, we decided not to analyze the actors, but instead analyze the actors' relation to the owner. We think that in many cases the relations are of more importance than the actual actors and that this element should replace, or at least complement, the element actors. According to us, it is important to add the element *performance measurements* to the system description since we think that these measurements have great impact on how the system works. We think that, in most cases, a system will strive for performing as good measures as possible and thus if the measure is ill designed it will have a bad influence on the system. On the other hand, a well-designed measure will help the system to continually improve its performance.

We constructed our evaluation model along the way, based both on different theories and our empirical findings. The risk with this way of working is that the model becomes too influenced of the empirical findings since interesting issues to study further comes up as the study proceeds. We however think that this iterative approach, when designing our evaluation model, is a good way to avoid possible faults along the way and therefore we consider the reliability in our thesis as high. When we performed our case study at SPA we found many areas that work well, but since our intention was to come up with ideas regarding what SPA could improve, the parameters included in the evaluation model may have a focus on problem areas. Therefore there is a risk that areas where other enterprises can improve have been neglected in our evaluation model.

[26] Eriksson, L. T., Wiedersheim-Paul, F., (2001), Att utreda forska och rapportera, Seventh edition, Liber Ekonomi, Karlshamn, p.150

Our first intention was to evaluate the whole supply chain from the supplier to the assembly line, but the focus shifted to the part of the supply chain that regards what happens from suppliers to the stock. There are two major reasons behind this choice of focus:

- Firstly, it seemed like SPA has least knowledge in this area, which makes it interesting to study.
- Secondly, as our work proceeded we mainly saw potentials of improvements within this part of the supply chain.

The downside of this focus is that we do not have a complete understanding of the supply chain and cannot really evaluate the consequences of our proposed solutions. Also we cannot be sure that we have not missed other parts of the supply chain where greater potential of improvements are present.

After mapping two was completed we thought that we should have chosen the flows for mapping three on random since the second mapping was quite time consuming. However, when we started to analyze the outcome of mapping three and started to work on the proposal for a work method, we had much use of the findings in mapping two and we also gained knowledge in how this information could be used.

The information in our case study comes from internal documentation, our own observations and interviews and discussions with several people within SPA. We think that the risk of retrieving incorrect information has been minimized since our information comes from many people with a broad knowledge, that is the validity in our thesis is, according to us, high. Also, since our assignment was initiated by SPA we know that SPA have an interest in our work and therefore we consider that the information we have received from the people at SPA will work as a good basis for our final results.

3 System Theory

In this chapter we introduce system theory, systems thinking and systems approach. The intention is to give a picture of what has been done in these areas and to consider how this can be used when describing a case study. This theory chapter is presented separately since we will use these ideas as a method in our thesis. First we discuss what has been written in the area of system and logistics together and then we continue with a section regarding the development of systems thinking, system theory and what is behind the ideas of systems approach. Since systems approach is a part of our method, the focus will mainly be of this part.

3.1 Development of Logistics and System Theory

The logistics theory of today has evolved from thoughts about transports of agriculture products in the early 1900s. Agriculture economics had big influence until the Second World War when military needs of transport gave birth to an engineering view of logistics with a focus on efficient physical distribution. The business sector saw the distribution as a function of the marketing function and thoughts about inventory control, material handling and transportation arose. During the 1960s the systems approach was explored and the main focus of logistics shifted from physical distribution to an entire system of activities. During this period the *total cost concept* was also applied to logistics. The total cost approach emphasizes that functions regarding moving and handling of materials should be regarded as a whole and not as separate functions and this is well in line with system theory. This period brought together areas of knowledge such as transport theory, institutional economics, inventory control and location theory to an area of expertise that defines what today is called logistics. In the 1970s focus on customer service emerged and the focus on minimizing costs was being replaced by a focus on maximizing profits. That is, the new thought was to use logistics as a service to satisfy customers. This development continued during the 1980s and the thoughts evolved to use logistics as a mean of differentiation and logistics became a key component in enterprises' strategies. During this era the thoughts about supply chain management emerged and the key issue was how to link the supply chain to create value for the customer.[27] The system theory and systems approach is evident in supply chain management and it is a good way to enable understanding of logistic systems since logistics regards networks of activities with the purpose of managing information, material and personnel.[28]

3.2 Development of System theory

There are several scientific theoretical traditions which all have some kind of philosophical background. Three traditions that we have chosen to partly use in our thesis are called systems thinking, system theory and systems approach and our intention is to describe the parts of those traditions that are especially relevant to

[27] Kent JR., John L., Flint D. J., (1997), *Perspective on the evolution of logistics thought,* Journal of business logistics, Council of logistics management, vol 18, p. 15-21

[28] Lambert, D. M. et al, (1998), pp. 7

research praxis. Some authors argue that systems thinking, system theory and systems approach do not differ substantially from each other and therefore they are used more or less synonymously[29]. Our intention with the description of systems thinking and system theory is, however, only to enable an understanding of what is behind the systems approach before we continue with a description of the use of it. We will thus not make too big efforts to distinguish between how different authors uses these terms.

The reason to why the ideas of system theory arose was that questions regarding why animals, water and so on, could not be treated with the traditional research method, where one factor is studied in order to understand its influence on other factors. In the end of the 1960s the system theory arose, partly with the purpose of summarizing general characteristics that were about to arise in the areas of for example biology and technique. A book that considers system theory as an overall approach is *General system theory* written by Bertalanffy (1968) and the focus of that book is on the use of system theory in the area of biology. Another book is *Systems thinking, systems practice* written by Checkland (1990) and it is concentrated on organizations theory. Churchman (1978) is another author in this area and in his book *The Systems Approach* he, among other things, discusses what a system is and how it can be used in different situations[30]. The thoughts about system theory came out of the need to observe, understand and plan for change in complex contexts where multiple factors alternately affect each other. The aim with system theory is therefore to show structures and contexts in a more comprehensive perspective.[31]

A system perspective is good to use when there are several interactive parameters in a system that represent system effects and synergies and when there is a need to follow processes and different courses of event. A wide description of a system is a group of objects, which alternately affects each other. This means that the system as a whole has different characteristics than those present in each object. Each object can itself be a system, and the studied system may be a sub system of another system. The system does not have to be physically delimited from its surroundings, instead it can be defined by its function. How the definition of a system is done can therefore differ depending on the specific situation and depending on which view that has been chosen[32]. The decision regarding what is to be seen as a system and what are supposed to be included and excluded from the system, can in some cases be obvious and in some not.[33]

Regarding how to describe systems there are for example two authors that have almost the same vision about what to include in the system. The authors are Checkland (1981) and Churchman (1978) with the same books as above. Checkland

[29] Gammelgaard, B., (1997), *The Systems Approach in Logistics*, Proceedings from NOFORMA.1/1997, p. 2
[30] Churchman, C.W., (1978), The Systems Approach, Gotab Stockholm
[31] Wallén, G., (1996), pp. 28 and pp. 44
[32] Checkland, P., (1981), System Thinking, System Practice, pp. 224
[33] Wallén, G., (1996), p. 56 and p. 28-30

suggests a definition of a system consisting of six elements while Churchman suggests five principal aspects to have in mind when talking about systems.[34] One difference between these two suggestions is that Churchman more explicit than Checkland uses performance measurements to evaluate the success of the system's different meanings or goals. Since the two suggestions are quite similar, we have chosen to describe only one of them in more detail, namely the one that Checkland suggests. We have however chosen to add the element regarding performance measurements to this model as is shown in the figure below (Figure 3.1).

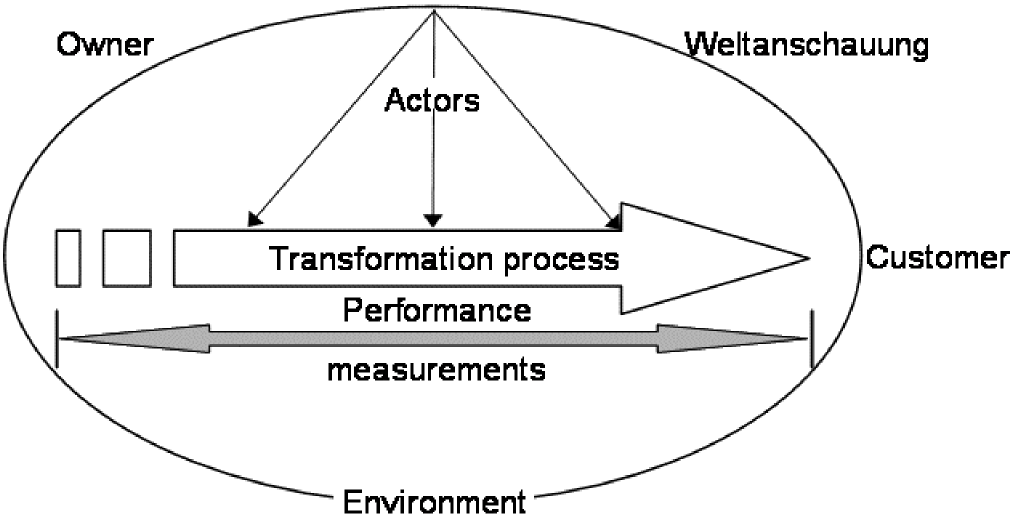

Figure 3.1, The elements in the system. (Source: Free from Checkland (1981) and Churchman (1978))

3.3 System Elements

As mentioned earlier the definition of a system can be different depending on which view is chosen and to ease the process of defining the system there should, according to Checkland, be six elements present in the root definition of the system. The system must have an *owner* in some sense that has the power to shut the system down. The system must have some kind of *meaning* in its environment and this meaning is called *Weltanschauung*. There must be a *customer* of the system and the customer can be either external or present within the system. The customer can be either beneficiary or "victim" of the transformation process of the system. Within the system there are *actors* who carry out the transformation process and other main activities in the system. The system resides in some kind of *environment* where the environmental constraints affect the system and can be taken for granted by the system. The core of the system is a *transformation process*, and can be reassembled by the process of converting input to output.[35] As mentioned above, we have chosen to complement these six elements with the element *performance measurement*. This element intends to provide the systems analyst with information regarding how well the system works,

[34] Checkland, P., (1981), pp. 224 and Churchman, C. W., (1978), p. 35
[35] Checkland, P., (1981), pp. 224

both internally and externally, based on the meaning and the goals of the system. When the performance measurement is to be established, the systems analyst needs information about as many relevant consequences regarding the activities in the system as possible to find the most appropriate measure or measures.[36]

With these ideas about systems we will now continue with a further description of how these ideas are to be used in the systems approach.

The systems approach is "*an approach to a problem which takes a broad view, which tries to take all aspects into account, which concentrates on interactions between the different parts of the problem*"[37].

When using the systems approach, the situation in which the perceived problem is found will be expressed in terms of structure and process and the relation between the two. The aim by using this approach is to enable increased knowledge in and understanding of a real-world situation that, by at least one person, is regarded as a problem.[38] This increase in knowledge and understanding is achieved by studying processes and courses of event where interactions between different parts as well as the systems' structure are important. To be able to decide about what is within and outside the system, a first step is to identify the function of the system and see what parts are included in the system and how. This is done with the aim of achieving an understanding of the system's relation to its surroundings and to be able to study flows of for example material and information within the system. It is interesting to study what control functions are present in the system and how the system changes over time.[39] To enable an understanding of what specific events are associated with the particular problem, patterns of behavior that characterizes the situation must be considered. Often this requires an investigation of how one or more variables of interest, for example costs or sales, change over time. A strength with the systems approach is therefore that once the pattern of behavior of a problem has been identified, it is possible to look for the system structure that is known to cause that pattern. By finding and modifying this system structure, it is then possible to eliminate the problem pattern of behavior.[40]

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[36] Churchman, C.W., (1978), pp. 36
[37] Checkland, P., (1981), p. 5
[38] Checkland, P., (1981), p. 16 and p. 241
[39] Wallén, G., (1996), pp. 29
[40] Kirkwood, C.W, (1998), *System Dynamics Methods: A quick introduction*, College of Business Arizona State University, Chapter 1, p. 1-4, www.public.asu.edu/~kirkwood/sysdyn/SDIntro/SDIntro.htm, 2003-03-03

4 Theory

In this chapter we present theories chosen with the aim to enable an evaluation of what influences the supply chain from suppliers to assembly line. First, overall theories regarding supply chain are presented and then theories regarding each of the three parts that we have chosen to divide the supply chain in, that is from suppliers to stock, stock at enterprise and from stock to assembly line, are presented. How the different parts in this chapter, together with the systems approach described in the preceding chapter, are linked is shown in Figure 4.1.

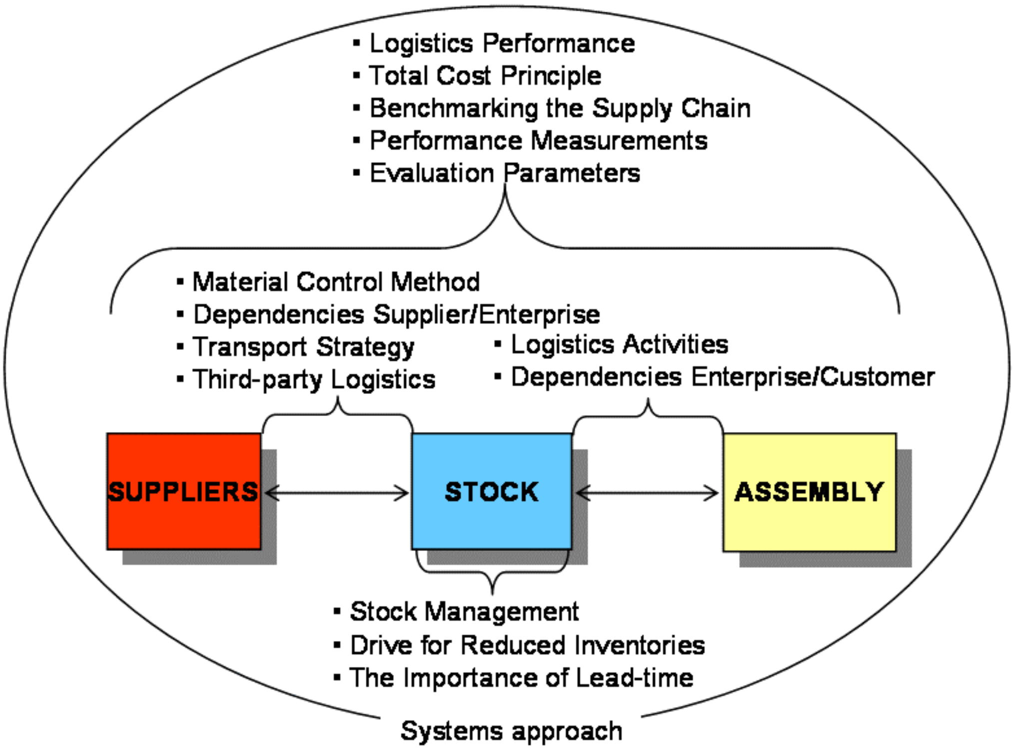


Figure 4.1, Theoretical context.

4.1 General Supply Chain Theories

"Logistics is the process of planning, implementing and controlling the efficient, effective flow and storage of raw materials, in-process inventory, finished goods, services, and related information from point of origin to point of consumption (including inbound, outbound, internal, and external movements) for the purpose of confirming to customer requirements."[41]

[41] Persson, G. and Virum, H., (1998), Logistik för konkurrenskraft, Liber Ekonomi, Second edition, p. 13

Some activities and areas of responsibility that often are associated with logistics are transports, stock control, material handling and packaging, order handling and customer service, forecasts, production planning and finally procurement and material supply. There are also other activities that can be seen as an enterprise's logistics activities, for example activities regarding spare parts and returning goods.[42] To avoid so-called sub optimization in an enterprise's supply chain, it is important for different functions to cooperate. For example the procurement function and the production function have to cooperate to find the best solutions viewed in a total perspective. The interest of controlling the material flow is not only concentrated to a specific enterprise, instead it becomes more common to also work with the coordination between the different enterprises in the supply chain. The aim with this is that as many actors in the supply chain as possible shall gain from cooperation.[43]

4.1.1 Logistics Performance

The primary reason to why an enterprise should develop its logistics function is that it can improve the effectiveness in the material flows through reductions in costs and increased revenues, by means of improved delivery service. An effect of this is that the enterprise's capital investments can be better used.[44] The major costs due to key logistics activities can be summarized in six categories; customer service levels, transport costs, warehousing costs, lot quantity costs, inventory carrying costs and order processing and information costs.[45] As we mainly will focus on physical flows in our thesis, we will however only describe the first five since we consider them as most relevant. To clarify how we attempt to use these cost categories in our thesis, we will discuss them in the section where we think they are most useful.

The focus on cost reduction has in the recent years driven several enterprises' operational and logistics strategies and as long as it is not achieved at the expense of value creation, it is a worthy goal. A result of low cost strategies may however be that they only lead to *efficient* logistics and not to *effective* logistics and therefore it is important to consider the effects of the total logistics function and also the supply chain for decisions of this kind.[46] An enterprise must thus have both efficient and effective management of inbound materials flow or else the manufacturing process will not be able to produce according to demand and price.[47]

The effectiveness of logistics can be improved through changes in the organizational structure, through better planning- and control systems and through changes in the physical material flow. Since there are several connections between these possible changes, it is important to treat them together as a whole. Since there are close connections between different functions within an enterprise, it is also important to

[42] Persson, G. et al, (1998), p. 15-17
[43] Persson, G. et al, (1998), pp. 20-23 and p. 35
[44] Persson, G. et al, (1998), p. 14
[45] Lambert D. M. et al, (1998), pp. 15
[46] Christopher, M., (1998), Logistics and Supply Chain Management, Financial Times Professional Limited, Second edition, p. 43
[47] Lambert D. M. et al, (1998), pp. 182

consider the impact of the different goals that the respective functions have. It is central to understand that what is efficient for a separate function might not be efficient when considering the function's influence in a total perspective, that is together with other functions. To handle this an enterprise has to communicate goals that concern the enterprise as a whole and that every function can identify with. Material *administration* is a strategic-tactical concept that emphasizes problems involved regarding management and coordination and it is therefore the aspect of logistics that is about doing the right things. Material *control* on the other hand is more about doing things right and is more of a tactical-operational concept, which for example includes delivery service (delivery time, delivery reliability, flexibility, number of variants and stock availability) and material administration costs (costs for stock, transports and control).[48]

To administrate and control the material management activities there must be proper methods to identify the performance of the activities. There are four measures relevant to this thesis:[49]

- *service levels* that can be measured by the number of delays caused by stock outs
- *inventory* that can be measured by stock days per part
- *price levels* that should be compared between suppliers and over time
- *quality control* that can be done by measuring the number of product failures due to deviation in the quality of materials.

Measures can also be done on a supplier basis where the ratio of returned goods is determined. The measures relate to how the product is produced and how inventory is controlled and the measures are also a good starting point for discussions on if and how the material flow system can be reengineered. One system that is commonly used is the Kanban/JIT system, which is part of the Toyota Production System (TPS).[50] This will be further discussed together with theories regarding material control methods (MCMs) (Chapter 4.2).

4.1.2 The Total Cost Principle

Logistics management is a flow-oriented concept with the objective of integrating resources in the chain extending from suppliers to customers and therefore it is desirable to have a means whereby costs and performance of that chain can be assessed. Since many enterprises lack appropriate information regarding costs and therefore knowledge about what happens in another area of the chain when some changes are made in one area, it is often difficult to adopt an integrated approach to logistics.[51] However, the challenge for an enterprise is most often not so much to create new data, but to adapt the existing data to meet the need of the logistics function. Through improving the availability of logistics cost data, management is in

[48] Persson, G. et al, (1998), pp. 14 and p. 18
[49] Lambert D. M. et al, (1998), p. 194-197
[50] Lambert D. M. et al, (1998), p. 194-197
[51] Christopher, M., (1998), pp. 71

a better position to make both operational and strategic decisions. This can for instance consider decisions regarding whether to enter a new market or not, level of inventories, frequency of deliveries and changes in packaging.[52]

One basic principle of logistics costs is that there shall be a focus on the output of the system, that is on what creates value for the customer and what costs that are associated with that output. Most often the customer in this case is the end customer but we will use those ideas for our specific case where the assembly line is seen as the customer. Since decisions taken in one area of the supply chain often have affects in other areas, it is important to take impacts of both direct and indirect decisions into account to avoid problems at the operational level. The key to managing the logistics function is therefore to perform a *total cost analysis*, which means that management should work with minimizing the total logistics costs, that is not only minimizing the cost of individual activities[53]. The aim with using total cost analysis in this context is to be able to identify changes in costs brought about these decisions and must therefore be viewed in incremental terms, that is what changes in total costs that is caused by change to the system. For instance an addition of an extra warehouse will result in cost changes in transports and communications.[54] Due to this an enterprise can use the total cost analysis for example to be able to evaluate different combinations of stock levels and number of transports. What is important with this visualization is that it shows the connection between elements in the material flow that gives rise to revenues respective costs. The aim with the visualization is to achieve an effective material flow by identifying the optimal balance between high delivery service and low costs for logistics.[55] When changes regarding the logistics system structure are made, these must thus be justified by comparing total costs before and after a change.[56]

4.1.3 Benchmarking the Supply Chain

The different actors in the supply chain play an essential role with respect to how well the supply chain works and therefore it is of great importance to include the quality of these relationships in the benchmarking process to understand how efficient and effective those are. The overall aim should be to improve the performance of the supply chain as a whole, which demands emphasis on the actors' contribution to reducing the total cost and increasing the customer value. It is not only the different actors' performance that is important to keep in mind, but also how the interfaces are managed. Questions regarding interfaces can for instance be how the enterprise manage the transmissions of orders to suppliers or how they co-ordinate their production schedules with those of suppliers.[57] Some typical measures for this purpose are shown below (Figure 4.2):

[52] Lambert D. M et al, (1998), p. 469 and p. 475
[53] Lambert D. M. et al, (1998), p. 469
[54] Christopher, M., (1998), p. 72-77
[55] Persson, G. et al, (1998), p. 18 and pp. 67
[56] Lambert D. M. et al, (1998), p. 495
[57] Christopher, M., (1998), pp. 116

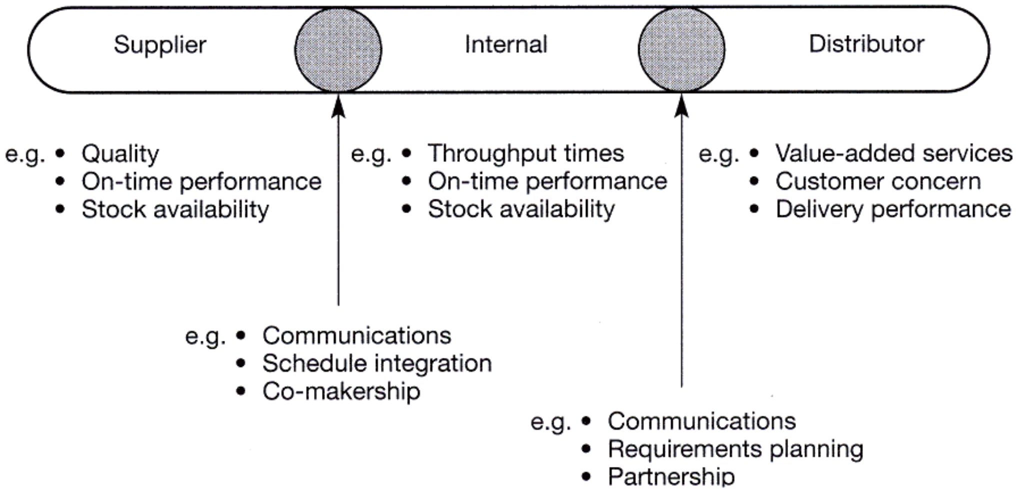


Figure 4.2, Benchmarking supply chain performance.[58]

Our intention is not to perform a benchmarking in this thesis, we will only use the ideas behind how to benchmark the supply chain with the aim at finding parameters that can be of importance for our study of material flows, relations and activities in the supply chain. In the following discussion we will therefore mainly present areas regarding what is important for the enterprise to consider when evaluating its performance. Since our focus is on the activities and costs in the supply chain from suppliers to stock and finally to assembly line, we will exclude parts of theory regarding other parts of the chain.

It can be good to work with different logistics missions to be able to achieve, as well as enhance, desired outputs. A result of this might be that the enterprise recognizes a need to improve processes and also to control them. The process in our case starts with the suppliers, runs through the own enterprise and finally to the customer, that is the assembly line. To be able to improve performance in the process, it is important to first create an understanding of the structure of the process, for instance by visualizing it in a flowchart. When this is done the next step is to identify critical points, that is points where the entire process will be affected if something goes wrong and at these points process control should be applied. When an understanding of each process and activity in the supply chain is achieved, the next step is to get an understanding of how these processes and activities are linked in the total supply chain through a mapping. The *supply chain map* is a time-based representation of processes and activities involved as the materials and or products move through the chain. A distinction between *horizontal* and *vertical* time in the process can be made. Horizontal time means time spent in process, for instance assembly time, whereas vertical time is when nothing happens and therefore only cost are added, for instance when the material is in inventory. These kinds of maps are not only useful when

[58] Christopher, M., (1998), p. 117

benchmarking against competitors but also as an internal benchmark with regard to for example process lead-time in relation to inventory levels.[59]

To evaluate an enterprise's position in an industry, it can be helpful to examine the relative cost positions of enterprises in the industry. By comparing the own enterprise's cost position in relation to other enterprises in the industry, it can get a better idea of how to become or remain cost competitive in the long run. This is called a *strategic cost analysis* and the primary activity in this is to construct a total industry activity cost chain, which shows the buildup of costs (also value) from raw material to the end customer. Different activities in the supply chain incur costs regarding for instance material, inbound transports, inbound materials handling, inspection and warehousing.[60] Costs for material handling and procurement can be referred to as *lot quantity costs*. The important thing with respect to material handling is that non-value-adding activities are eliminated as far as possible since also those activities incur costs. For procurement it is, among other things, important to choose the right suppliers, decide on what relations to have to them and what quantities to order. One way to deal with transport costs and warehousing is to use a warehouse located near several suppliers so that transports to the customer, that is the assembly plant, can be coordinated. *Warehousing costs* includes costs for warehousing and plant- and warehouse site selection. The decision regarding location is a strategic decision that not only affects transport costs but also customer service levels and speed of response. [61]

If an enterprise after performing this cost analysis realizes that it has cost disadvantages in the supplier's part of the cost chain, there are different strategic options to consider. Among these options are to negotiate more favorable prices with suppliers, to integrate backward to gain control over material costs, search out sources of savings for transports and other logistics costs and finally to try to understand the difference of cost savings elsewhere in the overall cost chain.[62]

4.1.4 Performance Measurements

In the past internal performance measurements as productivity, utilization and cost per activity were of great importance. Today, due to the intense level of competition, there are also other measurements that are important, for example the customer's perception of performance. Competitive benchmarking is a term used for continuous measurement of an enterprise's products, services, processes and practices against the standards of best competitors and other enterprises that are recognized as leaders. When evaluating supply chain performance activities it often becomes clear after a while that there are a number of critical measures of performance, so-called *key performance indicators*, which need to be continuously monitored. The idea of key

[59] Christopher, M., (1998), pp. 107 and p. 113-115
[60] Thompson, A. A. and Strickland, A. J., (1986), Strategy Formulation And Implementation-Tasks of the General Manager, The University of Alabama, Business Publication, INC. Plano, Texas, Third edition, p. 134-136
[61] Lambert D. M. et al, (1998), pp. 15 and pp. 270
[62] Thompson, A. A. et al, (1986), p. 137

performance indicators is that there are only a few numbers of critical dimensions that contribute more than proportionately to success or failure. Often these are non-financial measures that are connected to the enterprise's strategic goals. There are different activities for identifying key performance indicators: [63]

- The first activity is to think about how the logistics and supply chain strategy contribute to the overall achievement of corporate goals.
- The second activity is for the enterprise to decide what the measurable outcomes of success are and what processes that have an impact on these outcomes.
- The third activity for the enterprise is to identify drivers of performance within these processes.

Since what "*gets measured, gets managed*" it is important to choose performance measurements that incorporate appropriate indicators of logistics performance. It is also important to not only compare the enterprise's performance to that of immediate competitors but also to the enterprises that are the "best in the class".[64]

4.1.5 Evaluation Parameters

To summarize the discussion above, we will now present a checklist with some parameters that are important to think about when analyzing an enterprise's physical distribution structure. The analysis is intended to be done when the aim is to make improvements in the structure so that the product will reach the customer quick, safe and at reasonable costs. The parameters can also be useful for attempts to make both long- and short-term forecasts.[65] Even though these parameters are intended for an analysis of the distribution structure, we think that they also are useful when analyzing other parts of the supply chain. In our thesis we will have these parameters in mind when evaluating the activities of the supply chain and those parameters have also worked as a base for what to consider in the three mappings performed in the case study.

Goods volume and goods type regard way of packaging, order quantity, frequency of deliveries and number and characteristics (volume, weight etc.) of products. It can also be interesting to think about the customer structure (size, number and geographical location) and to see what possibilities a customer has regarding for instance stock capacity.

Cost development is about transport cost per mean of transportation divided in geographic distance and volume. It is also valuable to do an evaluation of whether to own or to buy transport services and to look at warehousing costs.

[63] Christopher, M., (1998), p. 103 and p. 122-124
[64] Christopher, M., (1998), p. 103 and p. 122-124
[65] Segerstedt, A., (1995), pp. 68

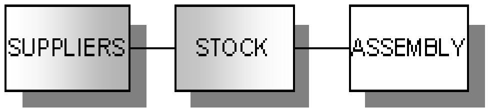
Transport rationalization concerns new or other ways of handling transports, for instance possibilities of transport coordination between suppliers and collaboration with other enterprises.

Legislation regarding transport means is about for instance vehicle length, axle load and working hours, whereas for products it is about for instance environmental requirements.

Variations and disturbances due to season or business cycle swings or unexpected peaks of demand are also important to concern and to see what possibilities there are to increase transport or stock capacity if necessary and how to secure the production.

Delivery service considers what demands the customer makes and has the right to make, for instance regarding packaging. It also concerns the probability for a product to be available in stock, the time from customer order until the product is delivered, delivery reliability (time, quantity and quality), information flow and flexibility regarding for instance changing conditions.

4.2 From Supplier to Stock



Here we will present theories that can be interesting when analyzing what happens between the supplier and the stock. The section regarding MCM will only discuss Kanban since thoughts behind this MCM are also present for other MCMs.

4.2.1 Material Control Methods

Different MCMs require different demands on transports and purchasing. The main philosophy with for instance Kanban, as a part of a JIT system, is that materials should be supplied when the production process needs it. The method has been applied to a variety of enterprises and the main benefits are:[66]

- Improvements in productivity and greater control between various production stages.
- Lowered levels of raw materials, work in process and finished goods inventory.
- Reduced production cycle times.
- Improved turnover rates.

There is however several problems associated with the implementation of a JIT system and it is not appropriate for every enterprise. Since JIT reduces the inventory level to the point where there is no safety stock, it may not be optimal for an enterprise for which a stop or slowdown in production raises great costs. The JIT system requires small frequent deliveries, which increases cost for transports since the deliveries will increasingly be done by less-than-truckload (LTL). It can also result in increased cost per unit from the supplier, since production of smaller lot quantities

[66] Lambert D. M. et al, (1998), p. 194-197

may raise setup and production costs. The distance to the supplier incurs a longer time for delivery and makes the transport time less predictable. The variability in transport time can cause stock outs, which causes disturbances in the production scheduling and may even cause stops in the production. These factors must all be combined and the enterprise must assure that the total cost of these factors does not exceed the savings in inventory carrying costs.[67]

4.2.2 Dependencies between Supplier and Enterprise

In a supply chain there are many dependencies, both direct and indirect, between the actors. Enterprises in the supply chain must gain understanding regarding these dependencies to be able to analyze efficiency improvements. Here we will present dependencies between a buying enterprise and its suppliers.[68]

The relationship between the buyer and its suppliers has a great influence on the supply chain that they are part of. With the most important suppliers the buyer has much to gain by continuously reconsidering and changing the way they co-operate in their activities. The reconsideration should be done in co-operation with the supplier and can concern many activities such as R&D, manufacturing, administration and logistics. The buyer can help the supplier by adopting similar behavior as other buyers, but the buyer must always bear in mind to compare the potential advantages of similarities with its disadvantages. An increase in similarity can, for example, reduce the opportunities of differentiation.[69]

Often a buyer has many suppliers and sometimes there is much to gain if the suppliers and the buying enterprise decide on standardized methods to communicate since this can decrease the administrative work between the enterprises. The buying enterprise can also gain benefits by, for example, co-ordination of incoming goods from different suppliers.[70] It is also important for the result of the whole supply chain that it can be assured that problems between the buyer and its suppliers are not solved by just moving them further back in the chain.

4.2.3 Transport Strategy

Transport costs is often the largest single cost among logistics activities and concerns among other things a product's characteristics with regard to density, stowability and how easy it is to handle.[71] The strategy of transports depends on both *external* and *internal* factors. The external factors are factors that have impact on the enterprise's business and its transport activities. The behavior of suppliers, customers and competitors has vital impact on the enterprise's business. Factors that have impact on the transport activities are legislation and constraints that control the price and services available, the economic prerequisites for different ways of transport and

[67] Lambert D. M. et al, (1998), pp. 200
[68] Gadde, L-E, Håkansson H.,(2001), Supply network strategies, John Wiley & Sons Ltd, p. 75
[69] Gadde, L-E et al, (2001), p. 77
[70] Gadde, L-E et al, (2001), pp. 75
[71] Lambert D. M. et al, (1998), pp. 15

actions taken by the transport enterprises. Two internal factors of great importance when deciding on the transport strategy within an enterprise are the *business strategy* and the *logistics strategy*. The business strategy has impact on alternatives useful to the personnel responsible for transports, on what products the enterprise is to manufacture and the geographical market of the enterprise's suppliers and customers. The logistics strategy has implications on the purchasing policy including the size and localization of warehouse and on how the deliveries to the enterprise should be done.[72]

The transport strategy's main objective is to balance the internal and external factors. The outcome is a plan that defines the possibilities and constraints on the decisions available to the personnel responsible for the transports. The decisions can be grouped into three main groups: [73]

- The first is what transport service must be present to fulfill the logistics strategy. Within this area the way of transport is chosen and under what prerequisites the transport enterprises are evaluated.
- The second is under what circumstances the transport service should be bought. The decisions to be made are, amongst others, how many transporters should be contracted and how much control the enterprise should have over the transports.
- The third group regards what resources are needed to support the transport strategy.

In addition to personnel resources and investment in transport equipment, the decisions regarding information systems are important so that the necessary support is available for implementing the transport strategy. The information systems are moving towards integration of stock control, order receiving and purchasing. The systems are becoming more complex and will have a direct affect on the enterprise's business opportunities. Information technology in conjunction with transports will therefore become key factors in the development of a modern flow of material.[74]

4.2.4 Third-party logistics

There are several benefits of outsourcing the logistics service to a third-party logistics provider. Third-party logistics is however still in evolution and is difficult to define. There are various definitions and we have chosen to use the following definition:[75]

"*Activities carried out by a logistics service provider on behalf of a shipper and consisting of at least management and execution of transportation and warehousing.*"

These are some of the benefits of third-party logistics that are interesting for this thesis: [76]

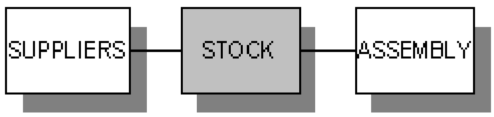
[72] Tarkowski J. et al, (1995), p. 108-112
[73] Tarkowski J. et al, (1995), pp. 112
[74] Tarkowski J. et al, (1995), pp. 112
[75] Schary, P.B., et al, (2001), p. 227

- An enterprise can convert fixed costs to variable costs by outsourcing transports and warehousing operations.
- The outsourcing of logistics service can help the enterprise to adjust its activities to an uncertain environment.
- Third-party logistics enterprises can use the similarities of its clients to better utilize its own assets thus reaching economies of scale.
- The service buying enterprise can focus its organization and systems on working with one or a few third-party logistics providers instead of having an organization working with various transporters.

Developing a third-party relationship is both stressful and difficult. The evaluation and selection of the appropriate third-party logistics service provider is a time and resource consuming process that requires management resources and definitions of joint information systems. The outsourcing decision is not a linear process but an iterative process where a good balance between costs and service benefits must be reached. Finding this balance is difficult since the costs can be very hard to identify and therefore continuous improvements is an important part of the process.[77]

However, outsourcing parts of the logistics function also raises some risks and there are some obstacles that can hinder an implementation. The enterprise can loose control over flows of materials. This risk can be reduced through a tight integration of information systems. Lack of cost data prevents the enterprise to be able to evaluate its own logistics function and therefore the enterprise has no basis for a discussion regarding outsourcing. Conflicts within the enterprise may hinder the implementation, for example the logistics function may see the outsourcing as a threat to its own survival.[78]

4.3 Stock at Enterprise



In this section we will present theories that we find interesting for analysis of the stock at the enterprise.

4.3.1 Stock Management

It is of great importance for an enterprise to work with inventory planning to ensure successful manufacturing operations. If there is a shortage of some material it can lead to disturbances on the assembly line and therefore also to changes in the production schedule. At the same time as material in stock may protect the enterprise from uncertainties, it can also lead to a reduction of profitability since excessive stock increases inventory costs. Therefore the enterprise must bear in mind that the cost of inventory in stock must be compared to the savings or costs avoided by holding it. To minimize problems and uncertainties regarding the stock level, the enterprise can

[76] Schary, P.B. et al, (2001), pp. 232
[77] Schary, P.B. et al, (2001), pp. 234
[78] Schary, P.B. et al, (2001), pp. 237

work more close to suppliers and transporters to improve reliability and allowing a reduction in the amount of security stock. A reason for an enterprise to have parts and components in stock is however that it might enable the enterprise to achieve economies of scale through higher order volumes and thus lower prices per ordered piece. It can also lower the cost for transport since the transport cost per unit is lower when utilizing full truckload (FTL) shipments instead of smaller shipments of less-than-truckload (LTL) size. As mentioned, there is a cost concerning warehousing and it is an essential parameter to consider for this section (Chapter 4.1.1). Here it is important since it affects the customer service levels and also the speed of response.[79]

Another type of inventory is so-called work-in-process inventory and it is maintained to avoid stops in production if a part of the production were to break down and to balance the flow within a production facility. Enterprises are focusing on having a more smooth production in order to decrease the need for having this kind of inventory.[80] In a supply chain the finished goods at the enterprise's supplier and the inventory in stock at the enterprise can be regarded as work-in-process inventory. To enable this view of work-in-process inventory within the supply chain the enterprise and its suppliers must have a good relation and a mutual understanding.

4.3.2 Drive for Reduced Inventories

Many enterprises try to reduce their inventories to release capital locked up in stock and consequently to reduce the holding cost of that stock with for instance the purpose of improving their flexibility and responsiveness to their customers. This development has resulted in that the delivery of the complete order at the time required by the customer has become an order-winning criterion. The solution for an enterprise with customers who require JIT deliveries is not to carry the inventory instead of the customer, but to substitute responsiveness for inventory whenever possible. This is mainly achieved through time compression in the supply chain, which results in less cost since the chain is shorter. The purpose with this is to enable an enterprise to achieve high service levels at a low cost.[81] As discussed, the relationship to the suppliers is of great importance for this to work (Chapter 4.1.2). In our thesis the customer in this case can both be the assembly line and the logistics department at the buying enterprise.

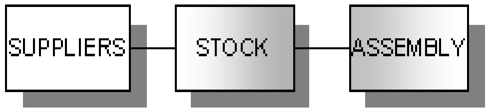
4.3.3 The Importance of Lead-time

Besides the ambition to reduce inventory levels, another competitive variable is the *lead-time*, which most often is referred to as the elapsed time from order to delivery (the order-to-delivery cycle). Important in the order-to-delivery cycle is also reliability or consistency of the lead-time. Sometimes it might be argued that delivery reliability is more important than the length of the order cycle since the impact of a failure to deliver on time is more severe than the need to order further in advance. Since long lead-times require forecasts for a longer time ahead, enterprises will

[79] Lambert D. M. et al, (1998), pp. 15 and p. 112-114
[80] Lambert D. M. et al, (1998), p. 114
[81] Christopher, M., (1998), pp. 151

continue to work with lowering the lead-times. The lead-time is crucial to handle since resources are being consumed and working capital need to be financed during this time. Therefore, when working with lead-times it is important to manage the total chain.[82]

4.4 From Stock to Assembly Line



In this section we present some ideas that we think are useful for managing the relationship between the stock and the assembly line, which is the customer in our case. In the preceding sub chapters we also concerned the role of the customer when the customer were viewed as the enterprise as a whole and some of these ideas are also applicable in this context.

4.4.1 Logistics Activities

Based on the key logistics activities mentioned when discussing the total cost concept (Chapter 4.1.2), we think that the two key logistics activities regarding this section are lot quantity costs and customer service levels.[83]

- *Lot quantity cost* regards material handling and procurement. The important thing with respect to material handling is that non-value-adding handling shall be eliminated as far as possible since also those activities incur costs.
- *Customer service levels* concerns customers service and return goods handling. It also involves getting the right product to the right customer at the right place, in the right condition and at the right time, at the lowest total cost as possible. Returns of goods can for instance take place because of performance problems for a part or component and are often very expensive.

4.4.2 Dependencies between Enterprise and Customer

Regarding the relation between an enterprise and its customer, that is in our case the logistics department (Chapter 5.4.1) and the assembly line (Chapter 5.3), the customer provides both opportunities to and restrictions on the enterprise. The customer can have very specific needs and demands on the products. This may require that the enterprise must consult the customer before changes in the material coming from the enterprise's suppliers can be possible to implement. The enterprise can also influence its customer in purchasing specific products so that economies of scale can be utilized.[84]

How to manage stock is dependent on whether the enterprise's production is driven by customer orders or not. The pull system means that the enterprise produces products when the customer demands it. In our case the line is the customer and thus the internal logistics function will provide parts when demanded by the line.

[82] Christopher, M., (1998), pp. 158
[83] Lambert D. M. et al, (1998), pp. 15
[84] Gadde, L-E et al, (2001), p. 76

Therefore the orders to suppliers and also the time of delivery are decided from the need of the customer. If an enterprise places orders and plans deliveries without direct regard to the customer, it is a push system.[85]

[85] Lambert D. M. et al, (1998), pp. 122

5 The Logistics System

In this chapter we present our empirical findings[86] by using a system structure (Chapter 3), based on seven elements[87]. Below is a schematic picture (Figure 5.1) of how we regard our system in the context of the systems approach (Figure 3.1). Our focus will be on the transformation process that we have divided in four parts; a general description of the process, the flow from suppliers to stock, the stock at enterprise and the flow from stock to assembly line. The way the system is divided into elements is done by us since Scania Production Angers (SPA) does not think in these terms, but our aim is to do this division as correct as possible in regards to the information we have collected.

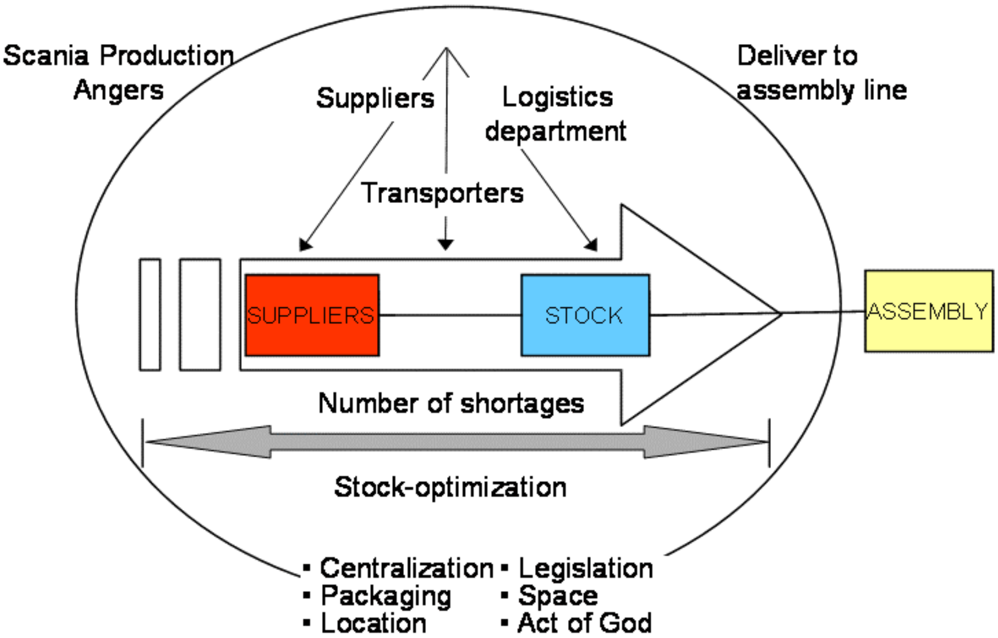


Figure 5.1, The logistics system.

5.1 Owner

SPA is responsible for delivering the trucks according to specification to its end customer. The enterprise is designed to fulfill its responsibility and the logistics system is a part of fulfilling this responsibility. SPA can be seen as the primary owner of the system with great interest in the systems function and performance and SPA

[86] The material presented here comes from interviews and discussions with people in the logistics department, from internal documentation and from our own observations at SPA.
[87] Owner, Weltanschauung, customer, actors, environment, performance measurements and transformation process.

also has the power to cease the existence of the system. SPA especially has the possibility to affect the stock and the assembly line.

5.2 Weltanschauung

The Weltanschauung with the logistics system is to deliver parts and components to the assembly line when needed. The flows within the system should have their starting point in the need of the customer and should be designed according to the demand stated by the customer. It is also stated that the system should meet these needs in a cost-effective way.

5.3 Customer

The system's customer is the assembly line at SPA. The system's top priority is to serve the assembly line with parts and components when needed. If the system fails in delivering to the assembly line, the system has failed its main objective. It is important to notice that the system decides the needs of the assembly line through the mixing[88] (Chapter 5.7.4), but the mixing shall be done in a way so the assembly line has a workload that is as smooth as possible. There is also an objective that the assembly line should receive pallets with a quantity that lasts for four hours of production.

The assembly line consists of clusters with 20 to 30 operators each. The total line is run with one fixed time, at Scania so called takt-time, which means that each cluster has to complete its contribution regarding parts and components to the unfinished truck within that time. Since the assembly line is seen as the customer of the system, all orders to suppliers depend on the assembly line's need. This need however completely reflects the need of the end customer and this need is in turn the base for the central mixing of trucks prepared in Södertälje two times a week. The central mixing determines what trucks that are to be assembled in Zwolle, Södertälje and Angers.

5.4 Actors

To be able to carry out the transformation process we have identified three main actors in the system: the logistics department at SPA, the suppliers and the transporters.

5.4.1 Logistics Department

The logistics department at SPA is responsible for the production sequence and planning, supplying parts and components necessary for the assembly process and the quality of parts from external suppliers and transport services. The logistics department is divided into functions that have the following defined areas of responsibilities:

- *Production planning*, which includes the mixing that is done twice a week.
- *Support and development* of the internal logistics service.

[88] The process of deciding in which sequence the trucks are to be assembled.

- *The material planning*, which includes placing orders to the suppliers, follow-ups on delivery and on suppliers' quality. Each material planner is responsible for about 30-50 suppliers and 200-300 parts and components.
- *Internal logistics*, which includes receiving goods, storing goods in the main store and delivering the goods from the store to the assembly line.
- *Coordination of transports* and follow up on the transporters.

5.4.2 Suppliers

There are approximately 245 suppliers in the system, of whom many are located in Sweden, and they have the responsibility to produce the specified amount of parts and components needed by the customer. The supplier has dedicated days, so-called pickup days, for when the parts and components can be picked up by the transporter and these pickup days varies on a supplier basis. It is the material planners at the logistics department who manage the relations with the suppliers. Every material planner has suppliers dedicated to them and thus a material planner handles all the contacts and flows for a number of suppliers. The relations with the suppliers are important for SPA and it has an action plan called *escalation model* for handling problems with suppliers. The main purpose with the model is that SPA helps the supplier to find solutions and helps it to establish action plans when it has problems with its deliveries.

5.4.3 Transporters

Which transporters to use are decided on a central level and when a supplier is contracted, the supplier receives information regarding which transporter to book for its transport of parts to SPA. The transport function at SPA has the overall responsibility for coordinating transports. The transports are usually made by truck, but if the transport is urgent, a so-called speed transport, it can also be done by plane. By using speed transports SPA can get parts delivered to the factory within 24 hours, but these transports are very expensive in comparison with ordinary transports. When using speed transports SPA and the supplier will agree on who should be responsible for the cost of the speed transport, that is sometimes speed transports are used because of faults on SPA's behalf and therefore SPA pays for the speed transport and vice versa.

The transporters vary on a country basis, except in Sweden and the Netherlands where there are two transporters present. When a transporter has been booked by a supplier the transporter has the responsibility to pick up parts and components at the supplier and deliver them on specified date and slot time to SPA. SPA has the responsibility of the goods as soon as the goods are picked up at the supplier.

5.5 Environment

There are many factors affecting the system that it must comply to but cannot control. We have included factors that cannot be changed within a near future and those factors that the system can affect but that are finally decided on at a central level within Scania.

- Scania is an enterprise with many centralized functions. For our system the *centralization* results in constraints regarding the suppliers and packaging. For most of the decisions that are on a central level, at least two of the three assembly plants have to agree. Since there is a centralized function for procurement, many of the suppliers are the same for the three assembly plants. Another environmental constraint that bears reference to Scania is the *location* of SPA, which has impacts on, for example, the distances to SPA's suppliers. Regarding the *packaging* Scania tries to find the smallest possible packaging corresponding to at least four hours of the average consumption for the three assembly plants and thus the packaging will be the same for all Scania's assembly plants. The reason behind having the same packaging is that it decreases the possibility for errors on the supplier side since the supplier always packs a part the same way and in the same quantities. Since the packaging is pre-defined it puts some constraints on the material planners since they must order parts in a multiple of the defined packaging quantity. This constraint does not affect the parts that are ordered in sequence.
- The *transports* of parts and components within the system put some constraints of the system. The legislation regarding heavy traffic differs between countries and has impact on which days transportation is possible and the system must take this into account when planning the expected day of arrival for consignments. Regarding the transporters it is also a constraint that several of the transporters are Scania's end customers.
- The system has a *limited space* for storing parts and components.
- Added to these environmental constraints there is also the *act of God* that can cause unpredictable disturbances.

5.6 Performance Measurements

There are many ways the system's performance is measured and they differ in level of detail. The overall performance measurement, from the customer's point of view, of the system's operations is the *number of shortages* per month, with the objective to have zero shortages.

The measurement of internal efficiency at the logistics department is mainly focused on *inventory levels* in stock and turnover of parts. To lower the stock level the material planners have a stock-optimization tool which can give suggestions on different parameters of the set up of a specific flow and which measures the material planners tied up capital in inventory on a monthly basis. The tool is supposed to be used by the material planners to give guidance regarding specific flows and to measure the total tied up capital in stock and not meant to be used as an evaluation tool on each material planner's performance.

For the suppliers, the measurements of most importance are that the goods are delivered to the transporter on time, that is neither late nor early, and that the quantity and quality is the requested. For the transporters the main performance indicators are that the delivery is on time, that the consignments are not damaged and that the consignments have the correct quantities of pallets.

5.7 Transformation Process

The transformation process of the logistics system can be seen as the procedure of filling the need of the customer, that is the assembly line. To do this the system uses its suppliers to produce parts and components, the transporter to deliver the consignments, the internal logistics function to store and deliver the pieces and components to the assembly line and finally the material planning function to order new parts from the suppliers.

5.7.1 General Description

The process from specification of a truck to delivered truck is schematically illustrated below (Figure 5.2). The process takes 27 days from that the customer has decided on the definitive specification of the truck until it is delivered to its first destination. When the specification is available to the logistics department, the day of production is decided through the mixing and necessary parts are ordered. To the internal suppliers, who all deliver components, the sequence is communicated so the components arrive on the correct day. Since the internal suppliers deliver on a pull basis, SPA has to order four weeks before all components and parts are needed. If the dedicated components for a truck have not been received within one day before the assembly of the truck is to start, the sequence will be changed thus delaying the assembly until the missing components have arrived. The total time for assembly of a truck is one and a half day. When the truck is assembled it goes through the final testing and there is a buffer for fixing deviations discovered during the testing process. When the truck is finished and passed through tests, it is finished for delivery. The truck is considered as delivered when it reaches its first destination, that is it may not be to the end customer but to a body builder for customization.

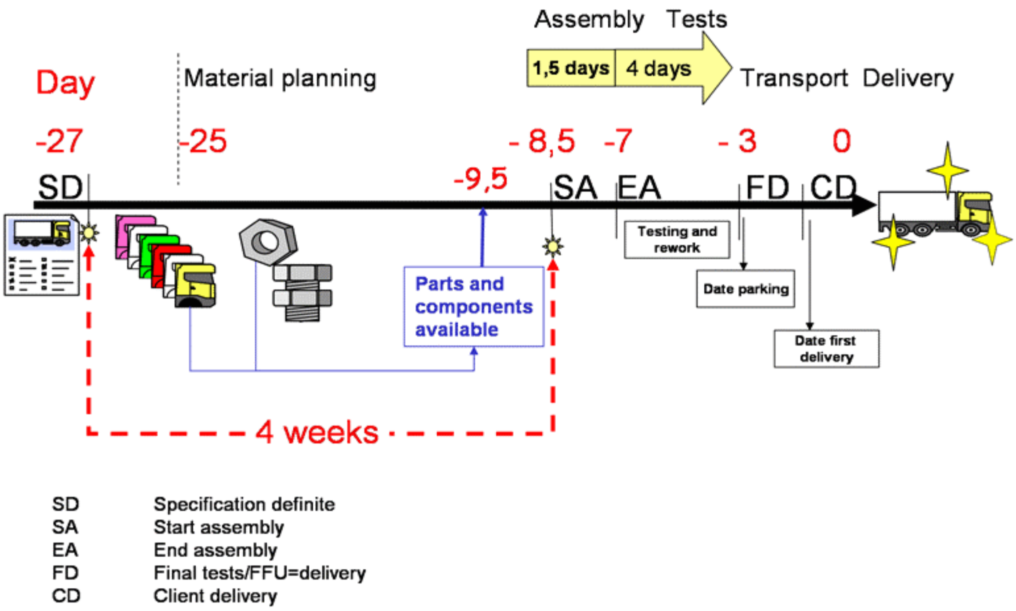


Figure 5.2, The time line from specification to delivered truck. (Source: Free from internal documentation, 2003-04-09)

We will now continue with a description of the flows of material and information from suppliers to stock, how the stock at SPA is designed and finally the flows of material and information from stock to the assembly line (Figure 5.3).

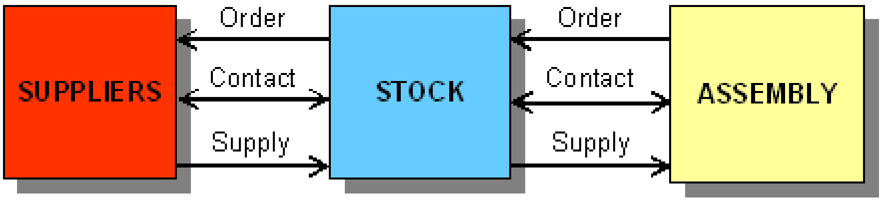
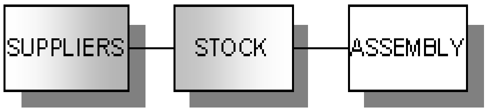


Figure 5.3, The transformation process.

5.7.2 From Suppliers to Stock



In this section we will first describe how orders are placed to the suppliers using different material control methods (MCM) and then how the parts and components are transported.

Material Control Methods

There are different MCMs used at SPA and the material planners have guidelines they should comply with when they decide on MCM for each of their flows.

Sequence

Components and parts delivered in sequence are already, at the supplier, dedicated for an individual truck at SPA. When the mixing has been done the material planners know what chassis are to be made and they can place orders on the sequenced components and parts. SPA uses the *sequence* MCM for components that are expensive, big and available in many variants. The sequence of assembly is communicated to the supplier so that the sequenced parts are delivered to SPA in the correct order. The sequenced components are visually buffered so that deviations are easily detected.[89] The components are delivered and placed in buffer one day before the assembly of the dedicated truck starts.

Kanban

For parts with high and regular consumption, the *Kanban* MCM is used. There is also a directive from Scania that as many flows as possible should be Kanban flows. When a Kanban-bin has been consumed by the production, a signal is sent to the stock system. At SPA the registration of Kanban cards are done during the day but the call-offs are accumulated and only done once a day. The Kanban-loop consists of a pre-calculated number of Kanban cards.[90] At SPA the Kanban loops are modified, for

[89] Scania, (1998), Standard STD4172, Issue 1, pp. 6
[90] Scania, (1998), Standard STD4172, Issue 1, p. 12

instance due to holidays, so that there is always two days of safety stock present to cover external disturbances of the flow.

Re-order Point

For low value parts, such as nuts and bolts, SPA uses an automatic *re-order point* as MCM (Figure 5.4). When using this method SPA defines a stock level, called re-order point, for a specific part. The stock level is decided by the total lead-time from order to arrival at SPA. When this stock level is reached SPA's system automatically sends an order to the supplier.[91] When using this MCM the material planners has the responsibility to check the system so that orders are placed according to the correct re-order point. The material planners are also responsible for that the stock levels in the system correspond with the actual stock.

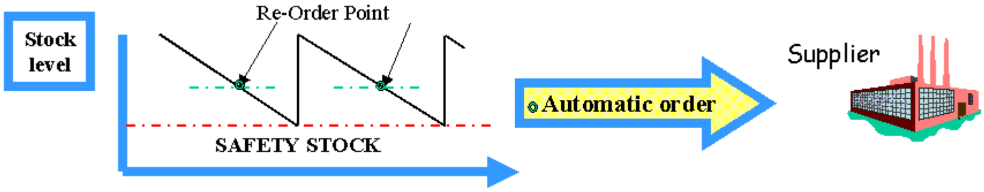


Figure 5.4, The re-order point MCM at SPA.

Batch

The *batch* MCM is used for parts with irregular consumption and low unit price. The total requirement is calculated from a long-term prognosis that spans over nine months and the requirements that can be calculated from the mixing. The net requirement is calculated by subtracting the actual stock level of the part and is then ordered from the supplier.[92]

Transports

Most of the material transported from the suppliers is packed either on a EUR pallet or on a half EUR pallet. The small box (SB) and mini box (MB) are also transported on EUR pallets. In the case of the SB it must be two boxes present on each half pallet to make it stackable. The same principle is used for the MB, but it must be four boxes present on each half pallet.

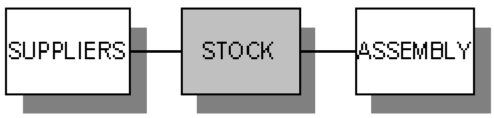
Transports by *full truckload* (FTL) are done for all the supplies from internal suppliers and other parts are sent with *less-than-truckload* (LTL), FTL or transported via a cross-docking terminal. When the parts are transported by FTL a pre-defined price is used. For transports with LTL the tariff is calculated by *weight*, space in *cubic meters* or *load meters* and there is also a minimum tariff. One cubic meter is recalculated to about 300 kg and one load meter to about 1900 kg. For example if a

[91] Scania, (1998), Standard STD4172, Issue 1, p. 15
[92] Scania, (1998), Standard STD4172, Issue 1, p. 17

consignment weighs 160 kg but needs one cubic meter of storing space, SPA is charged for a consignment with the weight of 300 kg, since the transporter chooses the most profitable calculation of the freight weight. The price is defined in certain *weight ranges* and the price per 100 kg is commonly lower the higher the weight range. In some cases the weight range corresponding to the weight of the consignment is not used.

Example:
The logistics department wants to deliver two consignments the same distance where the first consignment weighs 4800 kg and the second consignment weighs 5200 kg. The transporter has two weight ranges corresponding to the weight of the consignments. The first consignment is in the weight range 2500-4999 kg and the price per 100 kg is 7 €, therefore the price for the transport of the consignment will be 48*7 = 336 €. The second consignment is in the weight range 5000-6999 kg and the price per 100 kg is 5 €, therefore the price for the transport of the consignment will be 52*5 = 260 €. In this case the price for the lighter, first consignment, will be higher than for the second consignment. To avoid this the transporter will calculate the price on the first consignment in another way. The transport cost will be calculated with the next weight range's price, but the lowest weight in this range will be used instead. That is, the price for the first consignment will be 50*5 = 250 €.

5.7.3 Stock at Enterprise



In this section we will explain what happens after a transport has arrived at the gate at SPA and until the incoming goods are stored. We will also explain how the stock is managed.

Goods Arrival

When a truck arrives at the gate the personnel feeds information regarding what has arrived into a system that gives real time information for the material handling personnel. At the moment a new system, called *Webstars*, is under development. Webstars shall be connected directly to the suppliers and the transporters so the transporter at the pickup sends information to SPA regarding what it has picked up. In Webstars, parameters such as the real weight, pay weight, volume and load meters regarding the consignments will be registered. The aim with Webstars is to control the material flows and to increase the communication between suppliers, transporters and SPA.

When an arrival to SPA is accepted, the transporter continues to the reception and gets information regarding where to unload, which depends on what goods it is. The consignments are then checked and if there are any transport deviations these are reported to the system that updates the current stock levels. Thereafter the pallets are marked with a sticker that shows the pallet's store place. Every fourth months the color of the stickers is changed with the aim to visualize low demand parts to be able to work on it. When the pallets are marked with the stickers they are distributed according to packing store place. The principles for storing takes place according to packaging and line consumption, except for components that have certain buffer zones. Some goods have to be repacked before they are placed in the store. The repackaging is mainly done to avoid having parts stored at the line for too long time.

Stock Management

In the warehouse at SPA there are no visual signs of lack of space and the logistics department works continuously to lower the stock. The reasons behind this are to lower the costs for tied up capital, but more important is to have space available for future demands, for instance when new parts are introduced. SPA has succeeded at its work with stock in the meaning that the stock level today is lower than it was before the optimization began (Figure 5.5).

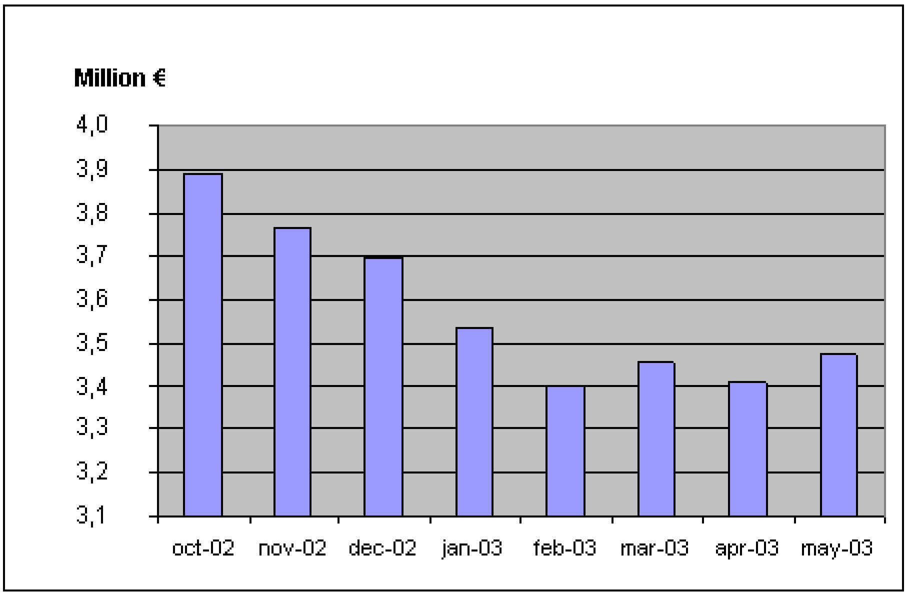
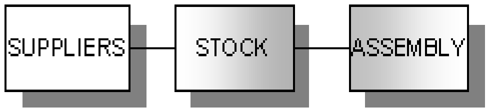


Figure 5.5, Tied-up capital in stock. (Source: Suivi evolution stock, internal document, 2003-04-22)

SPA has two types of safety stocks, one safety stock to absorb *internal* disturbances and one safety stock to absorb *external* disturbances. To absorb internal disturbances SPA has the general rule that it should have at least two days of consumption available. To absorb external disturbances SPA considers the total lead-time from the supplier to the stock and the combined performance of the supplier and transporter. That is, if the supplier and transporter were 100 % reliable there would be no safety stock for external disturbances. This is however not the case and for most of the flows there is at least two days of safety stock for external disturbances, irrespective of the supplier’s and transporter’s performance. On the whole there is at least a total of four days of safety stock.

5.7.4 From Stock to Assembly Line



In this section we will describe how the production sequence is decided, how the assembly line demands components and parts and also what methods there are for supplying the assembly line.

As mentioned above, the assembly line is seen as the customer and therefore all orders to suppliers depend on the assembly line's need, which means that there is a pull flow inside the factory. The assembly line is therefore not fed with parts and components until there is a need on the assembly line, that is when a certain truck is to be assembled. Together with the information from the mixing about what trucks to assemble in each factory, specifications for each truck are also sent. When the logistics department receives this information, it does its own mixing to decide about in what order the trucks are to be assembled. For the decision about in what order to produce there are ten different rules to smooth the workload on the assembly line, for example one rule that affects the mix of trucks is number of axles. The most important factor in the mixing is however when the truck has to be finished so it can be delivered on the agreed time to the end customer. First a computer program does a proposal of the mix and thereafter it is checked and changed manually, a procedure that takes about half a day to complete. When the mixing is finished, the next step is to check what parts there are in stock and what parts to order. Regarding the components they are ordered in sequence. Further information regarding placements of orders to the suppliers is described in the section regarding the flow between suppliers and stock (Chapter 5.7.2).

Between the assembly line and the stock there are mainly three different methods to handle deliveries.

- The first method is *sequence* and concerns components such as cabins and fuel tanks. Information about when to deliver the components to the line comes from a system which also shows if there is something wrong on the assembly line and if the sequence has to be changed.
- Then there is the *two-bin principle*, which means that there is a pull system according to real line consumption and when there is an empty bin at the line, there goes a signal via bar code to the system that manages the stock level. This system then sends a signal to the stock order treatment and material handling so that a new bin is supplied.
- The third method is *line feeding* where there is a so-called *milk run* that delivers small parts with predicted consumption directly to the line.

When a pallet is delivered to the line the parts are regarded as consumed, thus the parts on the line are not regarded as stock. The different types of packaging for the line are full pallet, half pallet, small box (SB) or mini box (MB).

6 Mappings

In this chapter we present information collected from the three mappings we have performed. The criterions used in the mappings are presented in our research process (Chapter 2.2). We will not present all findings from our mappings here, since this information is available in the appendix (Appendix 1-11). In our analysis and application of model we will refer directly to the appendix when we find it appropriate. The aim with the first mapping was to select countries for further study, in the second to select suppliers and in the third to select specific flows to examine in depth.

6.1 Mapping 1 - Selection of Countries

The first mapping was mainly performed to get a picture of SPA's situation regarding frequency of deliveries and costs for material and transports. What we found during this overall mapping was that it is very difficult to trace the transport cost for a certain delivery and therefore also to a specific part. The reasons for this are several:

- The transport invoices are only sent to SPA a few times per month and therefore contain a large amount of delivery dates, which makes it difficult to see what cost is related to what delivery and part.
- SPA has several different transporters, whom both deliver incoming goods and take care of returning flows with packaging.
- The connection between what a certain delivery contains and what SPA has paid for is very difficult to see.

Currently SPA is working on retrieving information on computer media, regarding transport costs from each transporter. This work has resulted in that SPA has received information regarding only one transporter in one country, since most of the transporters are not willing to give this information to SPA. Regarding the cost involved when making call-offs, we have understood it as it is not entirely clear how it works and it also seems to differ in some ways. For instance it seems that there is a cost every time a material planner puts an order to the supplier even if this is done several times a day. If we see indications of this in our flows, which will be selected in mapping three, we will investigate this further.

When searching for information regarding transport costs, we found that SPA pays a lot of money for handling of returning flows with for instance packaging and it is rather common with trucks arriving empty at SPA only to collect packaging. This will however not be investigated further since we have chosen only to examine flows *to* SPA in depth (Chapter 1.6). We also found that there often is a big difference in actual weight and the pay weight, which results in large cost for transports for SPA. When investigating specific flows we will discuss this problem further.

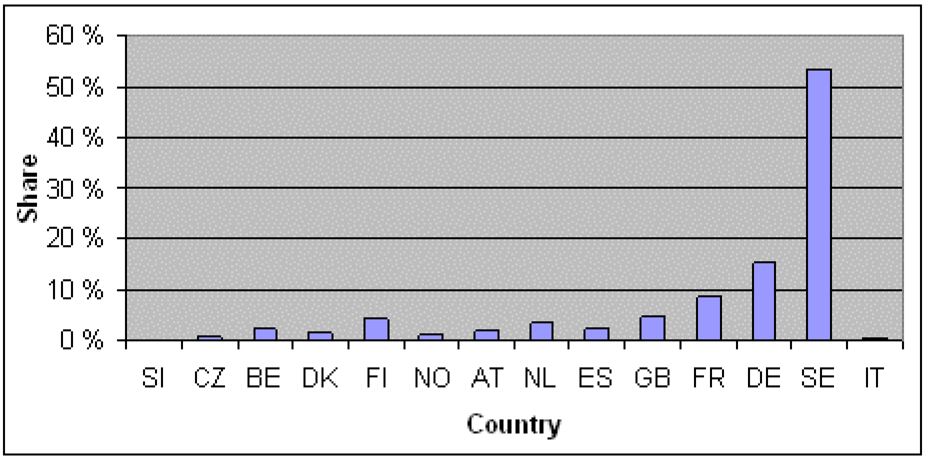


Figure 6.1, Share of all deliveries in January.

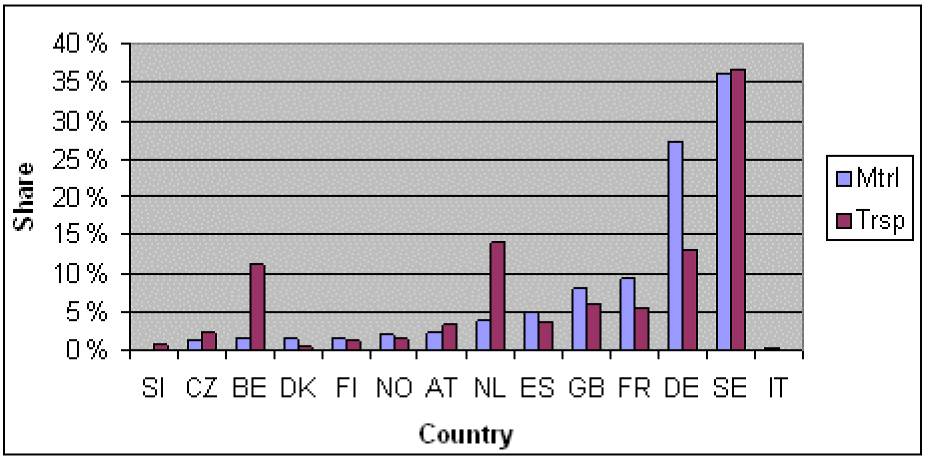


Figure 6.2, Share of material and transport cost for January.

The result of this mapping is visualized in the two diagrams above (Figure 6.1 and Figure 6.2). In broad outline it seems that the material flows from most of the supplying countries are working well and that they are relatively optimized. This is mainly true for countries with several deliveries and high material costs. For smaller flows the ratio between transport costs and material costs is very high and this is mainly the situation for flows from Belgium and the Netherlands. The explanation to this is that the material cost arises in another country than the transport cost. This situation can occur if a supplier delivers parts to a sub-supplier located in another country, which for examples paints the parts and then delivers them to SPA.

From this first mapping we identified four countries to examine further. We picked the four countries that represented the biggest share of deliveries to SPA together with the biggest share of material and transport costs, that is Germany, France, Sweden and England.

6.2 Mapping 2 - Selection of Suppliers

The second mapping was done to see what costs that are related to specific suppliers in the countries chosen from the first mapping. The main objective of this mapping was to generate enough information to be able to choose suppliers for further investigation. During this mapping we also visited one supplier and one transporter to achieve further understanding of how they work.

By just looking at the numbers presented in the overview of mapping 2 (Appendix 1) one can see that there is great variation in the ratio between transport costs and material costs. There are many parameters hiding behind the numbers and the ones that we have found are as follows:

- *Minimum charge is used*. From some of the invoices we can clearly see that there are many transports that have been charged with the minimum charge. That is, many of the consignments are so small that the price of transport is not based on the actual size of the consignment but on a minimum charged defined by the transporter. It is evident from the invoices and packaging lists that if a transporter has received two orders to pick up two consignments at the same time at one supplier, the consignments will be weighted individually and invoiced as two separate transports. For example, if a supplier has ordered transport for two consignments on two pallets with the weight of 80 kg each and the minimum charge is defined at 100 kg the transporter will invoice for two consignments with the weight of 100 kg each. If the supplier instead had put an order for the transport of one consignment of two pallets, the transporter would invoice for the transport cost for 160 kg.
- *Not optimized packaging*. From the invoices can also be seen that there are consignments arriving in small box (SB) or mini box (MB) but SPA is charged for the volume of one ordinary EUR-pallet due to the way the boxes are stored on the pallet. The outcome of this is for instance that SPA receives one MB with parts and three empty boxes but pays for the transportation of four boxes. The way of packaging is further described when presenting findings regarding transports (Chapter 5.7.2).
- *Weights of consignments are unfavorable in relation to weight ranges*. It was not until we started to study the actual invoices that we understood which great impact the price setting in weight ranges has on the transport cost (Chapter 5.7.2). As one can see in the diagram over transport costs from one transporter in Sweden (Figure 6.3), the way that the transport cost is calculated results in that the cost for transporting 1300 kg is the same as transporting 2500 kg. What we also saw during this mapping is that many transports have a weight around one to two tons, but with almost the same price for the transports.

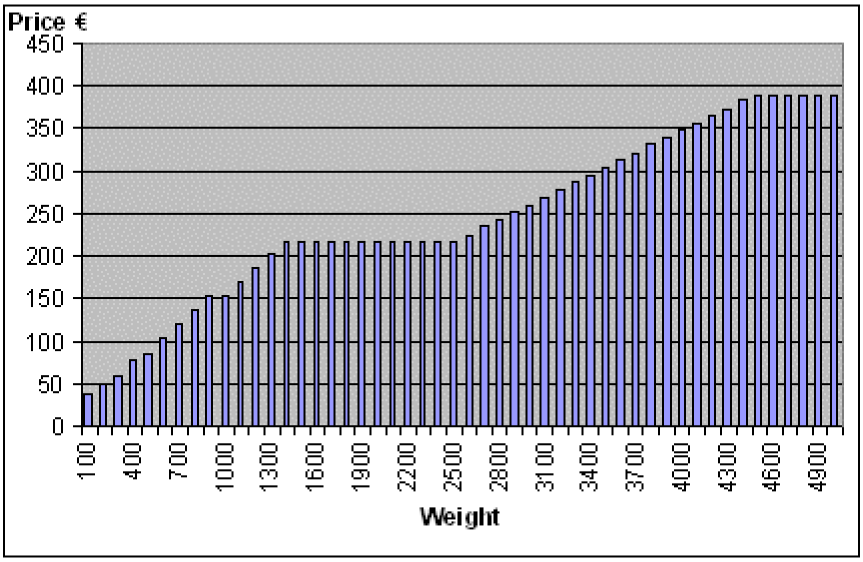


Figure 6.3, Cost for transport. (Source: Extract from freight tariffs Sweden)

6.2.1 Supplier and Transporter Visit

The supplier we visited supplies metal parts to Scania and about 25 % of its turnover is related to Scania. SPA places orders four times per week and has the same amount of inbound transports per week. Regarding the cost involved when making call-offs, we found that it makes no difference for SPA to place one order or several orders per day since there is no additional cost related to the placement of orders. The set-up time for the machines varies from 30 minutes to two hours, therefore the supplier runs a machine for at least six hours to be able to produce batches that are big enough from an economic perspective. Scania orders over 20 different parts from the supplier and the supplier has a dedicated warehouse for Scania with a stock level for two to four weeks of deliveries. This is also precaution from the supplier because it is aware of the great costs that arise at Scania if it cannot deliver the requested parts.[93]

The transporter we visited is responsible for the transports to SPA from suppliers in France. We visited the cross-docking terminal located about 85 kilometers from SPA. Most of the transports from suppliers in France arrive to the terminal during the evening, are cross-docked, and then transported to SPA the following morning. This procedure is done every working day. After discussions on different types of improvements of the flow, the transporter agreed with us that a simple optimization of the transports would be to transport larger consignments, thus having fewer pickup days at the supplier. In the terminal the transporter also has a warehouse used for third party logistic solutions for other customers. According to the transporter, it is not possible for it to coordinate transports from the suppliers situated close to each other, that is the transports are done with different trucks. The reason to this is referred to as

[93] Lamourette, C., Quality Responsible, Supplier J, 2003-03-25

that the truck would not manage to reach the suppliers in time for the pre determined pickup time.[94]

The result from this mapping was information regarding a number of suppliers that should be used when deciding on specific flows in the third mapping (Appendix 1).

6.3 Mapping 3 - Selection of Flows

For this mapping we chose specific flows of parts from the suppliers studied in mapping two (Appendix 2). When studying the stock levels of the parts, we found that the levels are higher than four days and in some cases they are up to ten days of consumption. In this calculation the parts on the assembly line is not regarded and this level can vary between four hours up to several days of consumption, depending on packaging and consumption. Here we will present a short description of what we have found regarding each material control method (MCM) (Chapter 5.7.2) and then each flow. For each flow we have collected information regarding for instance MCM, packaging, daily consumption and order quantity. The complete data regarding our findings for each flow is to be found in Appendix 3 to 11, were we give some comments on what we find of greatest interest for each flow.

6.3.1 Re-order Point

We have only studied one re-order point flow and therefore it is difficult to give any general commentaries on this MCM. For the studied flow we have however found that speed transport has been used and that the cost related to that is essentially higher than for an ordinary transport.

Supplier A

The part we have studied from Supplier A (Appendix 3) is a plastic pipe roll, which is transported on an ordinary EUR pallet with four collars. We have had problems finding both CMRs and invoices for these transports. This supplier delivers seven different parts to SPA and five of them are batch flows and two are re-order point flows. The number of deliveries is almost the same for all of the parts, except for one that is very high compared to the other.

6.3.2 Batch

For the batch flows we have found that they in most cases are not optimised regarding order quantity and frequency of deliveries. In some cases the difference between real weight and pay weight are substantial, which depends either on that the next weight range is used or that the consignment is charged on volume. For most of the batch flows there are several pickup days per week.

Supplier B

The flow from Supplier B (Appendix 4) is a small flow with only three pickups during January. The parts are packed in a MB, which is loaded on a pallet for transportation. For this part the volume of the pallet will be used for calculating the

[94] Prince, A., Manager, Transporter D, 2003-03-26

transport cost since it is a lightweight part. This supplier delivers twenty different parts to SPA, where two are Kanban flows, one is a re-order point flow and the rest are batch flows. The Kanban flows have the same number of deliveries and there are also several batch flows with the same amount of deliveries. There is also some batch flows with very few deliveries.

Supplier C

Supplier C (Appendix 5) delivers cable flutes on a regular basis. For this part we could not retrieve information on the real weight of the consignments from the CMRs, but since the transport cost was calculated on the volume and we know the volume of the pallet, the correct cost for this part could be calculated. From this supplier the batch MCM is used for all parts. The supplier delivers eight different parts and several of them have the same number of deliveries.

Supplier D

Supplier D (Appendix 6) has had economic problems during the autumn and SPA has worked a lot with it to secure its supplies. Earlier this flow was a Kanban flow, but since Supplier D has had problems SPA has changed the MCM to batch to be able to build a safety stock. The build up of the safety stock is also the explanation to why there are so big order volumes during the beginning of the year. The cost of deliveries has both been calculated on volume and in some cases on load meters. The calculations on load meters should only be used on calculations on transports of non-stackable consignments and since this is not the case the transports have been incorrectly invoiced. This supplier delivers seven different parts to SPA and now all of them are batch flows with the same amount of deliveries for several of them.

Supplier E

Supplier E (Appendix 7) delivers batteries to SPA. The batteries are heavy to transport and the price calculations are based on the weight of each delivery. The delivered quantities vary quite a lot but one must bear in mind that there are always 21 batteries packed on every pallet and hence the material planner can only order in multiples of 21. The transport cost of three or four pallets is the same since the weight of the transports are close to the next weight range. There are three batch flows from this supplier and the number of deliveries is very uneven, but for two of them quite low.

6.3.3 Kanban

The Kanban flows that we have studied are from suppliers far off and the transport time is three days for all of them. The flows are also uneven regarding order quantity. For two of the flows studied there are five pickup days per week and for one of the flows there is only two.

Supplier F

From Supplier F (Appendix 8) we studied a flow of silencers. Silencers are quite big parts that are not transported on the usual EUR pallet but on a wider and longer pallet. The transport costs are quite even with no big differences regarding how many parts are transported. The flows in the beginning of the studied month are quite uneven which can be explained by holidays at the supplier. When holidays occur the material planner must make changes in the Kanban-loop, which causes a disturbance of the flow. From this supplier three parts are delivered using batch and one using Kanban. The number of deliveries to SPA varies quite a lot and there are some batch flows with few deliveries.

Supplier G

The flow from Supplier G (Appendix 9) is quite even and the transport cost is always based on the weight of the consignment. In some of the deliveries there is a higher pay weight than the real weight. This is a consequence of that the weight specified on the CMR is not equal to the weight specified in the invoice. Unfortunately we have not found any explanation to why it is in this way, but the weights do not differ so much that it has a great impact on the transport cost. This supplier delivers four parts to SPA, one using the MCM Kanban and the other three using batch. The batch flows are quite even regarding number of deliveries.

Supplier H

The flow we have studied from Supplier H (Appendix 10) is a flow of clamp pads. The flow is quite even except the first order, which is quite big to compensate for low stock levels due to holidays. The transport cost for this part varies due to that the part is transported with other parts thus making the consignments bigger and less expensive in some cases. From this supplier there are two Kanban flows and one batch flow and they have almost the same number of deliveries.

6.3.4 Sequence

We have only studied one sequence flow, and as in the case for re-order point, it is therefore difficult to give any general comments. What we have found is however that this sequence flow in several cases works well with regard to packaging, but that the racks that it is packed in are not always full. The same packaging is used for most of the other parts delivered from this supplier.

Supplier I

The flow from Supplier I (Appendix 11) is a flow of side skirts for the right hand side of the truck. The packaging for this part is variable, that is there does not have to be a specific amount of side skirts on each pallet, but there can be a maximum of eight side skirts per pallet. The supplier has different types of side skirts and they must be delivered in the correct sequence and therefore there can be a mix of different types of side skirts on each pallet. The flow is quite uneven and the transport cost differs quite a lot between the deliveries. This supplier delivers five parts to SPA and four of them are Kanban flows and one is a batch flow. The different parts have almost the same number of deliveries.

7 Evaluation Model

In this chapter we describe our perception on how the logistics system should work, divided according to the elements we have used for the system. Since what happens in one part of the supply chain often affects another part, the same issues often have to be considered and we will therefore not divide the transformation process in the three parts as before.

7.1 The Structure of the Model

The basis for our thoughts, regarding what is important to include in the model, both bear reference to the theory chapter (Chapter 4) as well as to our thoughts that has been formed during our empirical study (Chapter 5 and 6). Our intention is that the model shall be used as a basis when evaluating the system. There are probably additional parameters for each element that could be interesting to evaluate, but we have chosen parameters that we consider appropriate in our case.

For each element we present parameters that we find vital for the system to work in an appropriate way. For each of these parameters we have defined a goal. When the goals are achieved for each element, the system works well. According to us, most of the reasoning regarding the element Weltanschauung and owner is well in line with the discussion regarding the customer, but will still be presented as separate elements to clarify the structure.

7.2 The Model

Owner

- The owner should show *interest* in all the parts of the system. **Goal**: Have an active dialogue with the actors in the system to create an overall understanding of how the elements contribute to the system's performance.

Weltanschauung

- The Weltanschauung should be clear, but possible to change. **Goal**: If the Weltanschauung is not synchronized with the system's abilities, find solutions to this by altering the system, the Weltanschauung or both.

Customer

- The customer's *demand* is of most importance, but there should also be a consensus between the demands and what is efficient for the system. **Goal**: The customer can agree on solutions suggested by the selling enterprise.

Actors

- The logistics should be *effective*. **Goal**: Both internal and external flows as well as the five costs are regarded (Chapter 4.1.1).

- The *communication* between the actors, the customer and the owner should work well. **Goal**: Information and knowledge is available for all parties and there should be standardized ways of how to communicate. Ideas on how to work come from various sources.
- The *relations* with the actors are of key importance. **Goal**: The relation should be, at least, so good that all actors are trusted to live up to stated directives, thus no verifications that these directives are followed should be done. If one actor identifies a possibility of improvement, it should be communicated to the concerned actor.

Environment

- The environmental *constraints* are identified and evaluated. **Goal**: The system has found ways to work efficient within these constraints, thus minimizing the negative effects and utilizing the possibilities of the constraints.

Performance Measurements

- *Internal* performance measurements should have focus on the internal process. The measure should be an aid in optimizing the internal process. **Goal**: The measure is comparable from one point in time to another and should reflect the possible performance changes in the process.
- *External* performance measurements should have focus on the outcome of the internal process. The measure should be designed to be comparable between concerned units. **Goal**: The concerned units do not feel they have to tamper with the measure so the measure shows the "correct" picture.
- *The purpose of a performance measure* must be thought through to minimize the risk of sub-optimization. **Goal**: The consequences of the measure are regarded.

Transformation Process

- *Non-value-adding* activities should be identified and eliminated. **Goal**: There is a continuous work with identifying and eliminating non-value-adding activities. The elimination of the activity should be of importance for the total performance.
- There should be procedures as aid when deciding on material control method (MCM) but no directives. The flows should be treated *individually* when deciding on MCM. **Goal**: The material planner shall not see any point in using another MCM.
- All the actors should be *involved* in the work of finding and executing cost-effective solutions and all actors should share the gain of improvements. **Goal**: Ideas on solutions come from all the actors. Actors communicate ideas that another actor gains from.
- There should be a *balance* between warehousing- and transport costs. **Goal**: The transport costs should be compared to the cost of holding inventory in stock.
- Stock levels should be easy to *verify*. **Goal**: Visualization of stock levels and dedicated storage for parts and components.
- The stock should be a utility for *adapting* the needs of the assembly line to cost effective solutions for the transformation process. **Goal**: There is a demand driven

flow from the stock to the assembly line. The material planners plan orders according to a longer time horizon.

- Stock levels should *correspond* to the consequence of stock outs and the performance of the transporter and supplier. **Goal**: A situation where stock levels are as low as possible without the occurrence of stock outs. A part is regarded as stock as long as it is not consumed.

8 Analysis and Application of Model

In this chapter we analyze our empirical findings based on the evaluation model (Chapter 7), that is based on seven elements[95]. In the analysis we refer to the model only the first time an evaluation parameter is introduced. Many of the sections in this chapter will be used as a base for our work method, but often the reasoning in this chapter is on a higher level of detail compared to the description in the work method. The transformation process is divided into three parts; the flow from suppliers to stock, stock at enterprise and the flow from stock to assembly line.

8.1 Owner

We find both the elements owner and Weltanschauung quite difficult to analyze to a greater extent, but our perception is that they are important to have in mind.

SPA is both interested in that the assembly line's demands are fulfilled and that the system works in an efficient way. Faults in the system that are so great that the assembly line's need cannot be met, that is the assembly line does not receive the parts needed, have a big impact on SPA's overall performance. Therefore we think a balance between efficiency and meeting the assembly line's need must exist. We think that SPA must consider this balance and communicate with both the logistics department and the assembly line since SPA can decide over both parts (Chapter 7.2, first owner parameter).

8.2 Weltanschauung

We think that the Weltanschauung of the system should be slightly altered. The system should be designed to meet the needs of the assembly line, but these needs must be synchronized with the whole system so that the transformation process can work in an efficient way within the whole system (Chapter 7.2, first Weltanschauung parameter). If there is a consensus between the demands and what is efficient, we think that the risk of sub optimizations can be reduced.

8.3 Customer

The assembly line's demands have impact on how the system's work is carried out and the system's main objective is to deliver the correct amount of parts on time to the assembly line. SPA regards the assembly line's demands as demands that the rest of the system should comply to. The problem with this approach is that the system is obliged to live up to the service stated by the assembly line and do this at the lowest cost possible. We see the assembly line as both a source for demands and possibilities and in this case only the demands are regarded. To be able to utilize the possibilities, for example to lower costs, we think that the implications the demands of the assembly line have on the system must be regarded (Chapter 7.2, first customer

[95] Owner, Weltanschauung, customer, actors, environment, performance measurements and transformation process.

parameter). We have got the perception that SPA wants to, in an even greater extent, focus on the demands of the assembly line and we think that this is a move in the wrong direction. The assembly line demands that it should only have four hours consumption of parts on the assembly line. This can result in parts delivered in mini boxes (MB) or small boxes (SB) to the line. This will, according to us, have one of the following implications on the system:

- The system orders the parts in the packaging needed by the assembly with the risk of paying for empty boxes (Chapter 5.7.2).
- The system orders the parts in the correct packaging but in larger quantities, thus storing extra boxes in the warehouse.
- The system orders the parts in standard pallets and then re-packs the parts on arrival at SPA into the correct packaging (Chapter 5.7.3).

We think that SPA must consider these consequences and maybe it is not such a big problem for the assembly line if some parts are delivered in bigger quantities and different packaging than demanded, if it reduces non-value-adding activities such as re-packing.

8.4 Actors

We have chosen not to analyze the individual actors, but instead the respective actor's relation to SPA since we consider that the relations are of vital importance for the system.

8.4.1 Relation to Logistics Department

A result of a low cost strategy can be that it only leads to efficient and not effective logistics (Chapter 7.2, first actors parameter). We see this as an interesting area of discussion in the case of SPA, since this to a certain extent is what our problem formulation is based on. Our overall perception is that a lot of work has been done regarding the internal flow and it also seems to work very well. The problem we have noticed is mainly lack of knowledge about what influences different activities in the supply chain regarding material flows. For the whole system to work well, that is all parts are considered so sub optimizations are avoided, and to be able to identify areas of possible improvements, it is important that the communication between functions and departments works satisfying.

When collecting data regarding what happens between the suppliers and SPA we have found that it today is very difficult to see the connection between a transport invoice and a delivery note. It is therefore not an easy task for SPA to increase its information regarding what it actually pays for. This is therefore an area where we see a clear potential for improvement both regarding the outcome and for the communication between the departments (Chapter 7.2, second actors parameter). The outcome should, based on our perceptions, be that deliveries to SPA should be further coordinated and probably more optimized regarding order quantity. Especially from our third mapping we have found good examples of material flows where the order quantity could be changed and still give rise to the same transport costs, as in the case of Supplier E (Appendix 7). For the material planners to be able to examine their material flows, this information has to be easily available.

Regarding the communication we think that there is a lot to gain from increased exchange of knowledge regarding for instance what actually is behind transport costs. Since the case today is that the logistics department and the financial department have different responsibilities regarding transport costs, we think that increased exchange of knowledge could make it easier to discover errors. During mapping three, regarding Supplier D (Appendix 6), we found that SPA had been incorrectly invoiced for a transport and this had not been noticed. In this case the wrong parameter for deciding on transport cost had been used and this is nothing that the financial department checks before is pays and it does not either have enough knowledge on how it works. According to us, having a number that connects an invoice to a delivery note, so that it is possible to see what is actually in a transport and to examine what SPA pays for, at least partly could solve this problem. Another solution could be to use Webstars as a way of communicating and making this kind of information available both to the logistics- and the financial department. For instance when an invoice is received, there could be a number that directly links it to a consignment and the information available on the invoice could be entered into Webstars. By working this way we also believe it could be easier to perform follow-ups that is of interest for at least these two departments.

Our perception is that the communication between different *functions* within the logistics department works very well and also the documentation, which means that knowledge regarding different areas easily can be exchanged. Since the communication within the department works well, this probably also enables for identifying more areas of improvements, as there is an understanding of how other functions work. We also see these functions as more dependent on each other than the different departments are, since each of them are responsible for a part of the logistics. This is also how we think it should work between *departments* since people working in one area often have ideas of what could be done in another way and therefore those ideas should be made use of and further communicated. By increasing the communication between departments we think that a further understanding of what is behind for instance different types of costs could be enabled.

8.4.2 Relation to Suppliers

Which suppliers SPA has is to a large extent decided on a central level and we see several consequences of this in how SPA plans its different functions and its work. The fact that the three assembly plants have many suppliers in common results in, viewed from a relationship perspective, fewer suppliers and relations seen from a total network perspective. We think that this is good since Scania, and its three assembly plants, easier can collect important information regarding each supplier and different flows. Since Scania in several cases orders parts from the same suppliers for its three plants, Scania also becomes an even more important customer and therefore improves its position in relation to the supplier. This can result in economies of scale, an improved relationship and an increased possibility to influence the work of the supplier and therefore the performance of the supply chain as a whole. A great dependence on one customer does not always have to be good, for instance if the customer for some reason changes its demands or goes bankrupt, since this has a great influence on the supplying enterprise.

Since we have not identified any remarkable changes in what SPA demands from its suppliers and since we think this also is the case for the other Scania assembly plants, we consider it being good for a supplier to invest in a relation with Scania. With respect to transport costs, it might however not be the best situation for SPA to have the same suppliers as the other assembly plants since this has great effects on the transport costs due to the distance. It can also mean difficulties for SPA since it becomes difficult for it to for instance change suppliers and packaging and this could mean worse conditions for SPA and that it cannot work as desired. The use of the same suppliers could also make it more difficult to understand how the supplier-customer network works, which makes it even more important to have well working ways of communicating. However, we see that the use of the same suppliers makes it easier to find standardized methods to communicate and for handling of goods. We consider Webstars as one way of making it easier to provide the parties with information. A benefit from using standardized methods for communication is that it can make it easier to coordinate incoming goods from different suppliers (Chapter 4.2.2). This is something that we think can be of interest for SPA since several of its suppliers are far off and since SPA has many daily deliveries.

Another reason to why it is important that the communication between the parties in the supply chain works well, is that the performances of all the parties in the supply chain have a decisive influence on the final quality of a product. Through a well working communication system it is easier to inform different parties of the present situation and if there are any problems they should be solved right away. Therefore it is also important for the suppliers to create an environment in relation to their suppliers where communication is encouraged so problems can be detected as early as possible. We therefore see communication as one parameter that is essential to examine when considering the suppliers' role with respect to how well the supply chain works. It becomes even more important that the information flow works well when an enterprise wants to have low stock levels, at the same time as it wants to secure its production, as is the case for SPA. Our overall perception is that SPA cares for its relations with the suppliers and that the relations work good. Our perception is also that the suppliers in most cases have understood how important they are for SPA and that they want to live up to the requirements SPA has on them (Chapter 7.2, third actors parameter). We think that SPA has succeeded at creating an environment with mutual investments in the relation, partly through their so-called escalation model where SPA shows its willingness to help the supplier if the supplier has problem. However we think that it maybe could be possible to extend some of the relations so that further possibilities for improvements could be found, for instance regarding coordination of transports. We think that it could be good for SPA to communicate an atmosphere where ideas regarding possible ways of decreasing costs are welcomed. For instance we believe that one way to achieve this situation is to clarify for suppliers where improvements are desirable and that proposals for improvements are encouraged. If a supplier proposes a solution where one or both parts gain and where the solution has a clear potential for an essential improvement that affects both parties, the gain can be divided between both parts. The communication is also important for managing interfaces since decisions made by one party often have an affect on another party. When working closer to its suppliers and also transporters, SPA can more easily secure its production, which is very important since a line stop is very costly. Since the production also is very dependent on the system, we think that it is important to consider possible effects on it from changes made by SPA. Thus as more information regarding the different actors and to them related activities is available, a broader knowledge, for enabling an understanding of what the effects will be, is built up.

Since SPA, according to us, seems to have a good relation with most of its suppliers, we think that it might be interesting to optimize flows within a supplier to reduce transport costs. As we have seen in our mappings, most of the suppliers have pickup days every working day of the week (Appendix 3-11). Therefore we think an optimization could be done through fewer pickups, which makes it easier for the supplier to plan its production and for instance to produce in larger batches without risking a high stock level or obsolete parts in stock. This is especially important for parts that are suited for a certain need and for a certain customer. As we learned from the visit at a supplier, it already produces in larger batches than ordered by SPA and we think this is common for many of the suppliers. Therefore we think that bigger batches will not be a problem for the suppliers. When using fewer pickup days it is however important that the information between the parties works well since a mistake in a delivery probably has a greater disturbance on the production at the buying enterprise. By using fewer pickup days it is however not a must to reduce the frequency of deliveries to SPA, but this will be further discussed regarding SPA's transport strategy (Chapter 8.7.1).

8.4.3 Relation to Transporters

Our overall perception regarding SPA's relation to its transporters is that it most often works well, but that SPA has not devoted as much time on developing these relations as the relations to the suppliers. What we mean is that SPA has less knowledge about how its transporters work, compared to its suppliers, and that SPA does not have same quality demands on the transporters as in the case of suppliers. We have seen different indications of this:

- One example regards the *unloading process* and although it mostly works well, it contains an activity when the goods arrive where SPA checks both that it has received the correct pallets and that no pallets have been damaged (Chapter 7.2, third actors parameter). This may not be seen as an unnecessary activity, but what is interesting is that there is no check of what is inside the pallets and we understand this as SPA trusts its suppliers. A reason to do this quality control regarding what the transporters deliver, could be that bigger problems could be detected here than inside a pallet and this is good since it probably is worse if a pallet is missing than a part inside a pallet.

- Another example regards the *transport costs* and what we found was that the transport for one supplier had been booked regarding load meters instead of volume (Appendix 6). This error concluded in SPA paying for seven tons more than SPA should have. There are many causes behind this error, but we believe that if the relation with the transporter was better the transporter would have noticed this and invoiced SPA for the correct amount.
- A third example regards the *responsibility* of the transporters. The transporters are only responsible for delivering what the suppliers have prepared for them and not for what is in the consignments. If there is something that is not correct in the consignment, it is up to the supplier to communicate this to SPA. It is the supplier that is responsible for booking the transport and our overall perception is that this most often works very well. A problem we have seen is however that it is difficult to decide who is responsible when there is a problem in a delivery.

We think that the consequences of the three problems mentioned above can be reduced through the use of Webstars. We suggest that the cooperation with the transporters should be extended and a first step towards a closer relation with the transporters is the use of the Webstars system through which SPA will, among other things, have information on what has been picked up at the supplier. When using Webstars SPA should not, according to us, check that the quantity or quality of the pallets are correct, instead there should be enough mutual trust between the transporter and SPA so that SPA can trust that the transporter fulfills its part of the cooperation. If SPA works closer to its transporters and gain a further understanding of what it really pays for, we think that this would result in additional possibilities for improvements. For instance we think SPA should clarify for its transporters, as proposed in the case with its suppliers, that proposals for improvements are encouraged (Chapter 8.4.2). From our visit at a transporter our perception was that also the transporter saw a closer relation to SPA as interesting. When discussing how the cooperation between SPA and the transporter works today, we understood that the transporter had some ideas regarding what could be done in a different way. Probably these ideas would not have come up if we had not asked. We think that this might be the case also for other transporters and therefore we see an additional reason for SPA to extend collaborations with transporters. For instance we think that ideas regarding whether to have a third-party warehousing solution with the transporter could be interesting for SPA, especially when there of different reasons are fluctuations in the material demand. An example of when we think that this could be the case is if a new truck model is to be introduced. Improvements that affect the daily work can for instance be further coordination of transports or a change in ordered quantity. This will however be further discussed in the transformation process (Chapter 8.7).

8.5 Environment

8.5.1 Centralization

The fact that Scania has three assembly plants in Europe, with a central unit for procurement, is a strategic decision that has several implications. For instance the central unit has strong barging power since it becomes a large volume customer, but the unit must also take the three assembly plants' demands into consideration and find solutions that are good for all of them. An example where we have seen some difficulties is in the packaging. Since the demands of the three plants differ, it sometimes can be difficult to find a packaging that suits them all. The four-hour demand on the assembly line at SPA also places some constraints on the packaging and means that some consignments have to be re-packed. We however think that it is good with different kinds of packaging for different parts, but we do not think that the solutions today always are the best. When deciding on packaging we therefore think that SPA has to consider the capacity of the assembly line, with regard to space and not only demand (Chapter 8.3). We think that it is good that the packaging is decided on a central level since it is probably cheaper regarding flows of returning packaging and it is also probably easier for the supplier if the packaging is the same for all the assembly plants. Another implication is that since Scania in several cases has the same suppliers for its plants, this complicates the situation since a change has to be good for all of the plants, which places further requirements on the information availability. That is, a solution shall be appropriate for SPA, the other Scania plants and the other parties in the supply chain. Of course it is not possible to consider the affection of all parties and SPA therefore has to decide about what relations that are of greatest importance and where it sees a potential for improvements. We also think that SPA should be able to, in a greater extent than today, choose its own suppliers for bulk parts such as nuts and bolts. This would give the advantage of less expensive transports and the packaging could be customized to the assembly line's needs.

Another strategic decision is the location of the three Scania plants, which for instance has implications on customer service levels and speed of response. We think that it is a good decision to have a plant in France since it enables Scania to come closer to the markets in Europe. This enables Scania a better knowledge of their customers in these areas and especially in France where we think it is important to be present to be accepted by the customers since there already are several truck manufacturers. The main problem today, as we see it, is that the implications of the location have not been evaluated in depth with regard to costs, for instance for transports.

8.5.2 Transports

The fact that several of SPA's transporters also are its customers means that it is not a good solution for SPA to have an own transport function since it would compete with the transporters. This can also be seen as a constraint for what possibilities SPA has to act, but we have not understood it as a problem. Another constraint that we see for SPA regarding their relation to its transporters, is the praxis in the transport industry, that is how the payment of a consignment is decided and what is legislated regarding for instance maximum load weight (Chapter 7.2, first environment parameter). However, only in one of the flows that we have studied in depth, we have found that SPA has paid for the transport based on wrong criterions. When the transport costs are high we think that it most often depends on lack of knowledge regarding the praxis in the industry or legislation and not on an individual transporter. We suggest that SPA should try to spread the knowledge about the transport praxis within SPA so that more people can come with ideas on how to improve SPA's collaboration with the transporters and find solutions that are good for both parts.

8.5.3 Stock

We do not see the limited space for storing parts and components as a problem and in cases when SPA needs further space, we see different solutions to this. This will however be further discussed in other parts regarding stock (Chapter 8.7.2 and 8.7.3).

8.6 Performance Measurements

8.6.1 Number of Shortages

The main key indicator for the performance of the system is, as we have understood it, the number of shortages in the production. We think that it is a good measure since it makes no difference if there is a shortage of a screw or a cabin and therefore the measure will always show if there are problems with the service provided by the system to the assembly line (Chapter 7.2, first performance measurements parameter). A problem we see with this measure is that it is used as a benchmarking figure for the assembly plants and we do not think it should be used in this way since it gives a distorted picture of the situation. The distorted picture the measure gives is a consequence of that there is different quantities of each part assembled on the truck. For example if an exhaust pipe is missing for one truck it is counted as one shortage per truck, since there is only one exhaust pipe present on each truck. Instead if there is a shortage of screws and there are ten screws mounted on every truck, it is counted as ten shortages per truck. The benchmarking is done on a central level in Scania and the problem that occurs, as we have understood it, is that the assembly plants do not use the measures the same way since they do not think the measure is fair. That is an assembly plant that has had a shortage of screws will probably count the shortage as one shortage and not as ten as it is supposed to. We think that it is quite evident that when benchmarking is done on a central level the measures must be developed, approved and used in the same way by the assembly plants (Chapter 7.2, second performance measurements parameter). We consider that a better benchmarking measure would be the number of trucks not being produced due to shortages. Although benchmarking between the plants can help to identify areas of improvements, we think that SPA should focus on having internal performance measurements that can help SPA to improve and evaluate its own performance.

8.6.2 Stock Optimization

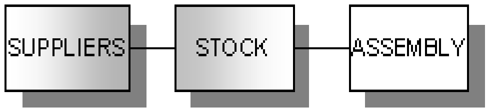
Our perception is that SPA is very good at working with stock levels and that SPA has been successful in lowering its stock levels through the use of a stock-optimization tool. As described, the tool is not used to measure the performance of the material planners (Chapter 5.6), but according to the device *"what gets measured, gets managed"* we see a risk that the material planners focus too much on performing good figures and overlooks the consequences when using the tool. As we see it, the problem with the approach that SPA uses is that the transport costs have been neglected and the optimization focus too much on costs for goods in stock (Chapter 7.2, third performance measurements parameter). If this tool could be modified to include the transport costs, the tool would give a better view of the current situation and would help the material planners to find a better balance between costs for goods in stock and transport costs. We think that an appropriate goal for the material planners would be to examine all their material flows from procurement to consumption so that an adjustment made in one area does not have a worse effect in another.

Since the transport cost varies with the size and weight of the consignments and the current fuel price, it is not easy to retrieve an exact transport cost. We do not think that the prices have to be 100 % exact, instead a rough number can be calculated from the invoices and CMRs. The only thing to bear in mind is to recalculate these numbers if the configuration of the transports is changed. When Webstars is used in full scale, we see that much of the time consuming work with invoices and CMRs can be skipped and we believe that with the use of Webstars a more precise optimization tool can be developed. As we see it SPA has lowered its stock levels through ordering in smaller quantities, which has reduced the total time from a call-off to delivery. We see this as "false" time compression since most of the suppliers produce in larger quantities to achieve economies of scale. The consequence of this is that the stock has just been moved from SPA to the supplier and the transport costs have risen due to a higher frequency of transports. Simplified we see that SPA is just moving the stock from the supplier with many small transports instead of moving the whole stock at the supplier at a lower cost. We think that the use of Webstars will enable time compression since information will be available for the concerned enterprises earlier. Our perception is that the material planners have good knowledge of their suppliers and the different parts and by increasing their knowledge of costs due to activities outside the plant, we think that it should be possible to find a more appropriate set of material flows. This knowledge could also be used when considering for instance warehousing outside SPA.

When information and knowledge regarding activities and costs, both inside and outside the enterprise, have been gained, it becomes easier to avoid sub-optimization in the supply chain. This is important when the enterprise is dependent on a certain party in the supply chain, which is the case for SPA. SPA works a lot with relations to its suppliers since their performance is decisive for the performance of SPA. This is something that we think that SPA really has succeeded in and it is clear that most of its suppliers have a great interest in SPA as a customer. We also consider the so-called escalation model as a good way of clarifying what is expected from the suppliers and in which ways SPA can help. By dedicating this amount of work to the suppliers, SPA points out the importance of its suppliers and its willingness to invest in good relations. We see this as a way for SPA to secure a long-term supply instead of focusing on low prices. By working this way we think that SPA and its suppliers can help each other to decrease costs through a long-term investment (Chapter 8.4.2).

8.7 Transformation Process

8.7.1 From Suppliers to Stock



Since Scania decides about procurement on a central level, SPA is a bit limited in how it can affect its material costs. How well the procurement activity works is to a large extent based on what suppliers the enterprise collaborates with and this is where SPA can influence the choice of source of procurement. That is when SPA has some ideas on what could be done in a different way, it needs to gather this material so it can be used for decision making and give it to the central function. The proposal shall also be a good solution for all of the three plants, which places further pressure on the plant to motivate a change. We think that this is both good and bad since it means that the idea really has to be thought through, at the same time as it might result in that nobody has the energy or possibility to collect this information.

Another thing SPA can do to affect the procurement activity is by working with improvements of the material handling and to eliminate non-value-adding activities (Chapter 7.2, first transformation process parameter). We think it is in this area that SPA has the greatest possibility to affect the costs for procurement, which except for direct material costs also includes costs for instance for transports. We have found some activities that we see as non-value-adding.

- One example is that some of SPA's loads have to be repacked before it is supplied to the line and this is a typical handling that adds no value for the customer. This is however a problem that is hard to find a good solution on since it depends on that the three assembly plants have the same packaging, but different pace of consumption. (Chapter 5.5).
- Another example is that the pallets are checked when arriving at SPA even though there is a quality directive that the transporters have to follow and the agreed quality is expected to be present. As mentioned we see this, as SPA does not trust its transporters as it trusts its suppliers (Chapter 8.4.3).
- Another issue regarding transports is that the transport distances are not value-adding if they could be possible to coordinate, that is if there are suppliers located near each other and where pickups could be done in the same route (Figure 8.1). Of course the acquisition of material itself is value adding, but if transports are possible to coordinate, more transports are not adding value.

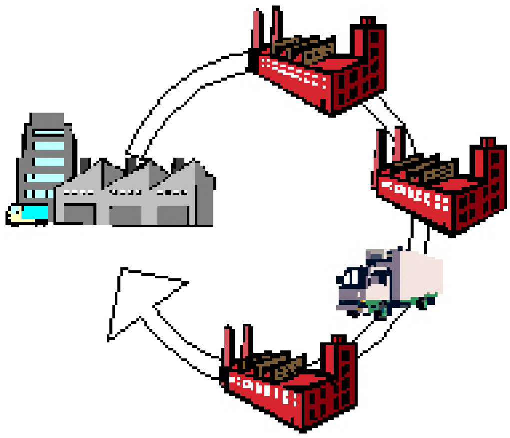


Figure 8.1, Milk run between suppliers.

Material Control Methods

The fact that the material planners have guidelines for what MCM to use for different kind of parts and components stresses some constraints since the conditions are often not the same for the three plants. Our perception is that the guidelines are not always suitable to use for all plants and therefore the material planners have to consider what is appropriate for each part and component separately. Another guidance regarding the different MCMs is the directive from Scania that as many flows as possible should be Kanban flows (Chapter 7.2, second transformation process parameter). We think that this directive was stated because Kanban has been successfully tested at the assembly plant in Södertälje where a shorter distance to most of the suppliers is experienced. The problem may be that the people stating the directive do not have information on why it works well in Södertälje and/or do not regard the conditions that the other assembly plants are working under. However, as we have understood it, the material planners are aware of that the guidelines are just guidelines and not rules to follow.

Kanban

When investigating how the different MCMs, used at SPA, influence costs in the supply chain, we did not find any remarkable differences regarding how well respective method works. The most obvious problem we have found is that several of the suppliers where the Kanban flow is used are far off. Since the method is developed by Toyota where most of the suppliers are very close to the plant, we think that this is something that should be considered when deciding on the use of this method. The adjustments that SPA has done to the original Kanban are, according to us, a good example of how an enterprise tries to apply methods that have been successful in other enterprises, but has to adjust them to suite its current situation. We cannot really see the point of using Kanban in this way, since the circumstances under which the method was developed differs to a great extent compared to the environment in which SPA resides. One of the main parts of the Kanban scheduling is that the lead times are predictable and the transports can be frequent without incurring high costs and this is not the case for SPA. For the Kanban flows we have studied the transportation distance is quite long and therefore the time for transportation is hard to predict and the transport costs are high. SPA states that the Kanban flow is a pull flow, but the combination of long transport times and the high stock levels has the consequence that the need the assembly line creates is not satisfied within at least one week. One example of this is Supplier H (Appendix 10), which has almost 12 days of consumption in stock. Since many of the suppliers are not located in France, SPA also has to adjust the Kanban-loop regarding both call-off dates and order quantities to compensate for holidays that differs between the countries. For many of our Kanban flows we see that the cost occurring depends a lot on that there are daily deliveries. According to us the flows could be optimized if SPA had fewer deliveries, but it is also important to regard other parts that are transported at the same time and not just look at one flow from the supplier. The coordination of flows would result in that the transports are priced in a higher weight range, hence lowering the price. Maybe Kanban is not appropriate for these flows and it would ease the coordination of transports if SPA used another MCM, for instance batch, where the future call-offs are easier to plan.

Sequence

Regarding *sequence* flows our perception is that SPA has made great efforts to enable them to work well and this might be one of the reasons to why there seldom are disturbances in these flows with regard to on time delivery. We have, however, noticed that the flows are less optimized regarding quantity and packaging and this has resulted in high transport costs. A reason to why the on time delivery works so well is probably that the demand for sequence parts is decided from the mixing meeting, that is about one month before the truck is to be assembled. Another reason might be that those parts and components are dedicated to a certain chassis when ordered and therefore it is easy to see disturbances in those flows. Regarding order quantity and how even the flows are, we see some possibilities for improvements. What has been most obvious to us is that transport costs regarding sequence flows often are very high. One imperfection we have noticed, from the sequence flow that we have studied (Appendix 11), is that the racks used for packaging not always were full, which means that SPA pays for empty space. Since the material demand is decided on about a month before assembly, we think that at least some further coordination of the flows should even the flows. One way to enable coordination would be to let the supplier do the optimization of packaging. This could be done by giving the supplier a time span in which it could deliver the parts and giving the supplier freedom to optimize the packaging within this time span (Chapter 7.2, third transformation process parameter). Supplier I (Appendix 11) has four sequence flows and one batch flow, and to avoid high transport costs in this case we think that it is important that the material planner tries to coordinate the batch flow with the sequence flows. This will result in some additional day in buffer, but we think that this cost at least has to be compared to the transport costs (Chapter 7.2, fourth transformation process parameter).

Batch

When we have carried out our mappings we have not found something special for the *batch* flows. We think it is difficult to come to any general conclusions regarding the batch flows, but we have found that these flows can be optimized regarding the size of the consignments. That is for a supplier that has many deliveries to SPA we think that the pickups can be coordinated resulting in less expensive transports. For these suppliers we think it is very important to look at all the supplied parts since the optimization of one flow would just make one transport less expensive and another delivery more expensive hence nothing is gained. We think one easy way to force an optimization of these flows would simply be to skip one pickup day to put more stress on the material planner to coordinate the transports.

Re-order Point

From our investigation regarding *re-order point* we have found that problems concerning this method often depends on the fact that it is automatic. Our perception is that this is the case since these flows are less visual for the material planner and therefore shortages are often not discovered until it is too late. Even though these parts are low-value parts, we think that it is important to further work with improvements of these flows since they in most cases are of the same importance for the final result as any part or component. From our mapping of Supplier A (Appendix 3) it is most evident that the cost for speed transports is very high and that they should be avoided. We also think that there are possibilities for improvements regarding the order quantity and frequency of deliveries. For many of these parts the SB or MB is used and the problem with these is, as mentioned earlier, that they need a certain packaging for security reasons. The result is that SPA often pays for air and we therefore consider that there is a lot to do regarding decisions on order quantity. We think that the flow of brackets from Supplier B (Appendix 4) is a good example of this, since it is clear that all the MBs from Supplier B could be transported on one pallet instead of three. It is also important to regard other MB or SB flows from one supplier since it may be possible to coordinate more than one flow of MB or SB.

We think that more even material flows could be worth striving for since it probably could make the production and transports planning easier for both SPA and its suppliers. We are however not sure that this would result in a decreased frequency of deliveries since SPA wants to have a pulse in the material flows to visualize that something actually happens and this might also be the case for SPA’s suppliers. What is important when deciding on material flows is however that the vision of a pulse not becomes more important than finding the most appropriate set of material flows, with regard to for instance total cost. Even if the consignments were to be bigger, we think that this would not have a great impact on the pulse at SPA since there will still be a steady flow of transports to SPA on a daily basis. Since the material need is decided on the mixing meeting, we consider that it should be possible for SPA to plan its material flows better. When working with making material flows more even, we however consider it as important to first make an estimation of what flows that are of greatest importance for SPA since the effort needed might exceed the benefit in some cases. We think that a good starting point is to look at the suppliers that have quite few flows and see what the consignments weigh in relation to weight ranges. Other flows where we see that there is much to gain are the flows from far off suppliers that supply many parts. According to us, these flows could be coordinated so that the transports are priced according to a less expensive weight range.

Transports

SPA's location is something that we think has a considerable influence on SPA's situation regarding transports, since several of its suppliers are far off. Since much of what happens between suppliers and SPA is like a black box, we think that more time should be spent on understanding this part. We also think that costs related to the location is something that SPA can continue to reduce when receiving more information regarding what are behind for instance the transport costs and warehousing. Retrieving information about transport costs is a difficult task since the transporters do not want to give this information on computer media. We think an easier way of mapping the costs are to look at the weights specified on the CMRs thus making the invoices obsolete for simple improvements. Even though the transport cost only represents about five percent in normal cases, we see a great potential in lowering these further. In the material flows that we have studied (Appendix 3-11), many of them represent transport costs much higher than five percent and they also fluctuate a lot even for the same part. A special case regarding transports is speed transports and even though they work well as a necessary solution, we think that it is important to try to avoid them. Speed transports do not add extra value to the assembly line compared to an ordinary transport and they are also very expensive, but compared to possible disturbances in the production, we think it is worth it. The information received from made follow-ups, regarding why a specific speed transport is needed, can be useful for instance when deciding on the level of security stock. For instance if there often are speed transports for some specific parts, it might be a good idea to increase the stock level to avoid shortages until the problems at the supplier has been solved.

The transport strategy depends both on *external* and *internal* factors and we will now evaluate SPA's transport strategy based on these factors (Chapter 4.2.3). One important issue regarding the external factor is, according to us, the relation to suppliers and transporters. Our perception is, as mentioned, that SPA's relation to its transporters should be further developed. Since some transporters are Scania's customers it is of great importance to have a good relation to them and not put too much pressure on them. We think that SPA should use the same approach as with the suppliers, that is the parties should divide the gain of proposed improvements. By working this way there would be a mutual exchange of valuable knowledge that could be used to improve the situation for both parts (Chapter 7.2, third transformation process parameter). As mentioned there are also some internal factors that affect the decision on transport strategy. The fact that SPA has several suppliers that are the same as for the other assembly plants places some constraints on the transport strategy from the start. SPA has to adapt its transport strategy to this fact and, as we have understood it, this mainly affects the packaging and the distance to the suppliers.

Since SPA wants an even material flow with daily deliveries, it is important to have suppliers and transporters that can handle this. As we have understood it, it is not the product itself that is the reason for the daily deliveries, instead it is a vision to always have a pulse in the production. Today one result from this vision is high transport costs. However we see some areas where SPA can make some improvements, for instance regarding the frequency and size of deliveries. This should be possible since the production at SPA is quite even and the material need is decided 20 days before production. We suggest that a good starting point for optimizations is to first look at one supplier and summarize what parts are delivered from the supplier, how often they are delivered, which MCMs are used, what the consumption is on the line and so on. From this material the material planner can try to figure out how the transports can be coordinated without having to go through invoices and CMRs. From this compilation it is also easy to see the parts that are delivered irregularly and find ways to coordinate transport of these parts with other transports.

One improvement that came up at our visit at a transporter was that it could be possible to coordinate flows to SPA and consequently lowering the frequency of deliveries. Through our supplier visit we found that this supplier always had finished goods for SPA in stock and therefore we think it would be possible for the consignments to be picked up at almost any moment during the day and not at a certain slot-time as today. Today many parts are also delivered in SB or MB and together with empty boxes for security reasons. The prerequisites mentioned here could, as we see it, be combined in different ways and result in several solutions for how SPA could work with its material flows. Here we will present three possible solutions but these can of course be combined in other ways.

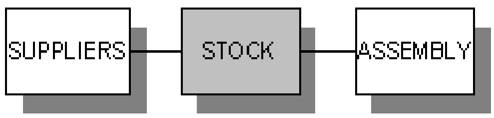
- One possible solution could be to have fewer pickup days at the supplier, which would result in larger quantities delivered to SPA.
- Another solution could be to coordinate the pickups at two or more suppliers located near each other in cases when the consignments are to be cross-docked at a central transport unit. The same transport will be used when picking up the goods at different suppliers, which would result in a lower transport cost viewed on the whole.
- A third solution could be to use the central transport unit for providing warehousing service and still having daily deliveries to SPA, but to coordinate incoming transports to the central transport unit. Since SPA wants to have a pulse in the material flow to the plant, we think that this could be a solution worth thinking about.

We suggest that SPA should try the third solution with the transporter we have studied and for those suppliers handled by the transporter that are far off, to see what the result will be. For instance the savings in costs for transports must be compared to increased costs for storage. The production at SPA will probably not be affected of this change since it is earlier in the supply chain. It is however also crucial to take the capacity of the suppliers into consideration when evaluating solutions of this kind. Regarding the larger quantities we do not think that it should cause any problems since it often is better for a supplier to produce in larger batches. Therefore this would mean a win-win situation for both parties. We however think it is of great importance that SPA has an active dialog with the suppliers regarding how big batches they produce and how much they keep in stock so that the risk of sub-optimizations can be minimized.

When this approach has been tested for one or some transporters and suppliers, there hopefully is some material to base further decisions regarding coordination of transports and warehousing services on. By first testing this approach on a small scale and on a larger scale as knowledge about how the approach works is gained, we think the changeover will be smooth. The use of an external logistics function will however have some effects on the internal logistics function that should be considered (Chapter 4.2.4). For instance by outsourcing different logistics activities, fixed costs can be converted to variable costs. This could be the case if SPA finds itself in need of extra stock space, for instance if a new truck model is to be introduced. Instead of building an extra stock that can handle fluctuations regarding the need of stock, we think it could be better for SPA to outsource this function when it is needed to avoid costs for unused stock space. The internal logistics function at SPA will not be affected of this decision since the situation will be more or less unchanged, as only fluctuations will be handled by the external logistics function. Another consideration is what the requirements of developing a third-party relationship will be. In the case of SPA we suggest that it uses an existing transporter since this is a relation SPA already has invested in and therefore knowledge about the capacity of the transporter already exist and can be further developed.

8.7.2 Stock at Enterprise

Goods Arrival



Our perception is that the process for receiving goods at the gate, unloading and storing in the stock seems to work well, except for earlier discussion regarding re-packing and the check of the received pallets (Chapter 8.4.3). We think that it is a good solution to have different unloading spots and personnel for the different flows since this reduces the risk for mix-ups. We consider that the layout of the stock works well and it is good to have visual stock levels for high mover parts. It is good that SPA utilizes different types of storage for the parts regarding their speed and point of consumption since it is easier to get a visual verification of the current stock situation (Chapter 7.2, fifth transformation process parameter). On the other hand the material planners have to check different storage to confirm the stock levels of many parts, which could have the consequence that a part is missed. We think it is a smart solution to try to visualize the parts that have been in stock for a long time by changing the color of the stickers on the pallets. However, we think that the color should be changed more often to show more parts with low turnover and would then be of better guidance for the material planners when deciding on stock levels.

Stock Management

The material planners base their flows on the needs of the assembly line. We think that when using this approach there is a risk that the consequences in the transformation process are neglected. The thoughts of the assembly line have been communicated to the logistics department and the logistics department has, in some sense, copied the behavior of the assembly line, thus it orders in small quantities and with high frequency. We do not think it has to be this way since the needs of the assembly line only regard that the received parts are in the correct packaging and are delivered when needed. Instead we suggest that the stock should be regarded as a utility for adapting the needs of the assembly line to what is cost effective for the transformation process (Chapter 7.2, sixth transformation process parameter). We also think that although the needs of the customer should be the starting point when deciding on the flow of a specific part, the material planners should take into consideration the consequences these needs have on the whole system and maybe adjust the flows to suite it better.

As we see it, there is no immediate lack of space forcing the logistics department to lower the stock levels. This gives the logistics department the ability to elaborate with the flows to a greater extent. In our opinion the flows of MBs and SBs should be optimized so that there are enough boxes in every transport to fill a whole pallet. This optimization will not affect the stock in a greater extent since the boxes do not require much storing space and will not carry high inventory costs, as the parts often are cheap. Besides the risk of having costs tied in inventory, there is always the risk for an item becoming obsolete due to changes in the configuration of the trucks consequently motivating a low stock level to lower this risk. This risk must be taken into consideration, but since the specification of the truck is frozen 20 days before the truck is manufactured, there will be no changes within this time. We believe that SPA should not even be tied to these 20 days since a change of a part in a truck is a time consuming process where the change has to go through quality assurance cycles and so on. That is, if SPA gets a notice that Scania is working on a change of a part in the truck, SPA can lower its stock level for the specific part to reduce the risk of having a great number of obsolete items in stock when the change is carried out.

Safety stock

Our perception is that SPA has lowered its stock levels by ordering smaller quantities on a more regular basis, but the lowering has only affected the variable part of the total stock level. As an example Supplier C has almost daily deliveries in quantities according to the daily consumption and a more or less constant stock level that equals to over six days of consumption (Appendix 5). Furthermore the quantity, of the concerned part, on the assembly line equals one to two days of consumption. We know that this is the situation for many of the parts and therefore we see a potential for SPA to lower its stock levels. To do this we think that SPA should have a focus on the safety stock quantities, regarding both external and internal disturbances, since lowering these levels should have a greater impact on the total stock level.

Regarding the internal safety stock, we suggest the rule of having two days of stock should be used as a starting point. The fact that many of the parts are considered consumed when they are delivered to the assembly line extends the internal safety stock time with at least four hours and up to several days and therefore we suggest that this stock should be included in the safety stock (Chapter 7.2, seventh transformation process parameter). We also suggest that the performance of the transporter and supplier should be regarded in the calculation of the internal safety stock level. We do not see why this level has to be so high if they show good performance or if the supplier is located near SPA. Regarding the safety stock for external disturbances we think that, if the lead-time is not too long and the supplier and transporter perform well, the safety stock dedicated to this can be shortened.

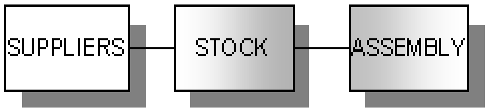
The main problem, as we see it, with the security stock is that the logistics department has divided the security stock in two parts since there is a minimum level regarding both parts. The outcome of this is that there always is a security stock level regarding at least four days of consumption. Our suggestion is that the logistics department should only have one security stock level based on the performance of the supplier and transporter. In the calculation of this safety stock there should also be a risk analysis present on the specific part. In the risk analysis we think it is, for example, important to consider the risk of speed transports since they are very expensive and we consider that a low security stock level cannot motivate the cost for these transports. Since the consequences differ of a stock out from part to part, we suggest that this measure also should be regarded in the decision on safety stock.

When working with the safety stock we suggest that SPA works slowly and flow by flow to lower the risk for stock outs and also so the stress levels of the material planners do not skyrocket. Since, for example, a missed scan of a used pallet on the line has greater consequences if the safety stock levels are low, we think that SPA must consider its procedures for assuring that the stock levels in the computer systems corresponds with the real levels. We see this as a key activity in the work to lower the stock levels or else we think there is a risk that the material planners have to check the levels with the consequence of higher personnel cost.

The Importance of Lead-time

Our main standpoint is that we regard the deliver reliability as more important than lead-time for SPA since a disturbance of the delivery can raise high costs. Since SPA knows the material need 20 days before manufacturing, we do not see any point in working with lowering the lead-time and instead SPA should use this time to smoothen and optimize flows. Our perception is that SPA also shares our standpoint regarding deliver reliability, but the problem as we see it is that SPA tries to use the same rules on too large groups of flows and, as presented, there are other parameters that we think should be regarded.

8.7.3 From Stock to Assembly Line



The different methods of supplying the line seems to work well and we have not noticed that the assembly line has had shortages due to that the internal logistics function has not been able to deliver the needed parts from the stock to the assembly line. Regarding the *two-bin* system, which is the most common supply method of the flows we have studied, our perception is that it works well apart from one point. Many of the parts are regarded as consumed when they are delivered to the line but the material planners are well aware of that there is at least one full pallet available on the line. We believe that the material planner regards the pallet as an extra safety stock, especially when there is a delivery problem. This can result in a stock out since there is always a possibility that a bin has been forgotten to be scanned. We think this problem is difficult to solve since it is a mental state of mind the material planners have. We consider that this problem is better solved if the stock on the line is regarded as part of the safety stock and procedures, for assuring that the scans of the bar codes are done, are established. The *sequence* supply method works well but has the flaw that all the sequence flows are dependent on each other. That is if a sequenced part is damaged, all the sequenced flows have to be reconfigured. This can be a quite time consuming process since many of the flows have automated feeding mechanisms, but we think that the benefits are greater then the disadvantages.

9 Conclusions

In this chapter we present our conclusions based on the elements in our evaluation model (Chapter 7.2). We will not give any specific comments on the elements owner and Weltanschauung here since we consider the conclusions regarding those elements are well in line with the conclusions regarding the customer. We will also give some comments on the usefulness of systems approach when constructing an evaluation model.

9.1 Customer

The assembly line is today seen as customer at SPA and therefore the material flows are dependent on what needs the assembly line has. We think that it would be better if the assembly line's needs and wishes should only be used as a base when deciding on material flows. Instead of letting the assembly line decide about material flows, the logistics department should have a dialogue with the assembly line and consider what possibilities there are for changes regarding for instance packaging.

SPA does not reach the goal of the parameter in our model regarding the customer and we do not think it ever will since it is deeply rooted that the assembly line's needs are to be met. Since the goal is not reached it is important that this is compensated by other parameters, in the case of SPA this can be compensated if it regards the stock as an adaptor.

9.2 Actors

Our perception is that the communication within the logistics department works well and that the different functions collaborate to find possibilities for improvements and good solutions to problems. According to us there is a lot for SPA to gain from increased communication between departments since the departments have different knowledge regarding the same issues and an increased understanding of what is behind different types of costs could be achieved. SPA should, as a first step, work with increasing the internal communication and thereafter continue to work with its relation to suppliers and transporters.

Several problems regarding costs are due to lack of knowledge about how transporters in particular, but also suppliers, work and therefore SPA should work on improving this. Indications of that the relation is not so good with the transporters is that SPA checks the consignments on arrival to SPA and that SPA has not worked with them to find possibilities of improvement to any greater extent. Also, several transporters do not want to inform SPA on how they work or share information regarding transport costs on computer media. This situation could probably be improved if SPA clarified its willingness to invest in a closer relation. SPA's relation to its supplier most often works well and this is good since the suppliers' performances are decisive for the final result of SPA's trucks. Since the final result to a great extent is dependent on the performance of the whole supply chain, a closer relation also to the transporters should be motivated. SPA should communicate to its transporters and suppliers that ideas are rewarded and what areas of improvements that are interesting to examine. If a good solution or proposal comes up, the gain could be shared between the two parties so that both parties see an incitement in finding solutions that do not directly relate to them.

A change made by SPA should also consider what is possible for the other parties in the supply chain, since a lot depends on the relation between them, for instance if it is possible with fewer pickup days. To be able to understand what affect a change will have on another party, a communication tool common for all parties should be appropriate. We think that Webstars can work as a good tool for linking activities both internally at SPA and externally between SPA and its suppliers and transporters and that it could indicate SPA's willingness to collaborate to find better solutions for all parties. Today SPA has good knowledge about why costs arise internally, and through the use of Webstars, SPA can gain further knowledge about what gives rise to costs externally.

Regarding the first parameter under actors in our model we consider that it is partly fulfilled by the relation with the suppliers, but that SPA has to involve the suppliers in the process of generating ideas. The relations with the transporters are not near the goal we have stated. The relation between SPA and the logistics department works well, but instead there are shortcomings in the communication between the departments. The communication with the suppliers is better than the communication with the transporters, but we think that this communication will be approved with the use of Webstars. We consider that the logistics is not as effective that it can be since SPA has had too much focus on the internal flows. Also, SPA has not regarded the five costs as there is a lack of focus on transport costs, but we know that SPA has started to work with the transport costs and this is a move in the right direction.

9.3 Environment

We think that it is both good and bad that Scania has a central unit for procurement. It is good since Scania is a large volume customer and therefore gets a strong bargaining power. Less good is that a solution always has to be modified to suit the three plants. In the case of SPA its location plays an essential role since several of its suppliers are far off and since there is a wish to have as small packaging as possible. This has resulted in a high frequency of deliveries to SPA, since SPA wants to lower its stock levels, but the transport cost has not been compared to the cost for having goods in stock. What we have found is that high transport costs, except for the high frequency of deliveries, depend on a lack of knowledge regarding praxis in the transport industry. Therefore SPA should spread its knowledge regarding how it works so that an increased awareness of this is achieved within the enterprise.

Our perception is that SPA has not considered how the environmental constraints affect them and therefore they do not reach our goal for the parameter under environment in our model.

9.4 Performance Measurements

Two performance measurements that SPA works a lot with are number of shortages and stock levels. The shortage measure is good since it considers all kinds of shortages. Today this measure partly is used for benchmarking between the three plants, but we think that it only should be used as an internal measurement that can help SPA to improve and evaluate its own performance. If the measurement is used for benchmarking between plants, there should be clear directives from the central unit regarding how to use it and what to include. The other measurement regards stock levels and SPA has succeeded to lower these levels by using a stock-optimization tool. We see a risk with focusing too much on stock levels and instead there should be a focus on the total cost chain. The present measure should therefore be complemented with parameters that consider costs that arise earlier in the supply chain, for instance transports. SPA should also avoid moving its stock in several transports and instead see if it is possible to order the whole batch that is produced at the supplier at the same time. Of course SPA has to evaluate the cost of having goods in stock compared to transport costs.

We think that SPA has a good measurement for internal performance that meets our goal, but the problem is that the measurement is also used as an external performance measurement and it does not reach our goal as such a measure. The stock-optimization tool does not meet the goal of our third parameter under performance measurements in the model.

9.5 Transformation Process

The material flows to SPA, regardless of material control method (MCM), varies both regarding frequency of deliveries and order quantity and the same variations are also present on a part level. More even flows could be worth striving for since it probably should make the planning easier for SPA, its suppliers and its transporters. The transport costs can be lowered and when doing this it is important to consider the whole consignment and not only separate flows. To lower transport costs an evaluation, on a supplier level, regarding the present weight range, if it is possible to coordinate deliveries of different parts, for instance by fewer pick-up days and see if the packaging can be optimized, has to be done. A big non-value-adding activity we consider that SPA has to work with is the lack of transport coordination between suppliers located near each other and there is a lot to gain by coordination of these flows. Another possibility for how to handle material flows is to only work on a part level, but then larger order quantities will be the result. However, the higher cost for inventory in stock will in many cases be compensated by the lower transport cost. If SPA does not want to use its own stock for this change, a solution could be to use a third party that stores the parts and that delivers to SPA in preferred quantities. Regardless on how to work with making material flows more even, it is important to first make an estimation of what flows that are of great importance for SPA since the effort needed might exceed the benefit in some cases.

Regarding the different MCMs' effect on costs in the supply chain we have not seen any clear differences. Most problems are found in the studied Kanban flows and the way this method is used today. The Kanban-loops are often modified due to holidays and the flows are hard to predict since most of the suppliers where it is used are far off. We see no point in why SPA uses this method and under the present circumstances it might be better to use a batch flow instead. By using batch for these flows, more time could be spent on coordination of these flows instead of on modifying the loop. Therefore it is inappropriate that Scania has a directive stating that there should be as many Kanban flows as possible. Regarding the sequence flows we think that SPA should give the supplier possibilities to optimize these flows regarding packaging and our recommendation is that the gain in lower transport costs should be divided between SPA and the supplier.

There is no immediate lack of space in stock and this gives the logistics department the ability to elaborate with the material flows to a greater extent. Today the stock levels are lowered through smaller order quantities and more frequent deliveries, but we consider that much more can be gained by instead lowering the safety stock. The safety stock levels are at least for four days of production for many parts and in this level the stock on the line, which can vary between four hours to several days of consumption, is not included. We suggest that the stock on the assembly line is included in the safety stock, that is there should only be one type of safety stock, and that the safety stock levels correspond to the risk and consequence of a stock out. When considering stock levels it is important not to have the same goal for all parts, since it for some parts is motivated with higher stock levels. This is for instance the case when it is a low-value part with low consumption that not requires much storing space and where the risk of becoming obsolete is small.

We consider that SPA should not focus on trying to short the lead-times from their suppliers since delivery reliability is more important than a short lead-time. Also, since the lead-time is shorter than the planning horizon we think that SPA should use this time to try to coordinate flows. We think that, by utilizing this difference in time, SPA could use the stock as a utility for adapting the needs of the line to cost effective solutions for the rest of the supply chain.

SPA does not meet the goals of any of the parameters presented under transformation process, except for the last one. Therefore there are several areas in where SPA can improve its performance, but in many areas SPA has come a long way. Also, in many areas SPA has the feeling that something is wrong but SPA has no proof of this. This is, for example, the case with high transport costs. As we see it SPA should focus on three areas in which we think there is much to gain:

- Transports.
- Safety stock levels.
- The relation with the transporters.

To summarize, we think that the three main areas we have proposed SPA to focus on, are also areas where several other enterprises have a potential for improvements. Our perception is that there often is a lack of knowledge regarding the total supply chain and that the focus on costs only considers one or some parts of it. In our specific case we consider that a first step for SPA to focus on the costs in the total supply chain could be to use our proposal of a work method on how to handle material flows. The work method is based on the parameters that we have found of most vital importance when considering the supply chain, that is in what areas we suggest to focus initially when evaluating specific material flows and creating an understanding of the total supply chain. Our proposal of a work method will work as a first step for SPA to be able to find a better set of material flows, which will lower the costs as a result of lower stock levels and more coordinated deliveries. From our mappings we learned that improvements of material flows can be done on different levels of detail. Our work method reflects these levels and goes into the details of individual flows. However, we think that there is much for SPA, and also for other enterprises, to gain by just studying flows on a supplier level. Our proposal for how a work method should be designed is presented in the following chapter (Chapter 10).

9.6 Reflections on Evaluation Model

We have found the use of systems approach to structure our case study as a good way of investigating and evaluating an enterprise facing a certain problem. Our perception is that this approach can be useful in most situations since it offers a clear structure at the same time as it works as a source for new ideas of what could be interesting to study further. According to us, the structure makes it easier to describe a situation that to a great extent is dependent of several different actors and activities and if not using this structure, it would be difficult to describe our case study without repeating different descriptions and reasoning. We also see it as a good tool when creating an evaluation model since it considers how different elements affect each other, which in turn contributes to the achievement of an overall understanding of the total supply chain.

The main strength with our evaluation model is, according to us, that it considers several different aspects of the supply chain and the system and from different perspectives. At the same time it clarifies the connection and interactions between the different elements. Another strength, as we see it, is that the model is based both on theories and empirical findings since this has helped us to find an appropriate level for the parameters and goals in the model and also what areas that could be interesting to include in it.

The fact that we have based the model both on theories and findings from our case study at Scania Production Angers, however also could be viewed as a constraint since it is difficult to know whether the model is possible to apply also for other enterprises and in other situations as well. Another weakness due to this could be that the parameters based on the literature sometimes are on a different level of detail than those based on our empirical findings.

It is difficult to design a model that is appropriate to use regardless of enterprise and therefore a model often has to be adjusted for the specific case. This is also the case with our model, since it is partly designed based on our empirical findings. However, we regard the elements included in the evaluation model as appropriate for this kind of model. The result from an evaluation is probably that a number of areas where improvements are possible are identified, which in turn could work as guidelines for what to focus on and how. We have designed our work method based on the results from our evaluation model together with information and conclusions from our mappings and consider this method as a good way of designing a model that suits the situation.

10 Work method

In this chapter we present our proposal on a work method for how to evaluate and decide on material flows. The work method is to a great extent based on our findings and conclusions from the mappings and evaluation model. The information from the mappings could be found in Appendix 3-11.

10.1 The Structure of the Work Method

Our proposal on a work method is intended to be used as a first step to increase the knowledge regarding material flows and the supply chain as a total. Therefore the work method is not intended to be used as a checklist when deciding on and evaluating material flows. Based on the knowledge and information from our mappings, we have tried to find an appropriate level for the different parts of the method. The areas that we have included in the work method are those that we consider Scania Production Angers should focus on as a first step.

In the analysis we presented several reasoning that are behind the design of this work method, but the main part of it is based on our findings from the mappings. The work method is a way for us to present our conclusions and knowledge on a more detailed level than in the overall analysis.

Our work method consists of several different objectives and for each objective we have stated an action, a description and for most objectives also an example. The intention with the objectives is to create a fundamental understanding of in what areas to find possibilities of improvements. The action is a first step for how to tackle the objective and the description is a proposal on how to perform this action. For some objectives we have a certain example that we think can work as a way of creating understanding and knowledge in an area.

10.2 The work method

Objective	Action	Description	Example
Get an understanding of how costs occur.	Regard other costs than stock value.	• When working with optimizing material flows it is important to consider in what areas improvements can be made. For instance bigger quantities can result in increased stock levels, but in less expensive transport. • Be aware of that there is not always a point in optimizing a flow.	See chapter 8

Objective	**Action**	**Description**	**Example**
Find appropriate flows.	Identify flows with high cost for transport.	• Our recommendation is to start by looking at far off suppliers that have few parts but are delivered with high frequency. Thereafter it is interesting to investigate suppliers that are far off and deliver many parts, that is the suppliers that have a total high frequency of delivered parts.	See Appendix 7
See if the supplier is appropriate to optimize.	Check the overall performance and if there have been speed transports.	• When working with optimizations it is important to check if there have been speed transports for the supplier earlier and why and also if the earlier problems can arise again due to the optimization. • The performance can also give guidance on whether it is possible to lower the security stock.	
Get an overview of the supplier's parts and deliveries.	Collect information on the supplier's parts during the preceding month.	• The parts with consumption, number of deliveries, packaging. Also note the pickup days at the supplier and what transporter is used. • A list with all the deliveries with information on which part and quantity sorted by date (preferred pickup date, otherwise arrival date).	See Appendix 3-11
Get an idea of what is behind transport cost of each delivery.	Calculate the weight of each consignment.	• Calculate the weight of each pallet and also note the total weight of the consignment. The weights can be found on the CMRs.[96] • When calculating be aware of if volume or weight is used to calculate the pay weight. In most cases the pay weight is calculated by volume if volume*333 > weight.	See Appendix 3-11
See if the transport is already optimized.	Put the weights in relation to the weight ranges defined by the transporter.	• For most of the transports it is much more expensive to transport in the weight range of 1000 kg to 2500 kg than in the next weight range.	See Figure 6.3[97]

[96] You can also use the pre-calculated weights of a pallet with parts. If you use pre-calculated weight it is important to regard if the consignment will be calculated by weight or volume. See chapter 5.7.2 regarding transports in thesis.
[97] Skip the flow if the transport already is optimized.

Objective	**Action**	**Description**	**Example**
Reach more appropriate weight range.	Try to find parts to coordinate the other transports after.	• If the transporter and supplier show good performance, move call-offs forward one day, otherwise move call-offs back one day. • Consider if it would help to skip one pickup day. • If there is one frequent flow and one less frequent flow, try to coordinate the less frequent flow so the pickups are done on the same day as the frequent flow. • First try to coordinate individual flows that are almost alike in number of deliveries and then try to fit the deliveries of less frequent parts with the already coordinated flows. • If one or more flows are Kanban or sequence, try to coordinate the other flows with these flows since Kanban and sequence often are more difficult to configure. Consider if the Kanban flow could be more easily coordinated using another MCM.	See Appendix 5
Optimize packaging.	Optimize quantities with regard to packaging.	• If the part can be packed in variable quantities per part, as is the case for some sequence flows, try to order in quantities so that the maximum quantity of the packaging is utilized. • If there are flows of small- and mini boxes try to coordinate these to have as full as possible pallets. If the parts are cheap one can order for a long time ahead to be able to have full or at least half-full pallets. It is also important that these flows are coordinated with other flows from the supplier.	See Appendix 11 See Appendix 4
Avoid problems at the supplier.	Discuss noticeable changes with the supplier.	• Investigate how big batches the supplier manufactures of a part. Consider if it would be better if the whole batch was delivered at once instead of moving the parts in smaller consignments. Is the proposed solution also good for the supplier?	

11 Future Research

In this chapter we present some ideas for future research. We think there are possibilities for research regarding our evaluation model, our work method and systems approach as a method for structuring case studies.

We see a potential in using systems approach since it was very hard to both describe and discuss our case study without the structure proposed in systems approach. We think that it would be of interest to use different authors' views on which parameters that should be present in the system and compare the results achieved from the use of the different structures. It could then be interesting to see if some conclusions could be drawn on which parameters that should be present in the system.

It would be interesting to see if our work method can be used as an aid in deciding on material flows and also if it could, by slight modifications, be usable for other enterprises. It would also be interesting to create an evaluation model and to modify it as further knowledge is gained from the application of the model for a specific case. The outcome from this iterative process of creating the evaluation model, should then be that the parameters included could be changed along the way and also that the different parameters are arranged according to their relative importance. We built our best case model based on both theories and empirical findings to find an appropriate level for it. Another approach could have been to initially only base the evaluation model on theoretical studies. Then the model could be applied in a certain situation and the knowledge from this could then be used to modify the original model to better suit the present case. The creation of the model should therefore be an iterative process where the appropriate level is found as the work proceeds.

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Appendix

Appendix 1 – Overview of Suppliers

Supplier	Country	Transporter	Transport cost	Material cost	Ratio	Nbr. of deliveries
K	SE	A	5917	110488	5.4%	8
C	SE	A	4119	11176	36.9%	17
L	DE	B	5029	137487	3.7%	21
I	DE	B	6176	58463	10.6%	22
G	DE	B	2523	255424	1.0%	45
M	DE	B	352	8615	4.1%	10
N	DE	B	1545	427841	0.4%	70
B	SE	A	4002	70203	5.7%	9
O	SE	A	4529	38055	11.9%	33
F	SE	A	10120	123568	8.2%	21
H	GB	C	1220	15556	7.8%	18
P	GB	C	1531	12906	11.9%	9
A	GB	C	2000	134978	1.5%	56
Q	FR	D	1661	100100	1.7%	25
R	FR	D	1316	45625	2.9%	15
E	FR	D	4024	110119	3.7%	23
S	FR	D	2597	61721	4.2%	74
D	FR	D	5854	124312	4.7%	99

Appendix 2 – Selection of Suppliers

Sweden

1. Supplier F, part number 1420278, Kanban
- Many deliveries to SPA (17).
- Medium ratio transport cost/material cost for Sweden (8,2%).
- Upper/Medium price range for the part.

2. Supplier B, part number 1379855, Batch
- Few deliveries to SPA (3).
- Relatively low ratio transport cost/material cost for Sweden (5,7%).
- Price per part 1,51 €.
- Interesting for a comparison with another batch flow from Sweden.

3. Supplier C, part number 1384474, Batch
- Many deliveries to SPA (15).
- High ratio transport cost/material cost for Sweden (37%).
- Price per part 1,47 €.
- Interesting for a comparison with another batch flow from Sweden.

Germany

4. Supplier G, part number 1353044, Kanban
- Low ratio transport cost/material cost for Germany (1 %).
- Many deliveries to SPA (17).
- Will be changed to another supplier in Brazil, interesting to see how it works today.

5. Supplier I, part number 1370780, Sequence
- Many deliveries to SPA (17).
- Relatively high ratio transport cost/material cost for Germany (10,6%).

France

6. Supplier D, part number 1411330, Batch
- Supplier close to SPA (40 km).
- Relatively high ratio transport cost/material cost for France and with respect to the distance (4,7%).
- Many deliveries to SPA.
- Medium price range for the part.

7. Supplier E, part number 1447570, Batch
- Has 100% of the deliveries for batteries to SPA.

- Medium ratio transport cost/material cost for France (3,7%).
- Many deliveries to SPA (18).
- Interesting to compare with the flows to Zwolle and Södertälje, good as a basis for evaluation.
- Possibilities for optimization?

England

8. Supplier A, part number 814562, Reorder point

- Low price range for the part (1,1 €).
- Low ratio transport cost/material cost for England (1,5 %).

9. Supplier H, part number 1354061, Kanban

- Relatively high ratio transport cost/material cost for England (7,8 %).
- Number of deliveries 6.

Appendix 3 – Supplier A

This is a list with a short explanation to some of the headings used in the following appendix.

Supplier Name	The name of the supplier.
Country	The country in which the supplier is located.
Transporter	The transporter responsible for the deliveries from the supplier.
Transport cost (on the first line)	The total transport cost for the supplier.
Material cost	The total material cost for the supplier.
Ratio (on the first line)	The transport cost divided by the material cost.
Part number	The part number for the specific part.
Description	A short description of the part.
MCM	The material control method used for the part.
Packaging	The type of packaging used for the part.
Price	The price in Euros for the part.
Line supply	The type of line supply used for the part.
Lead-time	The total lead-time, from order to delivery to SPA.
Safety stock time	The decided safety stock time, in days, for the part.
Transp. time	The time it takes for one transport from the supplier to SPA.
Pickup days	The pickup days at the supplier.
Consumption	The daily consumption of the part.
Stock quantity	The quantity in stock without the parts on the line included.
Arrival date	The date the consignment arrived at SPA.
Quantity	The quantity of parts that arrived to SPA.
Total in racks	Shows how many parts are in the rack.
Real weight	The real weight of the parts in the delivery.
Volume weight	The weight of the parts if recalculated from volume to weight.
Total weight	The weight of all the parts in the consignment. That is, not only the weight of the specific part.
Transport cost	The transport cost of the parts in the specific delivery.
Ratio	The transport cost divided by the material cost.

Supplier name	Supplier A	**Country**	GB
Transporter	Transporter C	**Transport cost**	2000 €
Material cost	134978 €	**Ratio**	1.5%
Part number	814562	**Description**	Plastic pipe
MCM	Re-order point	**Packaging**	14
Price	1.1 €	**Line supply**	2-bin
Lead-time	11	**Safety stock time**	2
Transport time	3	**Pickup days**	Mon, Thu
Consumption	177.57	**Stock quantity**	36800

Arrival date	Quantity	Real weight	Pay weight	Transport cost	Ratio
20030107	3200			965	27.4%
20030109	14400	734	2997	204	1.3%
20030114	27200	1387	5242	356	1.2%
20030123	27200	1387	5378	337	1.1%

The first delivery is a speed transport and it is evident that the speed transports are very expensive compared to ordinary transport.

Appendix 4 – Supplier B

Supplier name	Supplier B	**Country**	SE
Transporter	Transporter A	**Transport cost**	4002 €
Material cost	70203 €	**Ratio**	5.7%
Part number	1379855	**Description**	Bracket
MCM	Batch	**Packaging**	Mini box
Price	1.51 €	**Line supply**	2-bin
Lead-time	6	**Safety stock time**	2
Transport time	3	**Pickup days**	Mon,Tue, Thu,Fri
Consumption	2.79	**Stock Quantity**	58

Arrival date	Quantity	Real weight	Pay weight	Transport cost	Ratio
20030106	30	15	60	8.6	19%
20030120	30	15	30	3.6	8%
20030123	30	15	60	9.0	20%

If the mini box shares the pallet with one other box the transport cost is halved.

Appendix 5 – Supplier C

Supplier name	Supplier C	**Country**	SE
Transporter	Transporter A	**Transport cost**	4119 €
Material cost	11176 €	**Ratio**	36.9%
Part number	1384475	**Description**	Cable flute assy
MCM	Batch	**Packaging**	13
Price	2.18 €	**Line supply**	2-bin
Lead-time	7	**Safety stock time**	3
Transport time	3	**Pickup days**	Mon,Tue,Thu,Fri
Consumption	41.95	**Stock Quantity**	280

Arrival date	Quantity	Pay weight	Total weight	Transport cost	Ratio
20030106	80	500	3130	45	26.0%
20030107	40	250	2763	23	26.1%
20030110	80	500	3563	45	26.0%
20030113	40				0.0%
20030114	40	250	1132	40	46.1%
20030116	40	250	1499	40	46.1%
20030117	80	500	3196	45	26.0%
20030120	40	250	1399	40	46.1%
20030121	40	250	1731	36	41.7%
20030123	40	250	1432	40	46.1%
20030124	120	750	3196	68	26.0%
20030128	80	500	1365	80	46.1%
20030130	40	250	1465	40	46.1%
20030131	80	500	2997	45	26.0%

In this appendix one can see how transports can be coordinated to lower the transport cost. If the transports the 20th and 21st were to be coordinated the cost would be halved because the sum of the weights would reach a less expensive weight range.

Appendix 6 – Supplier D

Supplier name	Supplier D	**Country**	FR
Transporter	Transporter D	**Transport cost**	5854 €
Material cost	124312 €	**Ratio**	4.7%
Part number	1411330	**Description**	Noise shield assy
MCM	Batch	**Packaging**	14
Price	26.82 €	**Line supply**	2-bin
Lead-time	22	**Safety stock time**	2
Transport time	1	**Pickup days**	Mon-Fri
Consumption	32.45	**Stock Quantity**	120

Arrival date	Quantity	Real weight	Pay weight	Volume weight	Transport cost	Ratio
20030103	72	1212				0.0%
20030106	42	303	2720	1995	156	13.8%
20030107	36	606	2294	1710	97	10.0%
20030108	144					0.0%
20030115	276	4646	13110	13110	319	4.3%
20030116	36	606	2289	1710	91	9.4%
20030121	36	606	1710	1710	103	10.6%
20030122	126	2121	5985	5985	166	4.9%
20030128	6	101	285	285	11	6.8%
20030128	30	505	1425	1425	54	6.8%
20030128	66	1111	3135	3135	111	6.2%
20030129	42	707	2590	1995	57	5.1%
20030129	54	909	3330	2565	74	5.1%
20030131	30	505	1850	1425	56	6.9%

There is one invoice with arrival 9/1 for 35 pallets, 3525 kg, 33,263 m3, 7,2 Load meters, pay weight 13320 kg, cost 355 €, which cant be found as inbound transport. There are also some transports that have been incorrectly invoiced by load meters. The incorrect invoicing has raised extra costs for approximately seven tons of transports.

Appendix 7 – Supplier E

Supplier name	Supplier E	**Country**	FR
Transporter	Transporter D	**Transport cost**	4024 €
Material cost	110119 €	**Ratio**	3,7%
Part number	1447570	**Description**	Battery
MCM	Batch	**Packaging**	10
Price	62,82 €	**Line supply**	2-bin
Lead-time	4	**Safety stock time**	2
Transport time	1	**Pickup days**	Mon-Fri
Consumption	79,91	**Stock Quantity**	356

Arrival date	Quantity	Real weight	Pay weight	Transport cost	Ratio
20030106	21	1095	1095	106	8,0%
20030108	315	16425	16425	395	2,0%
20030109	84	4380	4380	177	3,3%
20030110	84	4380	4380	194	3,7%
20030113	63	3285	5000	200	5,0%
20030114	105	5475	5475	220	3,3%
20030115	84	4380	5000	200	3,8%
20030116	105	5475	5475	220	3,3%
20030117	42	2190	2190	138	5,2%
20030120	105	5475	5475	220	3,3%
20030121	84	4380	4380	178	3,4%
20030122	84	4380	5000	200	3,8%
20030123	63	3285	5000	200	5,0%
20030124	105	5475	5475	220	3,3%
20030127	84	4380	5000	200	3,8%
20030128	63	3285	5000	200	5,0%
20030129	84	4380	5000	200	3,8%
20030130	84	4380	5000	200	3,8%

The price is the same for 3 and 4 pallets since the charge for 5000 kg will be used in both cases due to weight range. We consider it better to deliver 105 batteries since the buyer would only pay for 475 kg extra but transport more than 1000 kg extra.

Appendix 8 – Supplier F

Supplier name	Supplier F	**Country**	SE
Transporter	Transporter A	**Transport cost**	10120 €
Material cost	123568 €	**Ratio**	8,2%
Part number	1420278	**Description**	Silencer
MCM	Kanban	**Packaging**	3
Price	118,14 €	**Line supply**	Kanban
Lead-time	6	**Safety stock time**	2
Transport time	3	**Pickup days**	Mon-Fri
Consumption	28,68	**Stock quantity**	137

Arrival date	Quantity	Real weight	Pay weight	Transport cost	Ratio
20030107	20	1114	1993	162	6,8%
20030107	30	1671	2989	245	6,9%
20030107	30	1671	2989	242	6,8%
20030107	40	2228	3985	323	6,8%
20030107	50	2785	4982	404	6,8%
20030113	30				
20030113	35	1950	3487	283	6,8%
20030113	70	2625	6974	565	6,8%
20030114	30	1671	2989	272	7,7%
20030116	10	557	996	93	7,9%
20030120	20	1114	1993	181	7,7%
20030121	40	2228	3985	323	6,8%
20030123	20	1114	1993	162	6,9%
20030124	15	836	1495	136	7,7%
20030127	30	1671	2989	269	7,6%
20030127	30	1671	2989	272	7,7%
20030128	30	1671	2989	272	7,7%
20030130	35	1950	3487	317	7,7%
20030131	40	2228	3985	323	6,8%

The call-off quantities varies between 10 to 70 pieces and the quantities that arrive to SPA varies between 10 and 200. This is an example of how uneven the Kanban flows can be.

Appendix 9 – Supplier G

Supplier name	Supplier G	**Country**	DE
Transporter	Transporter B	**Transport cost**	2523 €
Material cost	255424 €	**Ratio**	1,0%
Part number	1353044	**Description**	Steering Gear
MCM	Kanban	**Packaging**	12
Price	318,23 €	**Line supply**	Kanban
Lead-time	6	**Safety stock time**	2
Transport time	3	**Pickup days**	Mon-Fri
Consumption	30,91	**Stock quantity**	139

Arrival date	Quantity	Real weight	Pay weight	Total weight	Transport cost	Ratio
20030107	40	1945	1945	2289	161	1,26%
20030110	24	1167	1167	1167	109	1,43%
20030113	40	2069	2069	3831	157	1,23%
20030114	32	1556	1556	1887	145	1,43%
20030116	24	1167	1167	1312	109	1,43%
20030116	32	1556	1556	1556	145	1,43%
20030117	32	1556	1556	1958	145	1,43%
20030120	72	3501	3547	3831	269	1,17%
20030121	32	1556	1556	1752	145	1,43%
20030122	40	1945	2285	2500	173	1,36%
20030123	32	1556	1556	1684	146	1,44%
20030124	24	1167	1167	1498	109	1,43%
20030127	32	1556	1556	1701	145	1,43%
20030128	40	1945	1945	2003	182	1,43%
20030130	40	1945	1945	2218	166	1,30%
20030131	32	1556	1556	1614	145	1,43%
20030131	40	1945	1945	2404	153	1,20%

This flow could be improved by just reducing the number of pickup days.

Appendix 10 – Supplier H

Supplier name	Supplier H	**Country**	GB
Transporter	Transporter C	**Transport cost**	1220 €
Material cost	15556 €	**Ratio**	7,8%
Part number	1354061	**Description**	Clamp pad
MCM	Kanban	**Packaging**	22
Price	11,19 €	**Line supply**	Kanban
Lead-time	7	**Safety stock time**	3
Transport time	3	**Pickup days**	Mon, Thu
Consumption	31,05	**Stock quantity**	360

Arrival date	Quantity	Real weight	Pay weight	Total weight	Transport cost	Ratio
20030109	200	1380	1380	3036	102	4,5%
20030116	80	520	520	1316	66	7,3%
20030121	80	527	667	1000	111	12,4%
20030123	40	236	325	325	54	12,1%
20030128	80	520	520	1316	66	7,3%
20030130	80	520	520	1316	66	7,3%

Here one can notice that the stock quantity is enough for almost 12 days of consumption.

Appendix 11 – Supplier I

Supplier Name	Supplier I	**Country**	DE
Transporter	Transporter B	**Transport cost**	6176 €
Material cost	58463 €	**Ratio**	10.6%
Part number	1370780	**Description**	Side skirt
MCM	Sequence	**Packaging**	Max 8 per rack
Price	93.03 €	**Line supply**	Sequence
Lead-time	5	**Safety stock time**	2
Transport time	2	**Pickup days**	Mon-Fri

Arrival date	Quantity	Total in racks	Pay weight	Volume	Transport cost	Ratio
20030106	3	4	1235	3.71	107	38.4%
20030106	6	6	767	2.30	83	14.8%
20030106	22					0.0%
20030108	15					0.0%
20030110	6	6	834	2.51	79	14.2%
20030113	12	16	1244	3.73	90	8.0%
20030114	8	8	834	2.50	91	12.3%
20030114	8	8	868	2.61	76	10.2%
20030115	7	8	844	2.53	74	11.4%
20030116	7	8	715	2.15	57	8.8%
20030117	8	8	868	2.61	76	10.2%
20030120	5	8	620	1.86	59	12.7%
20030121	16	16	2211	6.64	149	10.0%
20030122	16	16	1635	4.91	131	8.8%
20030124	5	6	723	2.17	63	13.6%
20030124	14	16	1402	4.21	123	9.4%
20030128	8	8	1184	3.56	104	13.9%
20030129	14	16	628	1.89	50	3.9%
20030130	1	2	722	2.17	63	68.0%
20030131	12	16	1201	3.61	105	9.4%

From the arrival 20030130 one can see how high the ratio is in the case when the packaging in not full.