Logistics and Transport Management

Master Thesis No 2003:6

# Gaining Competitive Advantage through Improved Management of Information and Material Flows

A Case Study at Flextronics Network Services

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ISSN 1403-851X
Printed by Elanders Novum

# Abstract

The future competitive advantage of a company will come from responding to customers needs at the end of the supply chain in a better way than competitors. Logistics plays a key role in this process. The underlying philosophy behind the logistics concept is planning and co-ordinating the material flows from source to user as an integrated system rather than managing the goods flow as a series of independent activities. The cost of purchased materials and supplies is a significant part of a total costs in most organisations, but there is also a major opportunity for leveraging the capabilities and competencies of suppliers through closer integration of the buyers' and suppliers' logistics processes.

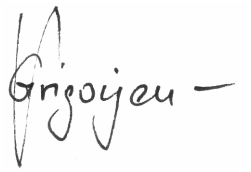
The purpose of this study is to investigate for Flextronics Network Services the current situation regarding tied up capital in the inventory and to formulate proposals that will reduce the tied up capital. Flextronics Network Services requested also a proposal of how the company could gain a competitive advantage with their project logistics in the future. In order to solve the problem, a case study was conducted with one business process in focus. To investigate the tied up capital in inventory, a mapping of material and information flows of one of Flextronics' business processes was carried out. To identify where in process information is generated and how the information could be used. The mapping was the tool for finding where information was occurred. When information flow was identified the articles were traced and by this mapping the tied up capital in inventory was calculated. A proposal for how reduce the tied up capital in inventory has been given. It consists of reducing or, if possible, eliminating demand and suppliers' uncertainties. For a company to gain a competitive advantage with its supply chain, it has to be co-ordinated together with other members of supply chain. This implies that there is a need for companies to integrate business processes across the supply chain, both internally and externally. Since the future competition will be between supply chains, the main pathway for FNS should be the integration of its supply chain by optimising it, first internally and then externally.

# Acknowledgements

We would like to thank Curt Pettersson at Flextronics Network Service for giving us the opportunity to do our Master thesis for Flextronics Network Services and for his support through the research process. We also thank Magnus Rickman for helping us with organisational questions, providing us with valuable contacts and information.

We are also grateful to all helpful people from Flextronics Network Services who have been involved in the research. Without your help this research would not have been possible to carry out.

Finally we would like to thank our tutor Ove Krafft, Senior Lecturer at the School of Business and Commercial Law, Göteborg University for his guidance through the research.



Maria Hogström Vladimir Grigorjev

Göteborg, December 2003

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3GIS - 3G Infrastructure Services, a consortium between Vodafone and 3

CLM – The Council of Logistics Management

ERP – Enterprise Resource Planning

FNS – Flextronics Network Services

OEM – the original equipment manufacturer

MRP – Material Requirement Planning

PTS – Swedish National Post and Telecom Agency, Post- och Telestyrelsen

SEK – the official abbreviation for the Swedish kronas

SKU – stock-keeping units

SUNAB – Swedish UMTS Network Ltd., Svenska UMTS Nät AB

ZM – the Zone Manager

UMTS – Universal Mobile Telecommunications System

USD – the official abbreviation for the American dollars

# 1 Introduction

*The aim of this chapter is to present the subject of this research project for the reader. Problem background, the company and its business environment description have led to the problem definition, purpose statement and research limitations.*

## 1.1 Background

Logistics has gone from being a military matter to being one of the key business issues today. The underlying factor to this situation is, in fact, that logistics is a cross-functional subject, cutting across functional boundaries. Logistics is the work required to move and position inventory throughout a chain of participants. From initial purchase of material or component, the system of logistics adds value by moving inventory when it is needed and where it is needed. Materials and components gain value at each step of their change into finished inventory.[1] A basic definition of logistics is as follows:

*"Logistics is the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and related information flows) through the organization and its marketing channels in such a way that current and future profitability are maximized through the cost-effective fulfilment of orders."* [2]

There are a number of theories and methods that are described in the business literature about how to succeed today and stay competitive in the future. Companies must recognise that the competition today is through their capabilities and competencies. By managing their core processes better than competitors manage theirs, organisations can create superior value for customers and consumers. The core processes include such activities as new product development, supplier development, order fulfilment, and customer management. If an organisation can perform these activities in a more cost-effective way than the competitors, the organisation will gain the advantage at the marketplace.[3]

[1] Bowersox, D. et al., 2002, page 44.

[2] Christopher, M., 1998, page 4.

[3] Christopher, M., 1998, page 28.

With the use of logistics management, the goal is to link the marketplace and the operating activity business in such a way that customers are served at higher levels and at a lower cost. A broader definition of logistics management that is widely used comes from The Council of Logistics Management (CLM) and is as follows:

*"Logistics management is that part of the supply chain process that plans, implements and controls the efficient, effective flow and storage of goods, services, and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements."* [4]

In this definition, compared to the first definition, flows of goods, services, and information are included in the sectors of manufacturing and service. During the last decades important aspects such as quality and information have arisen within this field, since these aspects have a direct influence on companies' flows efficiency. It is not enough to know what has to be done; there must also be knowledge about how it should be done.[5]

With the use of a total system viewpoint of logistics management, the needs of customers could be satisfied through the coordination of the materials and information flows that extend from the marketplace, through the operation environment of the firm and to the suppliers.[6]

Materials can be raw materials, components, parts, tools, consumables, services or any other types of item.[7] The material flow represents the supply of product through the network in response to demand from the succeeding organisation. Often it is difficult to see where the flow starts in the chain and where it ends. The negative effect of this is the build-ups of inventory and slow response to demands of the end customer.[8]

The stream of data in different directions with variable contents between various databases (departments) within a company is defined as information flow. Today the information flow within the logistics has become vital. This flow enables

[4] Stock, J. & Lambert, D., 2001, page 3.

[5] Lumsden, K., 1998, page 221.

[6] Christopher, M., 1998, page 13.

[7] Waters, D., 1996, page 588.

[8] Harrison, A. and van Hoek, R., 2002, page 11.

chains to respond on real time and accurate data. Companies today look at information flow as an asset, since it is not possible to have efficient and reliable material flow without it.[9] The major problem is to gather useful information from different sources within the company, adapt it for regular utilization and spread it within the company's internal and external supply chains. Only by doing so, will the company achieve higher degrees of information visibility and accessibility in the internal supply chain.

The inventory is a major use of capital and, for this reason, the objectives of inventory management are to increase corporate profitability, to predict the impact of corporate policies on inventory levels, and to minimize the total cost of logistics activities.[10] Employing an inventory does not have to be wrong, as long as it is dimensioned from established criteria. However, optimizing a storage is something done with respect to a shorter time perspective. In the longer perspective, optimizing is more about how to work with the conditions in order to minimize the inventory . Safety stock can be optimized from formulas, but should in the long term be minimized by removing insecurities, e.g. by choosing more reliable suppliers.[11]

Logistics is a cross-functional subject cutting across functional boundaries of the organisation in focus into the supply chain. This implies the complexities of synchronising the movement of materials and information between business processes. The system's nature of logistics has proved a particularly difficult lesson to learn, and individual organisations still often think that they can optimise profit conditions for themselves by exploiting others in the supply chain. The emergence of logistics has therefore been dependent on the development of a cross-functional model of the organisation and there has to be an understanding of the need to integrate business processes across the supply chain, both internally and externally. The future competitive advantage will come from responding to customers at the end of the supply chain better than competitors do, and in this response, logistics play a key role.[12]

[9] Mattsson, S-A., 2002, page 76.

[10] Stock, J. and Lambert, D., 2001, page 235.

[11] Lumsden, K., 2003, page 159.

[12] Harrison, A. and van Hoek, R., 2002, page XI.

## 1.2 The research arena

This research project was initiated by Flextronics Network Services, FNS, that have identified that decreasing tied up capital in inventory in the Contracting Department within FNS was needed. Additionally, the solution should be given for improving FNS' competitive advantage for the logistics in the future. The research project is concerned with the logistics of carrying out network projects within FNS. In the research project the focus is on the logistics performance at the Contracting Department. At present the focal point for the Contracting Department is projects within 3G implementation in Sweden.

## 1.3 Presentation of Flextronics Network Services

In this section, the company will be presented to the reader, specifically its historical background, corporate vision and values.

### 1.3.1 Flextronics Group

Flextronics International, a 13,4 billion USD multinational services firm with 95 000 employees worldwide, is headquartered in San José, USA. Flextronics International started its business in 1960s, and by the end of the 1990s was one of the world's fastest growing company. Flextronics is registered in Singapore and is listed on the NASDAQ stock exchange.[13]

Flextronics offers advanced engineering, design, manufacturing, distribution and network services to original equipment manufacturers (OEMs), including Cisco, COMPAQ, Ericsson, Hewlett-Packard, IBM, Lifescan, Lucent, Nokia, Philips, Song and WebTV.[14]

### 1.3.2 Flextronics Network Services

Flextronics' International subsidiary company, Flextronics Network Services (FNS), is a 850 million USD (fiscal year 2003) global provider with 6 500 employees is headquartered in Stockholm, Sweden. FNS has regional offices in the

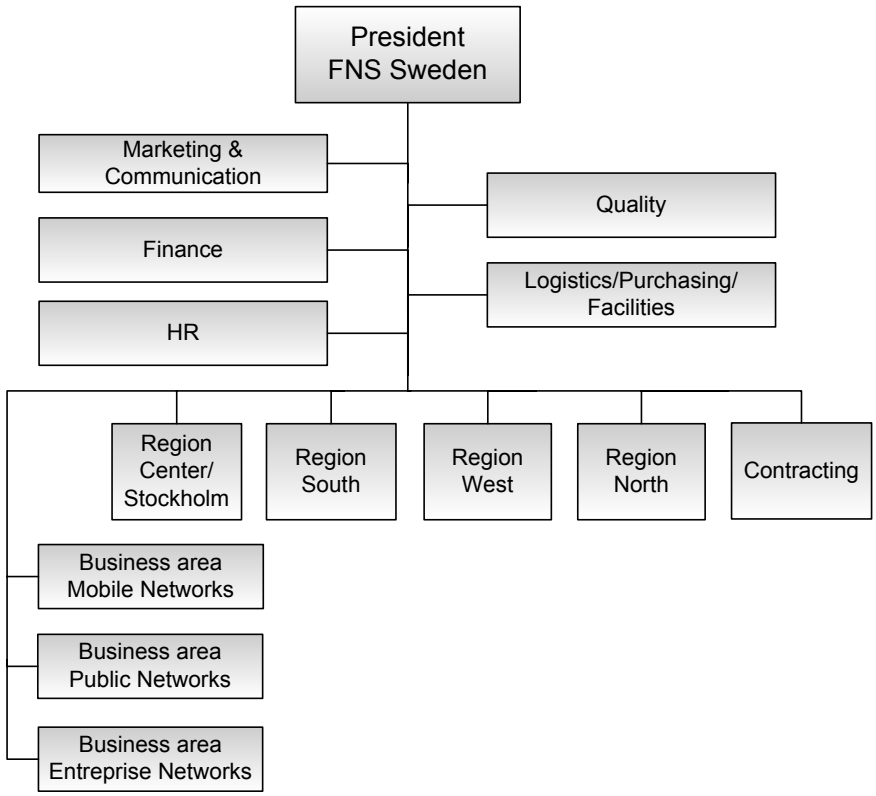
[13] http://www.flextronicsnetworkservices.com

[14] Ibid.

United States, Brazil, Denmark, Mexico, Norway, Finland, Venezuela, Singapore and Argentina.

When Hogström and Grigorjev started their investigation, FNS was in the middle of its organisational change. The present organisational structure of FNS Sweden is depicted in Figure 1.1. The formal structure is in Appendix 1.

Figure 1.1 Present structure of Flextronics Network Services.



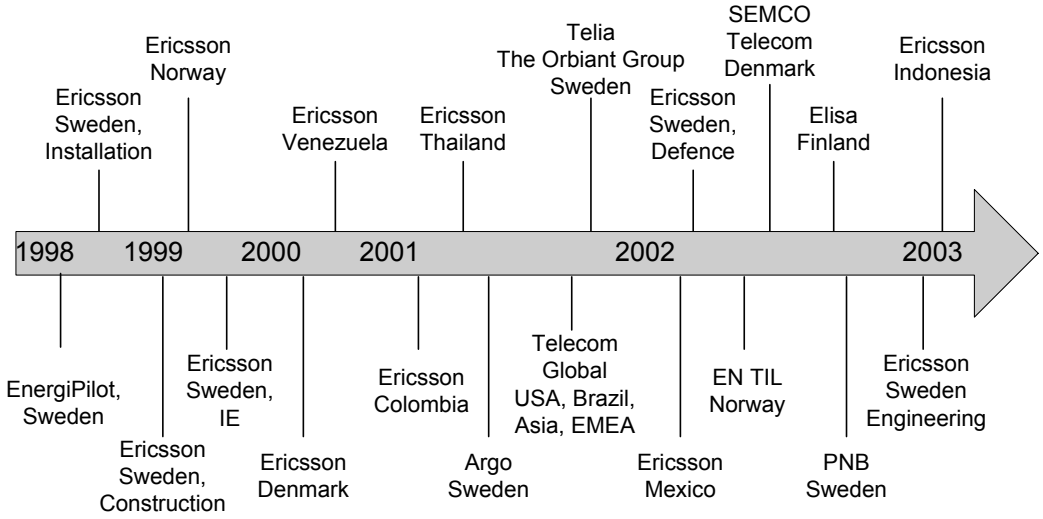

Source: Flextronics Network Services, 2003.

Flextronics Network Services was formed in 1997 with the acquisition of EnergiPilot, a small Swedish network installation company. In the next few years, Flextronics Network Services expanded globally through several outsourcing agreements with Ericsson in Sweden, Norway, Denmark, and Venezuela. More recently, Flextronics Network Services has grown in size as a result of further major acquisitions and outsourcing agreements involving Telia, Sweden; Elisa, Finland; En-til-en Tele, Norway; and Semco, Denmark (see Figure 1.2).[15]

[15] http://www.flextronicsnetworkservices.com

In Sweden, when Telia outsourced its Orbiant Group of six companies to Flextronics, it was one of the largest outsourcing programs for network services to date.[16]

Figure 1.2 Flextronics Network Services historical development.




Source: Flextronics Network Services, 2003.

### 1.3.2.1 Vision Statement and Core Values

Flextronics Network Services' vision is to become the preferred independent outsourcing partner for network services - the first choice for fixed and mobile operators and systems vendors around the world.[17]

Flextronics Network Services' core values: [18]

- Be prepared with high competence and broad experience to meet the increasing demands from the market.
- Be committed and motivated to find and deliver the smartest and most efficient solutions.

[16] http://www.flextronicsnetworkservices.com

[17] Ibid.

[18] Ibid.

## 1.4 3G Implementation in Sweden

On 16 December, 2000, The National Post and Telecom Agency[19] (PTS), decided to grant UMTS-licenses to Europolitan (Vodafone), HI3G (3), Orange and Tele2. All four operators made commitments to cover at least 99,98% of the population in Sweden as early as the end of year 2003.

Soon after the licenses granting, Tele2 and Telia, which did not receive a license, formed a joint company Svenska UMTS Network (SUNAB) for the development of 3G in Sweden. Also, Vodafone and 3 have established a joint venture, 3G Infrastructure Services (3GIS) in order to meet PTS requirements. Later, due to financial reasons Orange announced its withdrawal from the Swedish telecommunication market

PTS required from operators that the 3G networks shall be rolled out by 31st December 2003. On 1st March 2004, the 3G operators should submit status reports and details charts of the coverage to PTS.[20]

According to the consulting company, Northstream, there is a wide difference in European countries in requirements for the percentage of the population to be covered and the timing of the milestones. The highest requirements for population coverage are in Norway and Sweden. This means these operators have committed to a greater rollout pace.[21]

Five different 3G network service providers are struggling for 3G network rollout orders from three UMTS licences owners in Sweden. In order to make the current market situation more speculative, they are competing for the orders from only two consortia: SUNAB and 3GIS, and furthermore, one member of SUNAB joint-venture has the direct financial interest in one of the network service providers (TeliaSonera owns 49% of shares in Swedia Networks). It is obvious that 3G network implementation market in Sweden could be described as tense competi-

[19] Post- och telestyrelsen, PTS, the Swedish National Post and Telecom Agency, is the governmental authority for all issues relating to the telecoms, IT, radio and postal services. PTS also issues regulations and ensures that existing legislation is followed.

[20] Fact Sheet Time plan for the evaluation of 3G, PTS-F-2003:3, 2003.

[21] 3G rollout status, Version 1.2, PTS-ER-2002:22, Northstream 2002.

tion. Almost all market actors have the similar products and service portfolios. For further descriptions of market players see section 5.3.

## 1.5 Problem Definition

Within Flextronics Network Services there is a current task going on concerning coordination and improvement of logistics' flows and, especially, inventory management. One part of the company's business is tailor-made solutions according to customers' preferences; these activities are called *project logistics* within FNS. The company would like to have an investigation and evaluation made regarding total cost-efficiency of its project logistics with the focus on achieving a minimum of tied-up capital in inventory. Furthermore, the suggestion should include ways for improving customer service and how to gain competitive advantage for the company in the future.

## 1.6 Purpose

The purpose of the thesis is to investigate the current situation regarding tied up capital in the inventory and to formulate proposals that will contribute to reductions of the inventory tied up capital. Proposals should also be given for how the company could gain a competitive advantage with its project logistics in the future.

## 1.7 Limitations

As always, time puts constraints on what can be accomplished, and therefore in order to manage the investigation in this thesis one process is chosen. This research project will focus on one specific business process within Flextronics Network Services Sweden and the information and material flows that are linked to this process. The activities are analysed within the AAA (an anonymous customer of FNS) rigging process and, as a result, the proposals for improvement will be only formulated for the AAA rigging process. The process of its implementation is not considered in this thesis.

Furthermore, data in the form of calculations in this thesis has been altered and does not reflect the true figures at FNS due to the obligation to preserve confiden-

tiality. However, the proportions between the calculations carried out are maintained and reflect the reality.

## 1.8 Thesis Disposition

*Chapter 1. Introduction.* The aim of this chapter is to give an introduction to the research project. Problem background and the company and its business environment are presented in this chapter. The problem definition, purpose statement and research limitations are defined in the Introduction.

*Chapter 2. Theoretical Framework.* Theories that are applicable for problem area in this thesis are presented in this chapter. The literature search is split into four area: the first part is about logistics and its attributes in order to establish in what framework logistics could be studied; the second part is about the ways of mapping a process; the third part explains inventory management and how to calculate tied-up capital in inventory, when different circumstances exist and the last part is a desktop study about how to gain competitive advantage through logistics.

*Chapter 3. Research Questions.* The areas of research with following research questions are stated in this chapter.

*Chapter 4. Research Methodology.* In this chapter research approach is described in terms of data collection, method used and research evaluation.

*Chapter 5. Empirical Framework.* The empirical investigation is carried out in this chapter. The first and second research questions are covered in this chapter. At the same time, the third research question number 3 is placed in section 2.4 as it is a desktop study.

*Chapter 6. Analysis.* Hogström and Grigorjev analyse their findings from the previous chapter with empirical information. Firstly, after discussion with the company and evaluation of required information about inventory for analysis, Hogström and Grigorjev come to a decision which attempts an implementation of the Lead-time analysis approach in order to reduce inventory level for FNS. Secondly, analysis of current inventory management is carried out, which includes the examination of possible alternative models for safety and cycle inventories using

modified various inventory variables. Comparison and analysis of different values for tied up capital will be accomplished.

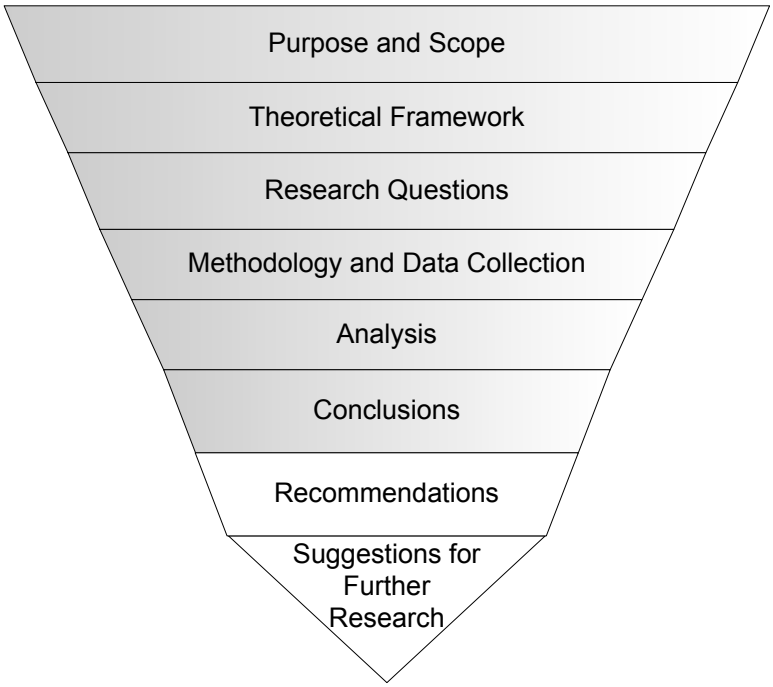
*Chapter 7. Conclusions.* Conclusions that are founded on the results of empirical chapter analysis are developed here.

*Chapter 8. Recommendations.* Practical recommendations for implementation are stated in this chapter.

*Chapter 9. Suggestions for Further Research.* Suggestions for further research that would be valuable for Flextronics Network Services in order to continue developing company's logistics system are presented in this chapter.

The final thesis disposition is presented in Figure 1.3.

Figure 1.3 Thesis disposition.



# 2 Theoretical Framework

*In this chapter Hogström and Grigorjev will present theories that are relevant to solve the of problems in this thesis. The literature search is split into four areas: the first part is about logistics and its attributes in order to establish in what framework logistics could be studied; the second part is about the ways of mapping a process; the third part explains inventory management and how to calculate tied-up capital in inventory, when different circumstances exist and the last part is a desktop study about how to gain competitive advantage through logistics.*

## 2.1 Logistics

The environment that companies do their business in is constantly changing; examples of this are the customer service which has gone through an extensive development; the global area of performance and the integration of organisations in order to achieve the ultimate goal which is to satisfy the customers.[22] But one of the most visible changes has been in the way which time has become a critical subject in management. Today product cycles are shorter than they used to be, customers and distributors take for granted just-in-time deliveries and end users are more willing to accept a substitute product if their first choice is not availably at once.[23]

In the past a company's capabilities have been to compete with the physical product and the functionality of the product and its quality. This is changing, since for a company to be an order winner, the offer has to include a service that is competitive. In an offer from a company today there is always a product and a service and the mix between these two will differ depending on the business. One important part of the service offered is activities that are related to logistics.[24] The physical product is not as important as the services that surround the product and the effort of logistics service is needed to compete and to satisfy the customer.[25]

[22] Christopher, M., 1998, page 23.

[23] Christopher, M., 1998, page 26.

[24] Mattsson, S-A., 2002, pages 35 and 36.

[25] Mattsson, S-A., 2002, pages 37 and 38.

For a company to stay competitive and to keep up with the development, the focus of logistics must shift. The focus of logistics has to adjust to the following:[26]

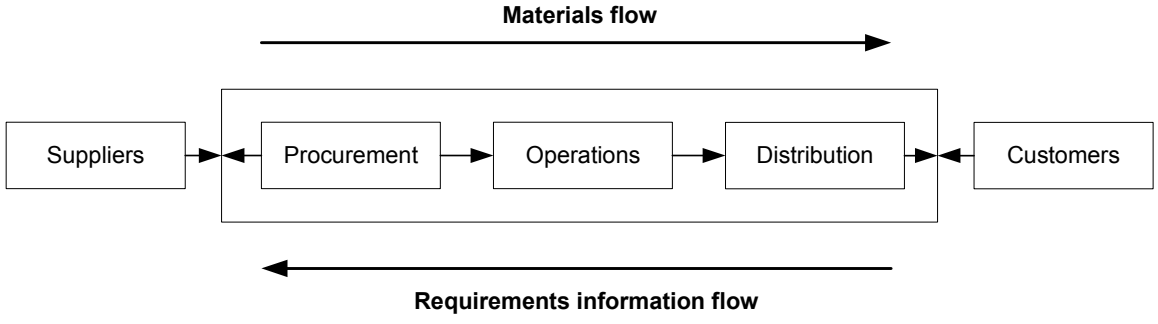
| From | To |
|---|---|
| Cut costs | Generate income |
| Satisfy customers | Successful partnership |
| Product orientation | Customer orientation |
| Focus on material flow | Focus on information- and material flow |

With the above focus in mind it is possible to develop solutions that are competitive to manage the material flow.[27]

### 2.1.1 Logistics and Its Attributes

Logistics best practise is presented as a work in progress, subject to a continuous change based on the evolving nature.[28] With the use of logistics management the goal is to link the marketplace and the operating activity business in such way that customers are serviced at higher levels and at a lower cost. According to Christopher with the use of a total systems viewpoint of logistics management (see Figure 2.1), the needs of customers could be satisfied through the coordination of the materials and information flows that extend from the marketplace, through the operation environment of the firm and to the suppliers.[29]

Figure 2.1 Logistics management process.




Source: Christopher, M., 1998.

[26] Mattsson, S-A., 2002, page 38.

[27] Ibid.

[28] Bowersox, D. et al., 2002, page 4.

[29] Christopher, M., 1998, page 13.

Logistics management focus is to optimize flows within the organizations and to have a planning orientation that seeks to create a single plan for the flow of product and information through a business.[30]

Stock and Lambert point out that information is not a process, but a key enabler of supply chain integration. Bowersox et al also point out that product flow always takes place only after information flows is initiated. Logistics is a functional silo within the companies, but it is also a bigger concept that deals with the management of material and information flows across the supply chain.[31]

Christopher points out that it has to be kept in mind that even if logistics is described as an integrative concept that seeks to develop a system-wide view of the firm, it is still primarily a planning concept. The mission of logistics management is to create a one-plan mentality within the business.[32]

Logistics in contrast to supply chain management is the work that is necessary to move and position inventory throughout a supply chain. Integrated logistics serves to link and synchronise the overall supply chain as a continuous process and is vital for effective supply chain connectivity.[33]

Over time there has been a growing recognition that it is through logistics and supply chain management that the twin goals of cost reduction and service improvement can be realized. The pipeline can, with better management, serve customers more effectively, at the same time the costs that deliver that service are reduced.[34] To study logistics, there has to be a basic understanding of supply chain management. The supply chain decisions establish the operating framework and logistics is performed within this framework.[35]

Logistics is the key conduit of product and service flow within a supply chain arrangement.[36] Logistics can be seen as part of the overall supply chain challenge

[30] Christopher, M., 1998, pages 16 and 17.
[31] Stock, J. and Lambert, D., 2001, pages 55 and 56.
[32] Christopher, M., 1998, page 14.
[33] Bowersox, D. et al., 2002, page 4.
[34] Christopher, M., 1998, page ix.
[35] Bowersox, D. et al., 2002, page 4.
[36] Bowersox, D. et al., 2002, page 6.

and often the terms logistics and supply chain management are used interchangeably, although Harrison and van Hoek also pinpoint that it has to be kept in mind that logistics is a subset of supply chain management.[37]

Logistics has always embraced the total system view and flow oriented aspect. On the other hand, supply chain embraces the whole chain with internal and external customers and therefore must the definition of logistics to be complete. Service has to be included since this has become more significant for the product offered by a company. Surrounding and added services constitute a larger and integrated part of delivered physical product today and should therefore be included in the material flow. With this understanding of supply chain, logistics is only a part of supply chain management.[38]

*"Supply chain management is the integration of key business process from end user through original suppliers that provides products, services, and information that add value for customers and stakeholders."*[39]

This is a definition of Supply Chain Management and it is much broader than the definitions of logistics. The most important difference is the management of the key business and they are: customer relationship management, customer service management, order fulfilment, manufacturing flow management, procurement, product development and commercialization and returns (see Figure 2.2). In addition to these key business processes is the product flow and information flow that take place in a supply chain. Supply chain management has been re-conceptualized from integrating logistics across the supply chain to integrating and managing the key business processes across the supply chain. This states that logistics management is only a part of the supply chain management. [40]

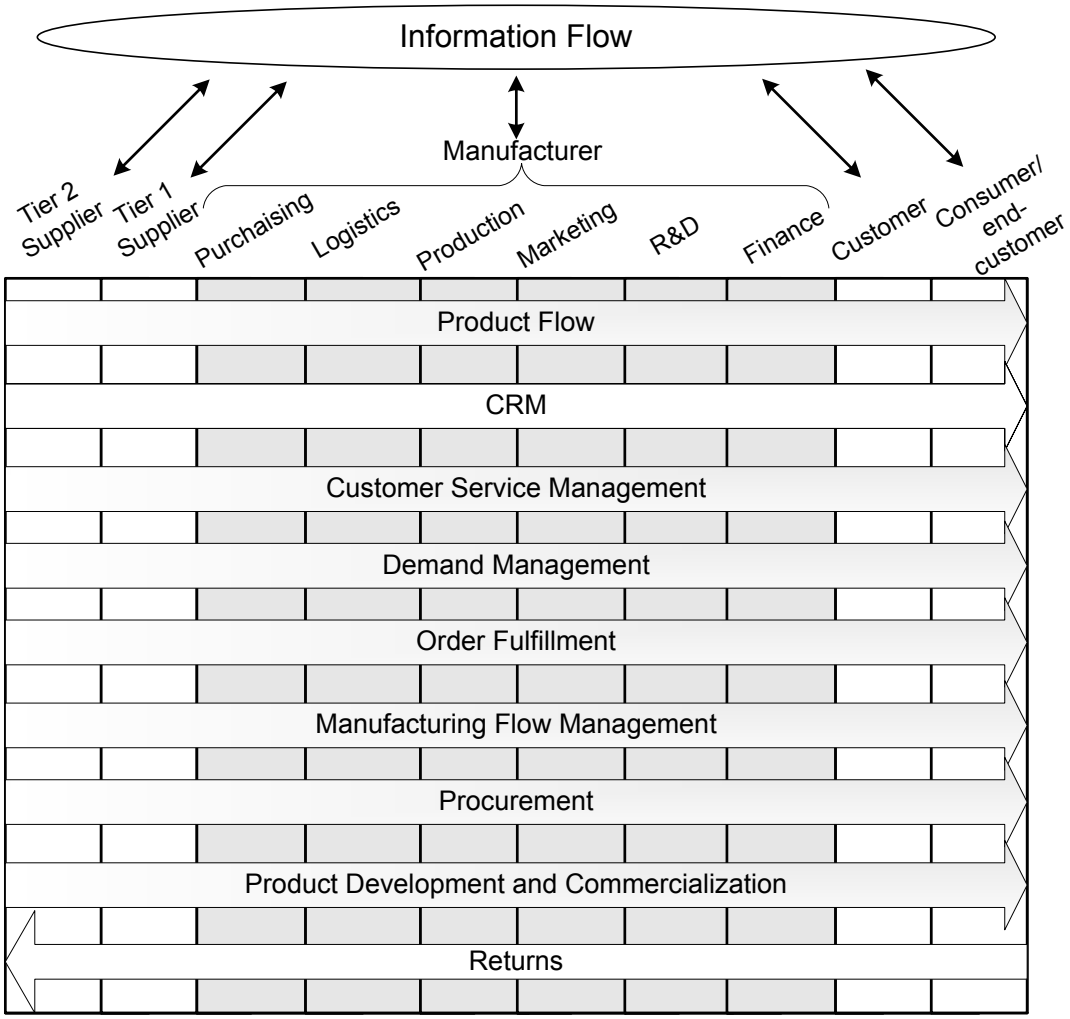
[37] Harrison, A. and van Hoek, R., 2002, page 6.

[38] Mattsson, S-A., 2002, pages 77 and 78.

[39] Stock, J. and Lambert, D., 2001, page 54.

[40] Stock, J. and Lambert, D., 2001, pages 54 ff.

Figure 2.2 Supply chain management: Integrating and managing business processes across the supply chain.




Source: Stock, J. and Lambert, D., 2001.

Authors used in this thesis tend to use several different subjects when explaining what attributes logistics have. In the end, the summary is that logistics' most significant attribute is probably that it is cross functional, it crosses boarders within the company and also crosses barriers to other companies. It is probably because of this cross functional attribute that definitions of logistics often include a definition that considers the links to the supply chain. It is easy to use logistics and supply chain interchangeably, but as it has been pointed out, logistics is a subset of the supply chain. Supply chain is concerned with key business processes within a company and logistics is primarily concerned with information and material flow. The cross functional attribute also makes it difficult to apply a system view on lo-

gistics, and therefore it is important for an organisation to have a strategy for logistics.

### 2.1.2 Flows in Logistics

Earlier in the chapter logistics has been described through its attributes and logistics is concerned with the flows within the chain. The flows of logistics are monetary, information, material and resources. Monetary flow is concerned with invoicing and payment, resource flow represents the resources that are needed to move the material within the chain and the material flow is the goods to be moved. The information flow is the initiator for both monetary flow and material flow.[41] In this thesis Hogström and Grigorjev will focus on material and information flow since the information flow is the initiator for material flow, and therefore these flows are in focus and explained below.

#### 2.1.2.1 Material Flow

The material flow represents the supply of product through the network in response to demand from the next organisation. The issue here is how long does it take to get the product through the various stages from one end of the chain to the other. The focusing on time is important here because it measures how quickly a given network can respond to demand from the end customer. Often it is difficult to see where the flow starts in the chain and where it ends. The negative effect of this is the build-up of inventory and the slow response to the demand of end customer.[42]

Therefore there are different strategies for managing inventory and the material administration, strategies for inventory will be further discussed in section 2.3. Normally material flow always goes from supplier to customer except when there exist reverse flow.[43] Bowersox et al prefer to call it inventory flow, this is probably referring to finished goods since business discussed are often manufacturing or retail business.

[41] Lumsden, K., 2003, page 31.

[42] Harrison, A. and van Hoek, R., 2002, page 11.

[43] Mattsson, S-A., 2002, page 73.

#### 2.1.2.2 Information Flow

Information is a collection of facts that is organized in such way that they have additional value beyond the value of the facts themselves. Data on the other hand consist of raw facts, such as an employee's name and number of hours worked in a week, inventory part numbers or sales order.[44] The value of information is directly linked to how it helps decision makers achieve their organization's goals.[45]

Today the information flow within the logistics has become vital as, this flow enables chains to respond in real time with accurate data. Companies today look at information flow as an asset, since it is not possible to have efficient and reliable material flow without it.[46] The material flow cannot be isolated from information flow. There are strong links between the physical flow and the information that flows both upstream and downstream. To manage and communicate a material flow today, IT is necessary. But an information system is not only IT solutions but also other communication and data processing that are linked to material flow.[47]

#### 2.1.2.3 Reflections regarding Material and Information Flow

There is no doubt that information flow is important and it is important to evaluate what kind of information adds value to the particular logistics system in focus. The ability to change data into useful information is essential; otherwise it will only be data. The term information is often used as if it is clear to anyone what information is, but this is not always the case. To transform data into information that is of no use only costs money. Therefore the companies or departments within a chain have to agree about what kind of information adds value before taking decisions on what information should be produced and shared.

In Christopher's discussion concerning material flow and information flow it has to be noticed that the information flow is concerned with requirements. The flow is only going in one direction and is concerned with customer requirements. Harrison and van Hoek agree with Christopher about material and information flow

[44] Stair, R. and Reynolds, G., 2001, page 4.
[45] Stair, R. and Reynolds, G., 2001, page 7.
[46] Mattsson, S-A., 2002, page 76.
[47] Lumsden, K., 1998, page 223.

and that the direction of information flow is from customer to supplier. Instead of calling it requirements, Harrison and van Hoek refer to it as demand.

According to Mattsson 2002 there is also an information flow in the other direction that is concerned with the issue of what is possible to obtain. Mattsson 2002 claims that it is not just the supplier who needs different types of information regarding requirements. Customers also need different information about what is possible to obtain in the struggle to be able to reach a shorter reaction time to market. Mattson 2002 also consider the monetary flow, as one of the logistics flows, and this is often invoicing and payment.

To Lumsden 1998 logistics is about material flow and the activities and the system that are linked to the material flow. Lumsden 1998 does not specify what activities these might be, but he says that material flow cannot be isolated from the flow of information and there are several strong links between the physical flow and the information that flows both upstream and downstream.

Logistics includes all the activities to move product and information to, from and between members of a supply chain according to Bowersox et al. Within the context of supply chain, Bowersox et al refers to five critical flows: information, product, service, financial and knowledge. Logistics is the primary conduit of product and service flow within a supply chain arrangement and the process of logistics is viewed in terms of two interrelated flows and that is information and inventory.[48]

What is common for all the authors used in this thesis is the material flow and information flow. The difference between the other flows is linked to the perspective the authors use when writing about logistics. The main difference is how they consider the flow of information and in what direction the flow goes. This is probably more linked to what levering the supply chain has reached and how closely the participants in the chain work. In the beginning it is probably a one-direction flow, and when the co-operation is more trusting and closer, the information flow will extend between the partners within the chain. The authors mentioned above point out that information has over the years become a vital part of

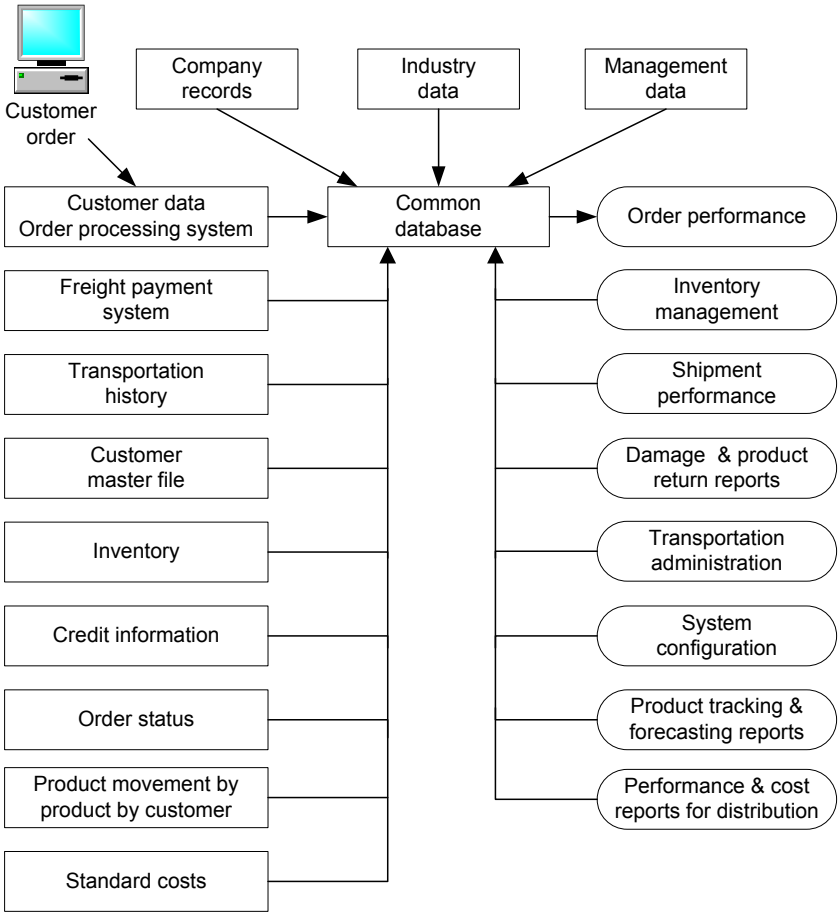
[48] Bowersox, D. et al., 2002, page 43.

the flow and sometimes even more important than the material flow. The enabler of this is the development of information technology.

### 2.1.3 Logistics Information Flow

The stream of data in different directions with variable contents between various databases (departments) within a company is defined as information flow. According to Stair and Reynolds, data for a logistics management information system can come from many sources.[49] At the same time, Stock and Lambert define the most important sources of data for the common database, which are the order processing system, company records, industry data, and management data[50] (see Figure 2.3).

Figure 2.3 The logistics information flow.




Source: Stock, J. and Lambert, D., 2001.

[49] Stair R. and Reynolds G., 2001, page 4.

[50] Stock, J. and Lambert, D., 2001, page 176.

Moberg et al identify two types of logistics information such as operational and strategic information. Operational information typically encompasses short-term, quantitative information about daily logistics/sales activities or status information on orders and inventory levels. It is primarily used to reduce order cycle times and inventory levels and to improve customer service. In contrast, strategic information covers long-term issues related to the firm's marketing, logistics, and other business strategies. This long-term, qualitative, and sensitive information is primarily used to improve collaboration among supply chain partners and plan future logistics practices based on upcoming strategy changes.[51]

Moberg's et al definition of operational and strategic information is almost equal to Bowersox's et al characterization of logistics information utilisation in two major logistics processes:[52]

*Planning/coordination*: the overall purpose of planning/coordination is to identify required operational information and to facilitate supply chain integration via strategic objectives, capacity constraints, logistics requirements, inventory deployment, manufacturing requirements, procurement requirements, and forecasting.

*Operations*: accurate and timely information to facilitate logistics operations. Operational information is required in six related areas: order processing, order assignment, distribution operations, inventory management, transportation and shipping, and procurement.

As a result, Bowersox et al name four reasons why timely and accurate information has become more critical for effective logistics systems' design and operations:[53]

- Customers perceive information about order status, product availability, delivery schedule, shipment tracking, and invoices as necessary elements of total customer service.

[51] Moberg C. et al., 2002, page 757.

[52] Bowersox, D. et al., 2002, page 233 ff.

[53] Bowersox, D. et al., 2002, page 192.

- With the goal of reducing total supply chain assets, managers realize that information can be used to reduce inventory and human resource requirements.

- Information increases flexibility with regard to how, when, and where resources may be utilized to gain strategic advantage.

- Enhanced information transfer and exchange capability utilizing the Internet is changing between buyers and sellers and redefining the channel relationships.

The authors mentioned above emphasize the importance of perceived information for logistics operational and strategic planning and performance. The major problem is to gather useful information from different sources within the company and adapt it for regular utilization. Quite often, companies have multiple information systems or databases operating in each department. Therefore, there is the additional challenge of how to connect all the systems in order to achieve a higher degree of information visibility and accessibility in the internal supply chain.

## 2.2 Ways of Mapping Processes

Process mapping is the visualising of the activities and objects of a process, and how their relationships are carried out. To map a process is to create a model of a process.[54] In this section Hogström and Grigorjev will go through different ways of business process mapping according to three different approaches presented by Harrison and van Hoek, and Mattsson. Harrison and van Hoek focus on time the activity takes. Mattsson 2003, on the other hand, points out that the time measured could also be the passing through time; he also suggests a process mapping that considers what departments or persons carry out the activity. Before the description of the possible ways of process mapping, an explanation of process definition is required.

[54] Ljungberg, A., 1998, page 103.

### 2.2.1 Business Process

Business process is defined as a coordinated sequence of activities that has its purpose to transform some kind of input to output. The input could be in form of information, material or payments.[55] The most typical characteristic for business processes, especially core processes that add value to the products and services, is that they reach across functional boundaries. Process perspective means organizing resources and responsibilities around core business processes instead of around tasks and functions.[56]

Processes often include customers and suppliers, although many companies have not reached the level to include external participants, but this does not mean that a process should not be mapped. Both Mattsson 2002 and Lumsden 1998 define process as either with internal or external customers. The next activity in the process should be regarded as a customer and should also be treated this way.

To make supply chains more effective, there is a need to improve the conditions regarding the exchanges and flows between companies. Due to the conditions that companies today meet on the market, a process oriented view has influence in the way they organise and conduct their business.[57]

### 2.2.2 Processing Mapping When Time is in Focus

The purpose of supply chain mapping is to give transparency to the processes within the supply chain. When a supply chain mapping is taking place it is the actual process that requires focus, not result. The key is to track one order, one product, or one person through the process with the respect to time. A map is a mirror of what takes place during a given time period and during this time period the actual time that it is observed is recorded. By mapping the process, key operations are still visible, but the subprocesses that often consume time and generate the greatest inefficiencies are revealed at the same time. This causes solutions to problems to be generated and thus the supply chain is improved.[58]

[55] Mattsson, S-A., 2002, page 191.

[56] Mattsson, S-A., 2000, page 271.

[57] Mattsson, S-A., 2002, page 80.

[58] Harrison, A. and van Hoek, R., 2002, page 122.

*Create task weakness:* Before the mapping process, the supply chain processes that cross all functions of the organisation need to be identified. This stresses the importance of the key functions to be represented.[59]

*Select the process to map:* To make the mapping process feasible, identify the core processes within the organisation and the time they take before deciding on the priorities for detailed mapping. When selecting the process, make sure that there is a generic customer or group of customers that the process serves.[60]

*Collect data:* The most effective way to collect data is simply to follow the item through the process, also referred to as walking the process. An actual component or order will be followed through all stages that are included in the process. It is important to identify those individuals who are actively involved in the process and really knows what is happening. Each movement of the item should be described with respect to time.[61]

*Distinguish between value-adding and non-value-adding time:* Value-adding time is time when something takes place on the item that the end customer is willing to pay for. It is important that the definition of value-adding takes place within the organisation and the definition should be associated with the overall business strategy. When there is an understanding of the value-adding criteria at the strategic level, these criteria can be translated into value-adding criteria at an operational level. There are three criteria that are characterised for value-adding time:[62]

- If the process or elements physically change the nature of consumable item.
- If a change to the consumable item produces something that the customer values or cares about and also is willing to pay for.
- If the process is right the first time, and will not have to be prepared in order to produce the desired result, that is valued by the customer.

[59] Harrison, A. and van Hoek, R., 2002, page 122.
[60] Ibid.
[61] Harrison, A. and van Hoek, R., 2002, page 123.
[62] Ibid.

The non-value adding activity can be split into four categories: delay, transport, storage and inspection.[63]

*Construct the time-based process map:* The overall purpose of the time-based process map is to represent the data that is collected clearly and concisely. By doing this the critical aspects of the supply network can be communicated in an easily accessible way. If the process can be represented on a single piece of paper the members of the project can easily see the issue. To extract the relevant data, it is useful to sketch a flow diagram so that the linkages and dependencies between steps can be clarified before constructing the map. The flow diagram can be used to estimate the total time that the business process consumes.[64]

Figure 2.4 Example of process map.

| Step | Description | Symbol | Time | Notes |
|---|---|---|---|---|
| 1 | Machine complete | **O** | 1:37 | |
| 2 | Inspect | □ | 0:45 | |
| 3 | Wait transport | **D** | 5:53 | |
| 4 | Transport to heat treat | → | 0:08 | |
| 5 | Wait heat treat | **D** | 3:34 | |
| 6 | Heat treat | **O** | 4:15 | |

→ - transport ▼ – store O – operation □ – inspect D – delay

Source: Harrison, A. and van Hoek, R., 2002.

*Solution generation:* When the time-based process map has been produced, the opportunities for improvement are generally obvious. The next step is to collect ideas and categorise causes of non-value-adding activity by using problem-solving approaches.[65]

### 2.2.3 Process-Analysis and Function-Flow-Schedule

The process or processes that are in focus for redesign ought to be defined from the beginning to the end and the customers of the process should also be known.

[63] Harrison, A. and van Hoek, R., 2002, page 123.

[64] Harrison, A. and van Hoek, R., 2002, pages 123 and 124.

[65] Harrison, A. and van Hoek, R., 2002, page 124.

The next step with the rationalisation of the process is to map out and describe how the process/processes look at the present moment. This will always be a subject for discussion, but even if the process is known, the knowledge about how the total process functions is often poor. In a functional organisation every individual will have good knowledge about the activities that take place within that department. But since processes are cross-functional, the case is often that no one at the company has the knowledge about how the different processes look. Since processes also cross between companies, personnel from both supply and customers should participate in the work of analyse and redesign.[66]

There are different means that could be used when mapping out the process, but below there will be a presentation of two: process-analyse-schedule and function-flow-schedule.

#### 2.2.3.1 Process-Analysis-Schedule

The purpose of process-analyse-schedule is to map out and to document in what order the different activities within the process of the study occur. This is of great value when there is a need to study the time and the cost for carry out different activities. The figure below gives an example how the schedule might look.[67]

Figure 2.5 Process-analysis-schedule

| No. | Activity decsription | Time | Cost | Type of activity |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

Source: Mattsson, S-A., 2002.

In the form the processes are noted in the order that they are carried out. The time it takes is noted and also the cost. The time it takes could be of two different kinds, the actual time it takes to do the activity or the passing through time for the activity at each department. In the form there is also space to note what kind of

[66] Mattsson, S-A., 2002, page 263.

[67] Mattsson, S-A., 2002, page 264.

activity it is. For example, it could be that something is actually done, or it is waiting, or in transport or in a warehouse. With help from the noted time required and the cost, the total cost and total time required can be calculated for the process as a whole.[68]

#### 2.2.3.2 Function-Flow-Schedule

The function-flow-schedule not only shows the activities that are carried out but also in what order they are carried out. The schedule also shows who carries out the activity. Who in this case could be an individual or a department. If this is a schedule of a supply chain process, this will also include in what company the individual or department is to be found.[69]

Figure 2.6 Function-flow-schedule.

| Department A | Department B | Department C | Department D | Department E | Department F |
|---|---|---|---|---|---|
| Activity 1 | | | | | |
| | Activity 2 | Activity 3 | Activity 4 | | |
| | | | Activity 5 | | |
| | | | Activity 6 | Activity 7 | |
| | | | | Activity 8 | Activity 9 |

Source: Mattsson, S-A., 2002.

The function-flow-schedule is particularly useful when there is a need to map out how many individual and departments are involved in a process and whether the activity is executed in the different departments. This is useful when there is a wish to rationalise the process by redistributing and/or combining activities between different individuals.[70]

When all of the activities and connections between the activities are mapped, the processes should be critically analysed. A way to do this is to systematically question the activities by asking the following questions:

[68] Mattsson, S-A., 2002, page 265.

[69] Ibid.

[70] Ibid.

| | | |
|---|---|---|
| What? | The purpose of the activity | Why must this activity be done |
| Where? | The place for that particularly activity | Why must is be done at this particularly place |
| When? | The sequence in what the activity is performed | Why must it be performed at this moment |
| Who? | The individual who carry out the activity | Why must it be this individual |
| How? | The way the activity is carried out | Why must the activity be carried out in this way |

The overall purpose is to ask these questions for each of the activities and try to eliminate, combine, change or simplify the different activities that are carried out in the process that should be rationalised.[71]

Walking a process is necessary if an investigator wants to find out where does the process begins and ends. The different models described above are more or less the same. Harrison and van Hoek's model and the Process-Analyse-Schedule by Mattsson identify activities within the process, time, type of activity and cost. There is a possibility to combine them and add the column with costs used in the Harrison and van Hoek model. The third approach, Mattsson's model Function-Flow-Schedule, is used to illustrate how many departments or persons are involved in a process. It is important to realise that the activities in the same column are not carried out simultaneously. The Function-Flow-Schedule model only highlights the number of departments or persons involved in the process. By using the model, in the way it is proposed above, it could give a false picture of the situation. Therefore it could be a better to illustrate the process according to the adjusted model below:

[71] Mattsson, S-A., 2002, page 266.

| Dep. A | Dep. B | Dep. C | Dep. D | Dep. D | Dep. D | Dep. E | Dep. E | Dep. D |
|---|---|---|---|---|---|---|---|---|
| Act. 1 | | | | | | | | |
| | Act. 2 | | | | | | | |
| | | Act. 3 | | | | | | |
| | | | Act. 4 | | | | | |
| | | | | Act. 5 | | | | |
| | | | | | Act. 6 | | | |
| | | | | | | Act. 7 | | |
| | | | | | | | Act. 8 | |
| | | | | | | | | Act. 9 |

## 2.3 Inventory Management

The Institute of Logistics and Transport has the following definition of inventory management:

*"The effective management of stock, materials, parts and finished products, including additions and deletions (i.e. control of movements in and out). Essential for determining capital investment returns and viability of stock levels and for the avoidance of opportunity cost (i.e. money tied up in stock that could be better used)."* [72]

In theory, the best solution for a company in servicing its customers would be to locate an inventory in each facility that is closest to the customer. There are not many companies that could afford such a luxurious inventory commitment because the costs are discouraging. Therefore, according to the definition, the objective of the effective inventory management is to accomplish desired customer service with the minimal inventory level followed by lowest tied up capital in inventory.

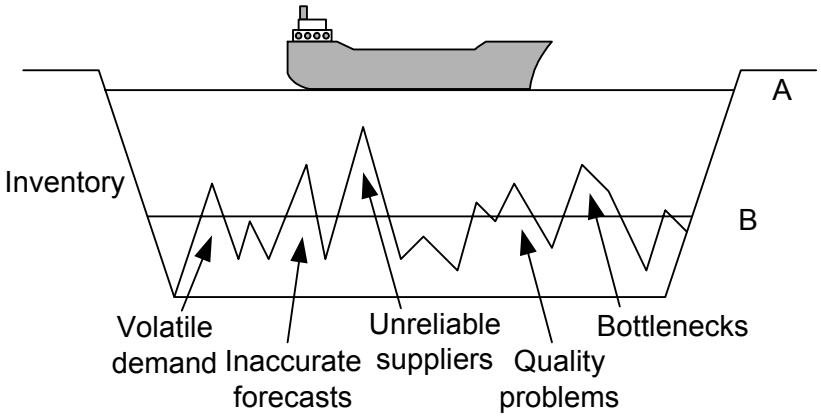
Lumsden states that having an inventory does not have to be wrong, as long as it is dimensioned from established criteria. However, optimizing a storage is something done with respect to a shorter time perspective. In the longer perspective, optimizing is more about how to work with the conditions in order to minimize the inventory. Safety stock can be optimized from formulas, but should in the

[72] Lowe, D., 2002, page 129.

long term be minimized by removing insecurities, e.g. by choosing more reliable suppliers.[73]

On the other hand, Christopher notes that the existence of an inventory can be sign that the logistics process is not stable enough.[74] Lumsden and Christopher illustrate the inventories function with help of Japanese manufacturing philosophy, "The Japanese Sea", which was developed from the concept of removing all inventories in order to identify problems in the company's logistics processes. In other words, lowering the inventory levels discloses problems that were previously hidden.

Figure 2.7 The Japanese Sea: Inventory hides the problems




Source: Christopher, M., 1998.

The inventories are still used among the companies and, of course, the companies do not have to hustle to lower or/and eliminate its inventories. It is almost impossible as well as dangerous for a company to make an effort to solve all previously hidden problems immediately. Obviously, the cautious step-by-step process of lowering the inventory levels in combination with the total logistics cost analysis would be the best solution in this situation.

It is not a mistake to use inventories. However, the utilization of inventory demands effective inventory management with defined inventory policy, order quantities, and inventory service levels. The objective of inventory management is to improve the corporate profitability and increase customer service level with mini-

[73] Lumsden, K., 2003, page 159.

[74] Christopher, M., 1998, page 186.

mal tied up capital in inventory. However, the inventory management strategy has to be seen in the greater perspective of the total logistics cost concept (see Section 2.4.2.) with possible negative consequences for other logistics costs. Furthermore, in the longer perspective, a company has to try to remove insecurities in the supply chain by establishing collaboration with strategic suppliers.

### 2.3.1 Purpose of inventory

Waters points out that the main purpose of inventories is to act as a buffer between supply and demand. They allow operations to continue smoothly and avoid disruptions. Waters names some other reasons for holding inventories: [75]

- To act as a buffer between different operations
- To allow for demands that are larger than expected, or at unexpected times
- To allow for deliveries that are delayed or are too small
- To take advantage of price discounts on large orders
- To buy items when price is low and expected to rise
- To buy items that are going out of production or are difficult to find
- To make full loads and reduce transport costs
- To give cover for emergencies.

### 2.3.2 Types of Inventory

There are different approaches to classifying inventories. Lumsden 2003 categorizes the inventories that are the process-based (storages, component inventory, consumption material and work in process), the flow design-based inventories(buffer, process and transportation) and, finally, the function-based inventories which reminds us of Stock and Lambert classification. In this paper, the invento-

[75] Waters, D., 1996, page 608.

ries will be described according to Stock and Lambert from a function-based point of view.

Inventories can be categorized into the following types, signifying the reasons for which they are accumulated:[76]

*Cycle inventory* is inventory that results from the replenishment process and is required in order to meet demand under conditions of certainty – that is, when the firm can predict demand and replenishment times (lead-times) perfectly.

*In-transit inventory* inventories are items that are en route from one location to another. They may be considered part of cycle inventory even though they are not available for sale and/or shipment until they arrive at the destination.

*Safety or buffer stock* is held in excess of cycle inventory because of uncertainty in demand or lead time. The notion is that a portion of average inventory should be devoted to cover short-range variations in demand and lead-time.

*Speculative inventory* is inventory held for reasons other than satisfying current demand. For example, materials may be purchased in volumes larger than necessary in order to receive quantity discounts, because of a forecasted price increase or material shortage, or to protect against the possibility of a strike.

*Seasonal inventory* is a form of speculative inventory that involves the accumulation of inventory before a season begins in order to maintain a stable labour force and stable production runs.

*Dead inventory* is the set of items for which no demand has been registered for some specified period of time.

### 2.3.3 Inventory management performance measurement

To be able measure inventory management performance, Hogström and Grigorjev will apply inventory turnover rate and inventory service level.

[76] Stock, J. and Lambert, D., 2001, page 232.

#### 2.3.3.1 Inventory turnover rate

The turnover rate of the storage is defined as the number of times per year storage is turned over.[77] According to Lumsden, there are different ways of calculating Inventory turnover rate that depend on institutional to company dependent relations.[78]

Hogström and Grigorjev will apply estimating Inventory turnover rate, which is provided by Lumsden since it covers tied up capital:

$$Inventory\ turnover = \frac{Turnover}{Tied\ up\ capital} \qquad \text{Equation 2-1}$$

#### 2.3.3.2 Inventory Service Level/Fill Rate

There are different names for fill rate in the logistics literature, although all of them have a similar characterization for inventory management. Fill rate is directly associated with service level. Lowe states that service level is the desired probability that a demand can be met from inventory which can be expressed in a number of ways, such as in case of inventory management percentage of units demanded which are met from inventory.[79] Stock and Lambert use the term "fill rate" which means the percentage of units that can be filled when requested from available inventory and thus affect customer service level.[80] Bowersox et al define service level as a performance target that is measured in terms of order cycle time, case fill rate, line fill rate, order fill rate, or a combination of these.[81] Christopher associates the customer service level to additional inventory required to satisfy customer demand.[82] Lumsden characterizes the service level concept as relation between probability for stockout and service level.[83]

[77] Lumsden, K., 2003, page 160.
[78] Lumsden, K., 2003, page 162.
[79] Lowe, D., 2002, page 220.
[80] Stock, J. and Lambert, D., 2001, page 249.
[81] Bowersox, D. et al., 2002, page 74.
[82] Christopher, M., 1998, pages 53 ff.
[83] Lumsden, K., 2003, page 174.

One way of increasing service level without increasing the number of items in safety stock is to substitute transportation costs for inventory carrying costs by using faster and more reliable modes of transport to improve customer service. Another possibility is to distinguish the differences in demand variations with each product and set inventory levels according to product categories.

### 2.3.4 Inventory Carrying Costs

Inventory carrying costs, the costs associated with the quantity stored, include a number of different cost components and generally represent one of the highest costs of logistics.[84]

*Capital costs*. The company's cost of capital – the rate of return that could be realised from some other use of the money – should be used to accurately reflect the true cost involved. In companies experiencing capital rationing, the interest rate (which is the minimum rate of return on new investments) should be used as the cost of capital.[85]

In order to calculate the company's total cost of capital, the calculation should cover the tied up capital during different production stages, such as safety stock, average cycle inventory and cost for inventory in transit:

$$\textit{Cost of capital} = \textit{Cycle inv.} \times I + \textit{Safety inv.} \times I + \textit{Inv. in transit} \times I \qquad \text{Equation 2-2}$$

Then the calculation of the holding costs for cycle inventory is:

$$\textit{Holding costs for cycle inventory} = \frac{Q}{2} \times C \qquad \text{Equation 2-3}$$

where, $Q$ - the order quantity, $I$ - interest rate, $C$ - cost per unit

To calculate the cost of holding inventory in transit in which the following formula can be applied:

$$\textit{Inventory in transit} = D \times T \qquad \text{Equation 2-4}$$

[84] Stock, J. and Lambert, D., 2001, page 193.

[85] Stock, J. and Lambert, D., 2001, page 196.

where, $D$ - the average flow per time unit (the order quantity times number of orders), $T$ - transit time

*Inventory service costs* that include insurance and taxes on inventory.

*Storage space costs* which include those warehousing space-related costs that change with the level of inventory.

*Inventory risk costs* including obsolescence, pilferage, movement within the inventory system, stockout costs and damage.

According to the problem definition, Hogström and Grigorjev will focus only on the calculations of tied up capital and capital costs for inventory, especially those of cycle and safety stock.

### 2.3.5 The Importance of Cash Flow

If a company receives or gives credit the tied up capital is displaced, and the inventory has not changed, but regardless of the inventory level, the tied up capital is not affected until cash flows out or in. When a company gives one month credit it has to tie up that capital for one more month. On the other hand, if the company is given one month credit and does not by itself give any credit, the capital needed is reduced by the same amount. The importance of credit time often is not valued enough. There is a good reason for a company to investigate the credit a company gives and gets.[86]

### 2.3.6 Inventory Management under Uncertainty

Nowadays companies operate in rapidly changing business environment. New opening markets, altering governmental regulations, increased competition on the markets, changes in customers' buying behaviour and other macro factors affect companies' way of doing business.

The issue of coping with uncertainty is important as it exists in a realistic operating environment. Uncertainty exists in the production system in many different ways.

[86] Storhagen, N., 1997, page 75.

The demand for the product and (replacement) parts is typically forecast, and as a result has a certain degree of uncertainty with respect to both the quantity demanded in a particular time period, and the timing of the quantity demanded. The uncertainty in the quantity demanded is obvious; however, there also often exists an uncertainty in timing. Another major source of uncertainty exists at the supply (purchased items) level. This could again occur in the form of quantity, timing, or both.[87]

Stock and Lambert believe that management has the option of either maintaining additional inventory in the form of safety stocks or risking a potential loss of sales revenue due to stockouts.

Hogström and Grigorjev have carried out a literature search about buffering against uncertainty and will introduce below one of the most common technique for decreasing insecurities in inventory management – safety stock technique.

#### 2.3.6.1 Safety Stock Calculations

The calculation of safety stock level that is necessary to satisfy customer demand during a replenishment cycle can be determined by computer simulation or statistical techniques. The statistical technique for variations of demand, and replenishment cycle, and additionally, for only variations in demand are introduced below.

*Safety stock calculation in case of demand variations and constant replenishment cycle*

According to Lumsden, in case of constant replenishment cycle lead-times or lack of statistical data for suppliers' performance, the calculation of safety stock level with variations in demand can be expressed as:[88]

$$SS = Z\sigma_s \sqrt{R} \qquad \text{Equation 2-5}$$

where

[87] Guide, V. and Srivastava, R., 2000.

[88] Lumsden, K., 2003, page 174.

$SS$ - the safety stock level, $Z$ - the safety factor, $\sigma_s$ - the deviation of daily sales (demand), $R$ - replenishment cycle (lead-time)

The standard deviation formula is:

$$\sigma_s = \sqrt{\frac{\sum fd^2}{n-1}} \qquad \text{Equation 2-6}$$

where

$f$ - frequency of event, $d$ - deviation of event from mean, $n$ - total observations.

There is no need of any safety stock if the deviation is decreasing the demand since it will be covered by the normal cycle inventory, i.e. in 50% of all cases. The service level concept might then be expressed as:[89]

$$Service\ level = SL = 1 - probabilty\ for\ stockout \qquad \text{Equation 2-7}$$

The meaning of this is that a service level of up to 50%, i.e. that every second customer order cannot be supplied, does not need any safety stock. The likelihood of a customer accepting this low service level is small, at least if he is an external customer with any other alternative. Hence, a safety stock has to be created to increase the service level.[90]

According to Lumsden 2003, the safety factor is only connected to the percentage of the demand that is above the safety stock, i.e. which defines the stockout and thereby also the service level. A progressively larger safety stock is required to reach a higher service level or a possibility to satisfy orders. The costs to keep a high level service do not increase proportionally. A one percent improvement of the service level is far more expensive the higher service level the company has.[91]

[89] Lumsden, K., 2003, page 174.

[90] Lumsden, K., 2003, page 175.

[91] Ibid.

*Safety stock calculation in case of demand and replenishment cycle variations*

In contrast with the previous calculation, additional data about variations in replenishment cycle lead-time is needed. Once the data are collected it is possible to specify the safety stock requirements by using the following formula:[92]

$$\sigma_c = \sqrt{\overline{R}(\sigma_s^2) + \overline{S}^2(\sigma_R^2)} \qquad \text{Equation 2-8}$$

where $\sigma_c$ - units of safety stock needed to satisfy 68% of all probabilities (one standard deviation), $\overline{R}$ - average replenishment cycle, $\sigma_s$ - standard deviation of daily sales, $\overline{S}$ - average daily sales, $\sigma_R$ - standard deviation of the replenishment cycle.

The calculation of the required safety stock level is:[93]

$$SS = Z \times \sigma_c \qquad \text{Equation 2-9}$$

where $SS$ - safety stock in units, $Z$ - the safety factor, $\sigma_c$ - the combined standard deviation.

## 2.4 Gaining Competitive Advantage

Organisations that will be leaders in the markets of the future will be those that have sought and achieved the twin peaks of excellence; they have gained cost leadership and service leadership. The underlying philosophy behind the logistics concept is that of planning and co-ordinating the materials flows from source to user as an integrated system rather than managing the goods flow as a series of independent activities. Under a logistics management system the goal is to link the marketplace, the distribution network, the manufacturing process and the procurement activity in such way that customers are serviced at higher levels and yet at lower cost.[94]

[92] Stock, J. and Lambert, D., 2001, page 245.

[93] Stock, J. and Lambert, D., 2001, page 249.

[94] Christopher, M., 1998, pages 12 and 13.

Today, it is generally accepted that the need to understand and meet customer requirements is a condition for survival. For a company to meet customers' requirements it is not possible for functions within a company to act independently of each other. Leading-edge companies include supply-side issues in the development of their strategic plans (the concept of strategy is explained further down in this chapter). The cost of purchased materials and supplies is a significant part of a total costs in most organisations, but there is also a major opportunity for leveraging the capabilities and competencies of suppliers through closer integration of the buyers' and suppliers' logistics processes.[95] Before going into how to achieve an integrated supply chain, the concept of functional and process perspective of business processes, the total cost concept and time-based management will be explained below.

### 2.4.1 Competing Through Logistics

Companies today can no longer act as an isolated and independent entities in competition with other similarly stand-alone organisations. In the past the ground rules for success were strong brands backed up by large advertising budgets and a selling that was aggressive. Companies today must recognise that the competition today is through their capabilities and competencies. By managing their core processes better than competitors manage theirs, organisations can create superior value for customers and consumers. The core processes include such activities as new product development, supplier development, order fulfilment, and customer management. If an organisation can perform these activities in a more cost-effective way than the competitors, the organisation will gain the advantage in the marketplace.[96]

Stock and Lambert believe that just like a good product, promotion, and/or pricing strategy, logistics can be a source of competitive advantage for a firm. Competitors can develop competing products in a short time but logistics is difficult to duplicate. Many organisations have recognized that logistics competency holds the key to developing or maintaining continued business success.[97]

[95] Christopher, M., 1998, page 14.

[96] Christopher, M., 1998, page 28.

[97] Stock, J. and Lambert, D., 2001, page 42.

The researchers cited in this thesis are all convinced that there is a possibility of achieving competitive advantage through logistics. They also states that is difficult to achieve this competitive advantage by themselves; it has to be reached in a network or chain, together with other companies who are world class in their respective areas. The key enabler to this is information and to what extent companies share information between them. The road to reach a level of the supply chain where the information is transparent is long. Not all companies reach this level, but those who have developed world-class logistics competency have the benefit of enjoying competitive advantage as result of providing important customers superior service. The literature refers to supply chain as it exists within all companies and information is shared between partners. This if far from the reality. Many companies are still struggling to streamline and adjust their activities within the company in order to reach a competitive advantage[98].

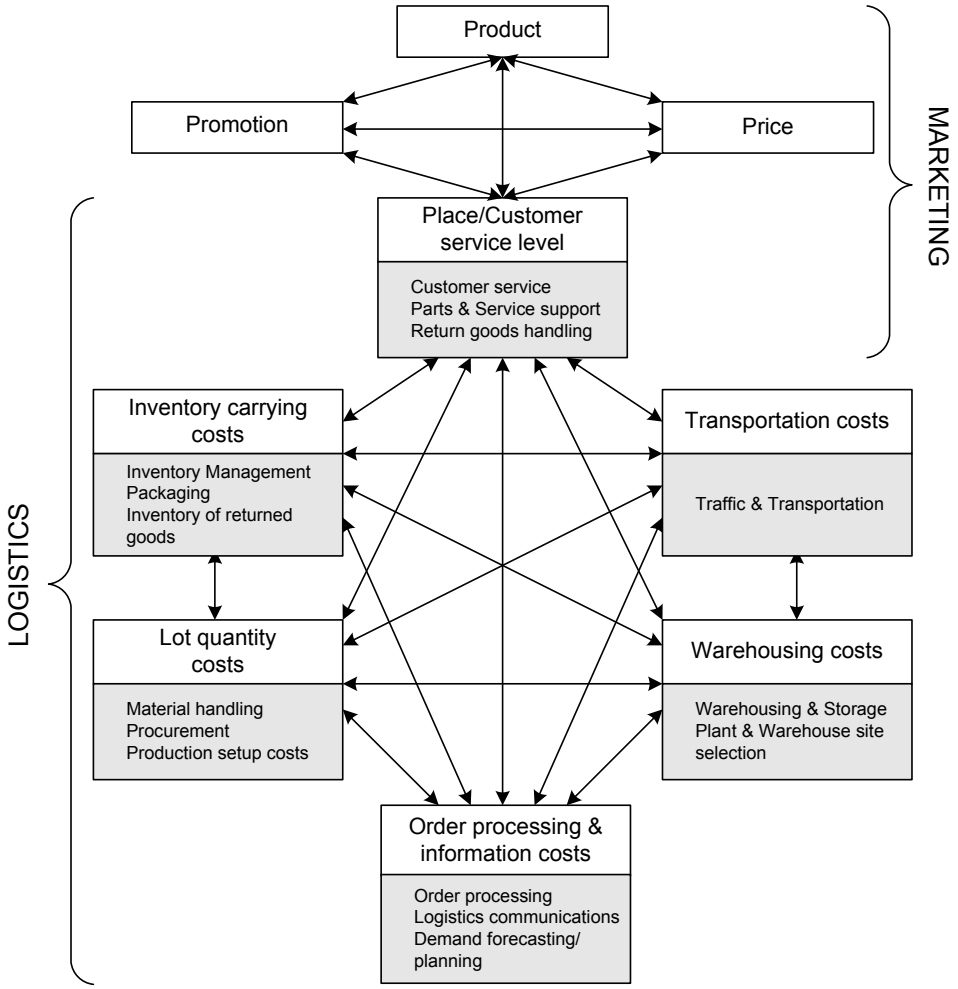
### 2.4.2 The Total Cost Concept

Lambert and Stock have a broad perspective on total logistics costs. Total cost analysis is the key to managing the logistics function. One of major goals of the organisation should be reducing the total costs of logistics activities rather than focusing on each activity in isolation. Reductions in one cost invariably lead to increases in the costs of other components. Effective management and real cost savings can be accomplished only by viewing logistics as an integrated system and minimising its total cost given the firm's customer service objectives.[99]

[98] Poirier, C., 1999, page 4.

[99] Stock, J. and Lambert, D., 2001, page 28.

Figure 2.8 Logistics' role in the economy and the organisation.




Source: Stock, J. and Lambert, D., 2001.

The major cost categories are customer service, transportation, warehousing, order processing, and information, lot quantity, and inventory carrying.[100]

### 2.4.2.1 Customer Service Levels

Customer service represents the output of the logistics system and the place component of the firm's marketing mix. It is a measure of the effectiveness of the logistics system in creating time and place utility for a product. The sum of the expenditures for such logistics activities as transportation, warehousing, order proc-

[100] Stock, J. and Lambert, D., 2001, page 28.

essing and information systems, production setups and purchasing, and inventory management can be viewed as the company's expenditure for customer service.[101]

There are various performance metrics for Customer service, Bowersox et al. name some of them: fill rate, stockouts, shipping errors, on-time delivery, cycle time, response time to inquiries, response accuracy and complete orders.[102]

The best approach is to determine desired levels of customer service based on customers needs, and to consider how those needs will be affected by expenditures on the areas of the marketing mix. Because each of the other five major logistics cost elements work together to support customer service, logistics managers need good data regarding expenditures in each category.[103]

#### 2.4.2.2 Warehousing Costs

Warehousing costs are created by warehousing and storage activities and by the plant and warehouse site selection process. Included are all of the costs that vary due to a change in the number or location of warehouses.[104]

There is no single best approach that a firm can pursue in warehouse productivity measurement. Management action is determined by a variety of factors, such as customer service levels (e.g., shipping performance, error rates, order cycle time); inventory accuracy (e.g., correct quantities of each SKU at all warehouse locations); space utilisation (e.g., the right inventory, square foot or cube utilisation of facilities), and labour productivity (e.g., throughput rates).[105]

#### 2.4.2.3 Order-Processing/Information Systems Costs

The order processing system can affect the performance of the logistics function in two major ways. First, the system can improve the quality of the management information system by providing such data as customer names, location of customers, items demanded by customer, sales by customer, sales patterns, order size,

[101] Stock, J. and Lambert, D., 2001, page 105.
[102] Bowersox, D. et al., 2002, page 558.
[103] Stock, J. and Lambert, D., 2001, page 28.
[104] Stock, J. and Lambert, D., 2001, page 29.
[105] Stock, J. and Lambert, D., 2001, page 423.

and sales data for the company's sales forecasting package. Second, the customer order is the message that sets the logistics function in motion. The speed and quality of the information provided by the order processing system have a direct impact on the cost and efficiency of the entire logistics process. Slow and erratic communication can lead to lost customers or excessive transportation, inventory, and warehousing costs. Implementation of the latest technology in order processing can lead to significant improvements in logistics performance.[106]

Order processing and information systems costs are related to activities such as processing customer orders, distribution, communications, and demand forecasting. Investing in order processing and information systems is extremely important to support good customer service levels and control costs. Order processing costs include order transmittal, order entry, order verification, order handling, and related internal and external costs such as notifying carriers and customers of shipping information and product availability.[107]

#### 2.4.2.4 Transportation

Expenditures that support transportation can be viewed in many different ways, depending on the unit of analysis. Cost can be categorised by customer, by product line, by type of channel, by carrier, by direction (inbound versus outbound), for example. Costs vary considerably with volume of shipment, weight of shipment, distance, and points of origin and destination. Costs and service also vary considerably with mode of transportation chosen.[108]

### 2.4.3 Cost-based versus Time-based Management

The traditional way to improve efficiency and effectiveness within a company has been based to a large extent on cost reduction concepts and strategies. However, according to Mattsson 2000, focusing directly on time instead of on cost is quite a different approach to making companies more efficient and more competitive. Using time-based management, companies reduce costs indirectly through compressing lead times. Faster inventory turnover and lower overhead costs are typical

[106] Stock, J. and Lambert, D., 2001, page 646.
[107] Stock, J. and Lambert, D., 2001, page 30.
[108] Stock, J. and Lambert, D., 2001, page 165.

consequences when lead times are compressed by eliminating breakdowns, delays and various kinds of waiting times.[109]

Focusing on lead time also means improved flexibility and faster response time and it provides leveraging effects on profits possibly not obtained by cost-based management. Focusing on lead time is also more oriented towards customers and customer service than toward internal efficiency, which is more typically the case with the cost-based management approach.[110]

Experience gained in companies around the world has repeatedly shown that the results achieving by applying time-based management are significant. As time is compressed:[111]

- Costs are reduced and productivity is increased;
- Prices can be increased;
- Customer service and profitability is improved;
- Capital tied up in inventory and work-in-process is reduced;
- Quality is improved.

### 2.4.4 Strategy

Strategy is defined as follows:

*"Strategy is the direction and scope of an organisation over the long term, which achieves advantage for the organisation through its configuration or resources with a changing environment and to fulfil stakeholders' expectations."*[112]

[109] Mattsson, S-A., 2000, page 152.

[110] Ibid.

[111] Mattsson, S-A., 2000, page 156.

[112] Johnson, G. and Scholes, K., 2002, page 10.

#### 2.4.4.1 The Importance of Planning

Mission statements provide the foundation from which the company develops strategies, plans and tactics.[113] It also provides direction and control for tactical plans and daily operations.[114]

As corporate mission statements serve to provide the starting point for developing corporate goals and objectives, the logistics statements will provide direction for developing business strategies. The components of a corporate mission statement or logistics mission statement are only one element of a firm's total corporate mission.[115]

In the absence of planning, managers must spend an disproportionate amount of their time as fire fighters reacting to crises rather than anticipating change and developing strategies to deal with it. [116]

#### 2.4.4.2 Levels of Strategy

*Corporate-level* strategy is concerned with the overall purpose and scope of the organisation and how value will be added to the different business units of the organisation.[117]

*Business unit* strategy is about how to compete successfully in particular markets. This concerns how advantage over competitors can be achieved; what new opportunities can be identified or created in markets; which products or services should be developed in which markets; and the extent to which these meet customer needs in such way as to achieve the objectives of the organisation.[118] *Strategic business unit* (SBU) is a part of an organisation for which there is a separate external market for goods or services that is different from another SBU. Because of this separate external market there is a need for different strategies.[119]

[113] Stock, J. and Lambert, D., 2001, page 593.
[114] Stock, J. and Lambert, D., 2001, page 684.
[115] Stock, J. and Lambert, D., 2001, page 593.
[116] Stock, J. and Lambert, D., 2001, page 685.
[117] Johnson, G. and Scholes, K., 2002, page 11.
[118] Ibid.
[119] Ibid.

*Operational* strategies are concerned with how the component parts of an organisation deliver effectively the corporate- and business-level strategies in terms of resources, processes and people. In most businesses, successful businesses strategies depend to a large extent on decisions that are taken, or activities that occur at the operational level. The integration of operational decisions and strategy is therefore of great importance.[120]

#### 2.4.4.3 Logistics Strategy

Logistics strategic planning has been defined as follows:

*"Unified, comprehensive, and integrated planning process to achieve competitive advantage through increased value and customer service, which results in superior customer satisfaction (where we want to be), by anticipating future demand for logistics services and managing the resources of the entire supply chain (how to go there). This planning is done within the context of the overall corporate goals and plan."* [121]

When overall corporate strategies and marketing plans have been determined, the logistics planner must evaluate the basic alternatives and recommend the system configuration that satisfies customer requirements at the lowest total cost. The process must begin with identifying and documenting customer service goals and strategies.[122] Management can use a customer service survey to determine the needs and requirements of the firm's customers. The plan must consider the specific requirements of customers, competitive service levels, changing environmental conditions, and the amount of service that the company is willing to offer.[123] It is not possible to design an efficient and effective logistics system without first establishing the firm's customer service objectives.[124]

### 2.4.5 Achieving an Integrated Supply Chain

Before describing the evolution of how to reach an integrated supply chain the concept of functional and process perspective has to be understood.

[120] Johnson, G. and Scholes, K., 2002, page 12.
[121] Stock, J. and Lambert, D., 2001, page 684.
[122] Stock, J. and Lambert, D., 2001, page 694.
[123] Ibid.
[124] Stock, J. and Lambert, D., 2001, page 97.

#### 2.4.5.1 Functional Perspective

The traditional way to organise a company is through functions due to the characteristics of activities and responsibilities. One of the main principles behind the practice of organising through functionality is from input and consumption of resources.[125]

When a company is organised through function it is more focused on effective administrative management of the company's resources than creating value adding flow from delivery of material to the company and to delivery of product to the customer. This leads to the fact that many different participants are involved in every chain of activity, which in turn leads to long run through time and a lack of flexibility and ability to adjust to changes in the market.[126]

#### 2.4.5.2 Process Perspective

Lumsden 1998 and Mattsson 2002 pinpoint what are common for processes: a process consists of activities, and the aim of the process is to create value and there is a customer who is the target for these value adding activities.[127] The process appears often as cross-functional flows of part-processes that overcome the gap between the functional units of an organisation. Process-view creates awareness of the customer, the product, the information flow and the resource consumption and more clearly point out the efficiency of the organisation in focus.[128]

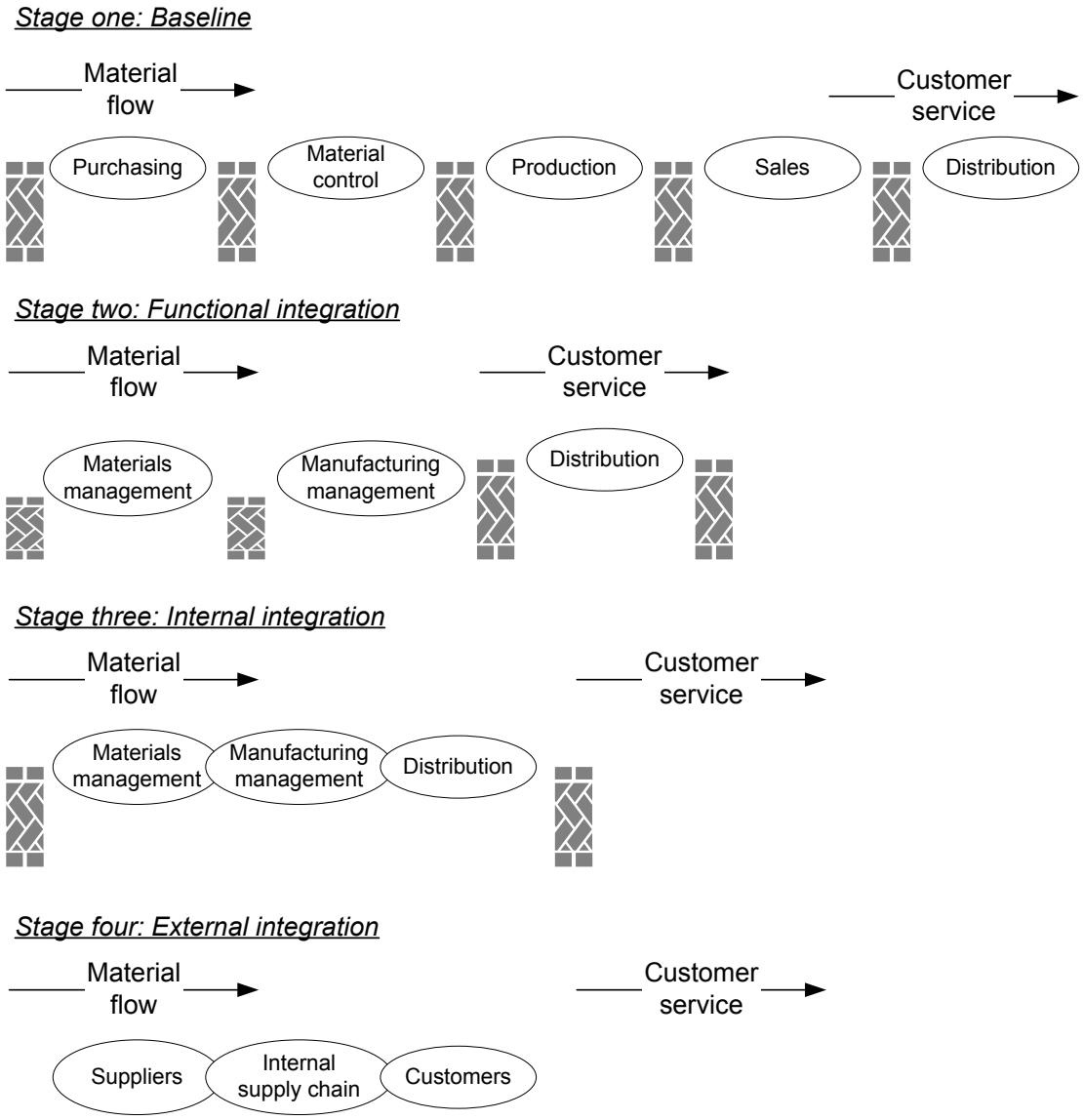
Since a company get its income from customers by delivering products, the most practical way to organise would be through the output instead of input. This means that a company should organise its activities after products and material flow with focus on delivery to customers.[129]

[125] Mattsson, S-A., 2002, page 81.
[126] Mattsson, S-A., 2002, page 82.
[127] Mattsson, S-A., 2002, page 84.
[128] Lumsden, K., 1998, page 629.
[129] Mattsson, S-A., 2002, page 81

### 2.4.5.3 The Evolution of Achieving an Integrated Supply Chain

The concept of supply chain management is in fact no more than an extension of the logic of logistics. Organisations do not go from managing logistics and to being a supply chain. The figure below suggests that there is in effect on evolution in integration.[130]

Figure 2.9 Achieving an integrated supply chain.




Source: Christopher, M., 1998.

[130] Christopher, M., 1998, page 16.

There is an evolution of integration from stage 1 which indicates a complete functional independence where each business function does its business in complete isolation from the other business functions. A good example of this is where production seeks to optimize its unit costs of manufacturing by long production runs without regard for the build-up of finished inventory and does not take notice of the impact it will have on the need for warehousing space and the impact on working capital.[131]

In stage 2 companies have recognized the need for at least a limited degree of integration between closest functions, like distribution and inventory management or purchasing and materials control. From stage 2 it is a natural next step to stage 3. This, however, requires the establishment and implementation of an end-to-end planning framework. Stage 4 represents true supply chain integration in that the concept of linkage and co-ordination that is achieved in stage 3 is now extended to suppliers and to customers. Again it should be pointed out that logistics management is concerned with a planning coordination and framework that seeks to create a single plan for the flow of product and information through business. The supply chain management builds upon this framework and seeks to achieve linkage and co-ordination between processes that take place between customers and suppliers and the organisation itself.[132]

Christopher is not the only author, who pinpoints the evolution of integration. Most of the literature used in thesis has an emphasis on this subject. Bowersox et al refer to it as the logistics organisational development cycle. They describe the subject of prevailing paradigm that goes from a fragmented to functional aggregation and to process integration.[133] But the evolution of integration follows the same stages that have been discussed above.

Harrison and van Hoek encourage different forms of collaboration, internal collaboration, function to function, and inter-company collaboration, a manual approach.[134]

[131] Christopher, M., 1998, page 16.

[132] Ibid.

[133] Bowersox, D. et al., 2002, page 520 ff.

[134] Harrison, A. and van Hoek, R., 2002, page 194 ff.

According to Mattsson 2002, every barrier between individuals, departments and organisations requires more time and lead times become longer. Therefore a natural way to have more effective business processes is to reorganise with a fusion of performance and responsibility for different activities and sub processes between different departments within the company so that the number of borders are reduced. To organise in a more effective way could also take place between companies.[135]

### 2.4.6 Supply Chain Optimization

Poirier and his associates have for over ten years studied more than two hundred global businesses in an effort to understand optimal supply chain integration. The studies were conducted with medium to large corporations seeking to gain advantage in their markets. Poirier and his associates have also conducted research into how companies build optimized supply networks. It is now apparent that the supply chain is the main pathway of all businesses. The observations and experiences have led to the identification of a supply chain progress range, from beginning efforts to a position of global advantage.[136]

In today's business organisations have shaped networks for sourcing raw materials, manufacturing products or creating services, storing and distributing the goods, and finally delivering the products and services to customers and consumers. A common name for this effort is supply chain management and the focus is moving externally as well as internally. Early efforts concentrated on improving only the internal efficiency of an individual firm or of a single component in the supply network.[137]

The road to a leading-edge position requires focus, dedication, creativity, and hard work. The figure below is an illustration of the four levels through which a firm progress to achieve advanced stages of supply chain management and to understand the rewards that result from a drive for optimisation. Based on the experience of many companies, there is no way to avoid moving through these levels of

[135] Mattsson, S-A., 2002, page 337 ff.

[136] Poirier, C., 1999, page vii ff.

[137] Poirier, C., 1999, page 2.

development. A firm in the first level that wishes to be at the fourth level must develop a strategy for rapid movement through the in-between levels.[138]

Figure 2.10. Levels of Supply Chain Optimization

| | Internal | | External | |
|---|---|---|---|---|
| | **Sourcing and Logistics I** | **Internal Excellence II** | **Network Construction III** | **Industry Leadership IV** |
| **Driver** | VP sourcing (under pressure) | CIO/supply chain leader | Business unit leaders | Management team |
| **Benefits** | Leveraged savings | Prioritized improvements across network | Best partner performance | Network advantage, profitable revenue |
| **Focus** | Inventory, logistics, freight, order fulfillment | Process redesign, system improvement | Forecasting, planning, customer service, interenterprise | Consumer, network |
| **Tools** | Teaming, functional excellence | Benchmarks, best practice, activity-based costing | Metrics, database, mining, electronic commerce | Intranet, internet, virtual information systems |
| **Action Area** | Midlevel organization | Expanded levels | Total organization | Full enterprise |
| **Guidance** | Cost data, success funding | Process mapping | Advanced cost models, differentiating processes | Demand-supply linkage |
| **Model** | None | Supply chain-intraenterprise | Interenterprise | Global market |
| **Alliances** | Supplier consolidation | Best partner | Formal alliances | Joint venture |
| **Training** | Team | Leadership | Partnering | Network processing |

Source: Poirier, C., 1999.

The levels labelled Internal occur within the organisation and represent the position of most business organisations that seeks for improvements in their supply chains. Eighty percent of the companies studied by Poirier are somewhere in the Internal stage of their supply chain's progress. The last two levels that are labelled External occur when the business joins forces with external firms to seek network

[138] Poirier, C., 1999, page 23.

savings. Few organisations have reached these latter levels.[139] When analysing what stage FNS is positioned in, when considering the supply chain optimisation according to Poirier, Hogström and Grigorjev believe that FNS is positioned on level one because FNS focuses more on inventory, logistics, transport and order fulfilment.

#### 2.4.6.1 Level One

In this section, the key elements of supply chain management evolution will be described.

*Driver:* The driver or supporter, who promotes the necessary change process in level one, could be a senior manager or department director who wants or is selected to organisation a change process. The emphasis generally begins with encouragement or a pronouncement from a CEO but emphasis rapidly moves to the vice presidential (VP) level or lower. The purpose could be to achieve a substantial gain in cost control, to organise an intensive improvement effort, or to reengineer a process that has risen dramatically in cost.[140]

Experience indicates that responsibility may start with a variety of functional senior executives, but it soon ends with a senior procurement manager, such as the vice president of purchasing or sourcing. This is not always the case, but it illustrates the typical process in level one. Often a large percentage of costs are controlled by activities in this sector. The natural step is to put intense emphasis on cutting the costs of purchased goods and services, and this involves all aspect of operations. Experience suggests that a company should be careful of the consequences of this approach. As participants examined and changed their supply base, processes, systems and practises to support current requirements and objectives, they also discovered changes that might not improve their positions in the marketplace. Firms become very skillful at cutting costs through the leveraging of their volume and buying positions with suppliers. Many firms also paid a price in reduced quality and control. If a supplying firm accepts costs transfers from a manufacturer, there is also a transfer of profits: the buyer gains and the supplier

[139] Poirier, C., 1999, pages 23 and 25.

[140] Poirier, C., 1999, page 25.

loses. In this case the supplier only has two choices: to get back the lost profits through internal efficiencies or to pass back a comparable amount of costs to the buyer. A superior technique that gives the process greater value is when organisations work with suppliers by removing costs from the systems of supply and manufacture so both parties gain an advantage and share in the additional profits generated.[141]

The lesson learned from efforts in level one showed the way for achieving true sourcing savings. The emphasis must be on using mutual resources for mutual advantage, rather than accepting cost pushback from one company to another.

*Benefits:* An early benefit of supply chain improvement efforts included project work by teams that reduced purchasing costs, inventories, logistics costs, and freight costs. As these teams were sent in search of quick opportunities, benefits were quickly identified and used to verify the importance of the effort.[142]

Experience has shown that some savings in level one are fictitious. If a cost is simply pushed back to a cooperative supplier, the inventory carrying cost has been temporarily transferred within the supply chain network. Real savings begin when the network completely eliminates the need for the inventory by simplifying the process or eliminating steps that require extra inventory. In these cases, the carrying cost is eliminated on the inventory which is no longer required to sustain delivery performance.[143]

*Focus:* As the focus is placed on specific supply chain projects such as inventory, logistics, freight, and order fulfilment, additional care must be taken to validate the assumed results. These areas were selected following purchasing because they represented large sectors of cost and were generally not being performed to leading-edge standards. Teams that went looking for opportunities to cut costs found some of the early savings mentioned. The teams' focus led to two approaches: redesign or reengineer the process to become more efficient or find an external firm to which the process could be entrusted in order for the firm to concentrate on its

[141] Poirier, C., 1999, pages 26 and 27.

[142] Poirier, C., 1999, page 28.

[143] Poirier, C., 1999, page 29.

core business. Order fulfilment turned out to be a challenge because most of the problems in this area were internal to the organisation. Absence of discipline was the source of most problems. The problem began with order entry and continued as the orders were processed and sent to planning, manufacturing, and delivery. Manual overrides were constantly necessary because of poor entry, omitted data, improper codes, incorrect pricing, and other mistakes. When companies found solutions to this problem they often rushed to eliminate people in this process. As errors were eliminated, processes were simplified, and automated systems were created and implemented and this often resulted in labours savings.[144]

*Tools:* The tools applied in the first level of supply chain management generally centre on teaming techniques. Most organisations cannot overcome the strong temptation to begin internally and focus on favourite departments or processes. The teams map the current work activities or process steps to get a rough picture, process flow diagrams, use scientific methods of decision making, and other tools to energize the group. Encouragement and support from senior management are crucial in these early stages because creative innovations may lead to significant improvements in old processes.[145]

*Action Area:* The action area occurs in the midsection of the organisation as functional managers and directors bear the burden of the responsibility for implementing the new processes. Purchasing managers know the intensity with which cost control is followed in these initial efforts. As other departments will be redesigned, the number of involved managers increases. In the beginning, team members tend to come from white-collar workers and later on blue-collar workers join the team, bringing their close knowledge of how work flows actually happen.[146]

*Guidance:* Guidance comes from whatever cost or financial data can be accessed. Often a company relies on the available internal metrics used to measure the performance of a function or department. Early results show that information is often approximate at first, but become more accurate as the savings are quantified, challenged, recalculated to provide accurate results and promote funding for fur-

[144] Poirier, C., 1999, pages 30 and 31.

[145] Poirier, C., 1999, page 33.

[146] Poirier, C., 1999, page 34.

ther efforts. Often other and more useful financial data is to be found in the effort to support the hypotheses. Areas that would not normally come under the attention of purchasing but still involve significant cost are investigated.[147]

*Model:* No formal model is customarily used in the first level. The teams create their own methodology, and follow generally agreed teaming techniques. A simple flowchart or block diagram might be used to stimulate the brainstorming of ideas. Such diagrams show the transfer of products and services along the supply chain and focus discussions on problems and opportunities. These brainstorming sessions are used to analyse these flow charts and to consider opportunities for improvement. On the basis of these sessions, a list of prioritised opportunities is drawn up so that the best potential initiatives can be selected and implementation teams formed.[148]

*Alliances:* With an increased level of cross-functional cooperation, the teams find that outside help and fresh advice can be very beneficial. Some supplier consolidations occur as the supply base is reduced and this is often the start of long-term alliances with some of the surviving suppliers. The real cross-company participation is held off until level two.[149]

*Training:* The training effort is focused on developing capabilities in team formation, problem identification, root-cause analysis, and the other elements of good teaming work in the early stages. Teams are sent out in a perpetual search for improvement opportunities. The teams enlarge their scope as success is achieved and begin to rely on outside advice as they search for higher levels of savings.[150]

#### 2.4.6.2 Uneven Gains

Preliminarily results from supply chain improvement initiatives have been mixed. Most firms have identified and benefited from fast gains and increased profits. Supply costs have been reduced to some degree through concerted improvements in the purchasing function. Inventories have been either cut or moved upstream in

[147] Poirier, C., 1999, page 34.

[148] Poirier, C., 1999, pages 35 and 36.

[149] Poirier, C., 1999, page 36.

[150] Ibid.

the supply chain and warehousing and transportation costs have usually been reduced. A few lessons stand out in early results. No firms as an individual can shrink its way to greatness. It must cooperate with valued suppliers and distributors. It must focus on specific markets, customers, and consumers. It must operate in an environment that is completely transparent to all element in the supply chain so that each player can see what and when moves the customers, and to identify sources of potential savings. The barriers that hold back the sharing of vital information, barriers that drive costs up and service down, must be uncovered and overcome as a new culture is built.[151]

A missing factor plagued the less successful organisations. The failure was in two key areas: a lack of trust and sincere effort among necessary participants in the chain and a narrow-minded view focused only on internal gains. Progress in developing trust was not made or sustained because the firms that were engaged in supply chain redesign did not seize the need for sharing the savings with the organisations that helped improve the system. These firms also failed to develop cross-organisational trust, which is now recognised as a crucial success factor. In these early efforts, some firms sought an advantage at the expense of suppliers by leveraging their position with those firms and pocketing all the savings. It became a zero-sum game, and that is a prescription for failure.[152]

Leading companies realise that internal operational excellence must be balanced with external supply network efficiency, the ultimate objective of which is to please the final consumer.[153]

Early efforts at supply chain optimisation proved that the enemy is typically within the organisation. Supply chain improvement efforts have to cross division, department, function, location, and territory boundaries. The people within those boundaries will initially support any effort designed to significantly improve processes, reduce operating costs, increase revenues, and bring the firm into the modern era. Much of this support is cosmetic and must be watched closely. There is far greater concern in the beginning of a supply chain improvement effort about

[151] Poirier, C., 1999, page 4.

[152] Poirier, C., 1999, pages 5 and 6.

[153] Poirier, C., 1999, page 7.

maintaining the status quo than in making necessary changes. A simple but hard-learned lesson is good to apply in this case: begin with a small project to prove the concepts and complications, and develop answers before proceeding to larger and more complex opportunities.[154]

#### 2.4.6.3 Transition to Level II

Once a business organisation has discovered the early, primarily internal benefits available from improvements within a supply chain, it can move to the next phase. This transition to a higher level of supply chain management is difficult for some organisations. The tendency is to get stuck in the early and relatively easy stages of the process. Most firms continue to find other projects that will enhance internal supply chain performance but never really move on to higher-order efforts and benefits. To make further progress requires redesigning the total supply chain system and eventually the total supply chain network. Standing in the way are several pitfalls. The organisations interested in reaching advanced levels must identify these obstacles and overcome them. Some examples are as follows:[155]

- To drive the organisation to higher levels of costs reduction, productivity, quality, and service, energy must come from one or more of three sources: executive motivation, a system that tracks progress and rewards the people who made it happen, and a vision that embraces ongoing change in the future.[156]

- Most firms stuck in Level I are characterized foremost by refusing to share savings from the improvement effort. Sharing the real savings is a mark of the organisation of evolution to Level II and beyond.[157]

- A Level I firm will not allocate, hire, or contract with the people that are necessary to move to the next level. This means that insufficient resources will delay the progress. It is far easier for these firms to ignore the advanced opportunities claiming that these resources are not worth the extra spend-

[154] Poirier, C., 1999, page 19.

[155] Poirier, C., 1999, pages 42 and 43.

[156] Poirier, C., 1999, pages 43 and 44.

[157] Poirier, C., 1999, page 44.

ing or stalling efforts until internal resources can be developed and applied.[158]

- A specific characteristic of Level I efforts is progress in virtually all areas of supply chain management, except one – forecast accuracy. Getting better information into a supply chain system regarding how much actual demand will exist in a specific time frame is a common challenge. With poor demand input, the planning process relies on educated guessing as best. The resulting system only works because of heroic service and not because of organised reactions. Level I firms are always responding to unexpected changes.[159]

- An argument always raised in Level I efforts revolves around what should happen first, the installation of new information systems or the redesign of processes for higher efficiency. The greater gains occur when the redesign of the process is logically tested and aligned properly with the IT application. For Level I firms, the tendency is to develop process improvements and technology enhancements without any real integration. Advancing to the next level requires the functional groups and the IT department to co-design the new processes with what will be the best IT format.[160]

- The single greatest obstacle to advanced supply chain improvement is a lack of trust among the parties who will benefit most from cooperation in pursuing joint goals. Supply chain improvements by its very nature requires total co-operation, and departments have to work together. Key suppliers have to play a role in design and application. Distributors have to play another role in handling small lots and specialised market sectors. Customers have to help determine what should be coming through the chain. In this situation interaction is crucial, but this interaction seldom happens in Level I. Savings do occur and will benefit the own organisation that trust will remain elusive.[161]

[158] Poirier, C., 1999, page 44.

[159] Poirier, C., 1999, page 45.

[160] Poirier, C., 1999, page 46.

[161] Poirier, C., 1999, pages 46 and 47.

# 3 Research Questions

*After the theoretical framework, the areas of research with following research questions are stated in accordant with thesis' problem definition, purpose and limitations.*

After completing the literature search within the area of the problems, the search results served as a foundation for the research questions. In the problem it was stated that the company would like to have an investigation and evaluation made regarding total cost-efficiency of its project logistics with the focus on achieving a minimum of tied-up capital in inventory. Furthermore, the suggestion should include the ways for gaining the competitive advantage of the company in the future.

Logistics is about various flows, primarily the flows of material and information. Therefore these two flows are to be investigated. It has been presented in the literature search that material flow is initiated as result of information flow. For Hogström and Grigorjev to find out how the information flow streams within FNS, a business process should be mapped.

The company would like to achieve a minimum of tied-up capital in inventory. Therefore is it necessary to investigate the inventory, and to make this investigation manageable one business process has been chosen.

The proposal should improve the customer service and gain competitive advantage for the company in the future. These two areas are linked, because increased competitive advantage will positively affect customer service. Due to this link, these two areas will be treated as one.

The following research questions have to be investigated in order to propose a possible solution according to the area of problem:

- 1. Mapping a business process: How does the information and material flows stream within the business process?

Information needs: how the order processes within the Contracting Department? Where does it start and where does it end? What activities are involved? What departments and persons are involved? How much time does it take for an order to pass each activity? Hogström and Grigorjev's intention is only to map activities within the Contracting Department. This part of the company rollouts the work of a 3G site. The business area Mobile Network does the design of the 3G networks. This process can take a long time since Mobile Network applies for building permits and the time required for this procedure is unpredictable. What material is needed for setting up a site? There are different site variations and each of them is unique. Hogström and Grigorjev's intention is to investigate if the sites could be classified in some way.

- 2. Inventory tied up capital: How is it possible to reduce tied up capital in inventory and with what methods?

Information needs: internal records about material specifications, prices for the material, safety stock levels, order quantities, demand quantity and timing, suppliers' quantities and lead-times and inventory policy for the AAA articles.

- 3. Competitive advantage: What can be done in order to gain competitive advantage for the company in the future?

Information needs: through the literature search, this will only be carried out as a desktop study. Questions underlying the information needs are: what is contemporary today concerning supply chain progress?

# 4 Research Methodology

*In this chapter Hogström and Grigorjev will describe their research approach, how the data were collected, what kind of data have been used, explanations of the method used, research evaluation, including a description of and excuses for possible errors.*

## 4.1 Research Methodology and Data Collection

A research design is the detailed plan used to guide a research study towards its objectives. The design of the process involves many decisions that are interrelated. The most significant decision is the choice of research approach, since the research design determines how the information will be obtained.[162]

### 4.1.1 Research Approach

Research approaches can be classified into one of three general categories of research: exploratory, descriptive and causal. The categories differ considerably in terms of research purpose, research questions, the precision of the hypotheses that are formed, and the data collection methods that are used.[163]

Exploratory: a study that is exploratory is undertaken when not much is known about the situation at hand, or when no information is available on how similar problems or research issues have been solved in the past.[164]

Casual research is used when it is necessary to show that one variable causes or determines the values of other variables. Descriptive research is not sufficient since this approach only shows that two variables are related or associated.[165]

The third type is descriptive which is the research approach used in this study and which will be discussed more in detail below.

[162] Aaker, D. et al., 1995, page 71.
[163] Aaker, D. et al., 1995, page 73.
[164] Sekaran, U., 2000, page 123.
[165] Aaker, D. et al., 1995, page 75.

#### 4.1.1.1 Descriptive Research

Descriptive study is used in order to discover and describe the characteristics of the variables of interest in a certain situation. The goal is to offer a profile or to describe relevant aspects of the phenomena of interest to the researcher from an individual, organizational, industry-oriented or other perspective.[166] Descriptive studies try to find the answers to questions of who, what, when, where and occasionally the question, how. Descriptive studies may or may not have the potential for drawing powerful conclusions and do not explain why an event occurred or why variables interact the way they do.[167] A descriptive study seeks data about a well-specified question. Often this study is also called mapping investigation. The purpose is to describe how the present situation looks without explaining why.[168] In general, the relationships studied will not be causal in nature, but they may still have utility in prediction.[169]

#### 4.1.1.2 The Topical Scope

The statistical study differs from the case study in many ways. Statistical studies are designed for breadth rather then depth. Case studies place more emphasis on a full contextual analysis of fewer events or conditions and their interrelations. An emphasis on detail provides valuable insight for problem solving, evaluation and strategy. This detail is obtained from multiple sources of information.[170]

A case study is wide-ranging description and analysis of a single situation. The data for a case study usually are obtained form a series of lengthy, unstructured interviews with a number of people involved in the situation, perhaps combined with available secondary sources and internal data sources. There are circumstances where a case study may be the only choice of method to understand a complex situation. A single participant may incorrectly understand the decision-making process in large organizations.[171]

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166 Sekaran U., 2000, page 124.

167 Cooper, D. and Schindler, P., 1998, page 11.

168 Lekvall, P. and Wahlbin, C., 1993, page 129.

169 Aaker, D. et al., 1995, page 75.

170 Cooper, D. and Schindler, P., 1998, page 133.

171 Aaker, D. et al., 1995, page 187.

A case study is often used in an exploratory study, as the researcher wants to use the possibility to discover conditions that he/she did not have in mind before the study. The most common application will be in a descriptive study or causal study where the researcher has the area of problem fairly clear from the beginning. A case study is most often qualitative.[172]

#### 4.1.1.3 The Research Approach and Topical Scope in This Thesis

The nature of the study conducted in this thesis in major part descriptive. In the beginning, it could be described as exploratory when Hogström and Grigorjev' knowledge about the company and problem was to some extent diffuse. On the other hand, the area of the problem is not unknown to Hogström and Grigorjev and even if the subject or area of the problem is known, there is always confusion in the beginning. If the approach was different, this thesis could be carried out as a casual study, but Hogström and Grigorjev see it as descriptive since this is a mapping investigation. Hogström and Grigorjev's intention is to map the current situation in the company, both concerning process and inventory.

Different constraints make it difficult to map all the processes and, for that reason, one process was chosen in order to make it more manageable when mapping the present situation. Hogström and Grigorjev wanted to describe a process more in detail in order to get a total picture of a particular process. Therefore, it was natural to conduct a case study and after the discussion with FNS, the chosen process is the rigging part of the AAA process.

### 4.1.2 Method of Data Collection

There is a wide variety of methods to consider, either singly or in combination. They can be grouped first according to whether they use secondary or primary sources of data.[173] A research that consists of only primary data is very unusual. At least in some parts in the work of investigation, there is a reason for using secondary sources.[174]

[172] Lekvall, P. and Wahlbin, C., 1993, pages 142 and 143.

[173] Aaker, D. et al., 1995, page 77.

[174] Lekvall, P. and Wahlbin, C., 1993, page 141.

#### 4.1.2.1 Secondary Data

Secondary data are already available, but what has to be kept in mind concerning secondary data is that it was collected for some other purpose, to solve another problem.[175] Secondary data are one of the cheapest and easiest mean of access to information. The first thing a researcher should do is to search for secondary data that is available on the topic.[176] There are several sources of external data, including books and periodicals, government's publications, census data, statistical abstracts, databases, media, annual reports of companies, for example. Much of internal data could be proprietary and not available to all.[177] The main problem for the researcher is to find data that is relevant.[178]

An investigation that only consists of secondary data is also called desktop investigations. A research could reach far with a desktop investigation only. It is not unusual that in a well carried out problem analysis, reaching a solution to the problem can be achieved without conducting a collection of primary data. A researcher should therefore carefully use all possibilities for secondary data before undertaking a field investigation.[179]

#### 4.1.2.2 Secondary Data in This Thesis

In this study, the Internet was used to obtain knowledge of the latest publications in the problem area. In this thesis Hogström and Grigorjev have tried to use references in articles in order to find the source of origin. Other secondary data are company's documents and internal data. The internal data was used to investigate the lead time in the AAA process and for calculations concerned with tied up capital in inventory.

[175] Aaker, D. et al., 1995, page 77.
[176] Aaker, D. et al., 1995, page 115.
[177] Sekaran, U., 2000, page 255.
[178] Lekvall, P. and Wahlbin, C., 1993, page 180.
[179] Lekvall, P. and Wahlbin, C., 1993, page 142.

#### 4.1.2.3 Primary Data

Primary data are collected especially to address a specific research objective.[180] Primary data could be qualitative and quantitative. A qualitative investigation is of that kind where the researcher gathers, analyses and interprets data where it is not possible to quantify meaningfully, i.e. express in figures. Information that is transmitted through words is called qualitative and information presented in digits is called quantitative. Qualitative investigation is often designed as a case study or a survey investigation with small samples. Qualitative data consist of detailed description of situations.[181]

A qualitative case study is to large extent build upon qualitative information that has been gathered from interviews, observations and documents of different kinds. Quantitative information that is derived from a survey investigation can be used to support the results from qualitative data.[182]

#### 4.1.2.4 Primary Data in This Thesis

To map the AAA process, Hogström and Grigorjev had to collect primary data. The process has not been mapped before, and therefore no secondary data was available. This primary data was gathered through the qualitative research method.

#### 4.1.2.5 Qualitative Methods

Primary data in business research is mostly collected through interviews with persons working at different departments. It could be carried out in two ways, through direct observation of what is in focus for the research or through asking questions.[183]

To get information about a company through questions, it is vital to ask someone who has the relevant knowledge. This person is called a respondent and the choice of the respondent is of vast importance. Different respondents within a company can describe same issue in totally different ways due to their position, interest and

[180] Aaker, D. et al., 1995, page 77.

[181] Merriam, S., 1994, page 83.

[182] Merriam, S., 1994, page 84.

[183] Lekvall, P. and Wahlbin, C., 1993, page 180.

knowledge. However, there is a difference between a respondent and a unit of investigation. If the company is the unit of investigation, it is common to use several respondents.[184]

To use questioning as a method could be executed verbally or in writing. A questioning inquiry is normally called interview inquiry. If the inquiry is carried out with questions and answers in writing, it is called inquiry.[185]

There are three main types of ways to communicate when using questioning as a method: letter, telephone or/and individual interviews.[186] Individual interviews are the method used in this thesis and also described more in detail.

#### 4.1.2.6 Individual Interviews

The benefit of individual interviews is the possibility for asking all sorts of questions. The interview could be extensive under the condition that it is perceived as interesting for the respondent. An individual interview is suitable when there is a need to do an extensive and comprehensive interview. The drawback is the cost for each interview, and therefore the method is seldom used as large sampling.[187]

Individual interviews can be carried out in different ways. The interviewer could conduct structured interview with prepared questions to ask and a detailed instruction for coding. On the other hand, it could be a totally unstructured interview, where the interviewer and the respondent together discuss a subject and a plan for the interview is not possible. In this case, it is common to work with an interview guide, which includes a wide area of prepared questions with follow-up questions that the interviewer wants to be answered. The prepared follow-up questions are only used if the respondents do not answer spontaneously to the wide area questions.[188]

Registration of the interview could be carried out through taking notes during the interview or/and using a tape recorder. There could be a problem to get in contact

[184] Lekvall, P. and Wahlbin, C., 1993, pages 182 and 183.
[185] Lekvall, P. and Wahlbin, C., 1993, page 183.
[186] Ibid.
[187] Lekvall, P. and Wahlbin, C., 1993, page 186.
[188] Ibid.

with the respondent and to set a date for the interview, especially for a respondent within a company.[189]

#### 4.1.2.7 Interviews in This Thesis

The intention is that primary information should be gathered through the individual interviews. The names of the persons to be interviewed were given to the authors by FNS. An interview guide will be used in the attempt to secure that needed information has to be answered and also to allow a more unstructured interview where it is possible to be surprised by the information that is given. The intention is that the result will be a detailed description of the AAA process and therefore respondents are from different departments.

Individual interviews were mainly used in this thesis. Communication through telephone and e-mail has only been used when there has been a need to clarify or supplement earlier interviews. Individual interviews have taken place at several occasions with different persons within the company.

In the beginning of the study, before the problem area was clarified, the interviews were more like meetings. The purpose of the meetings was to understand how FNS is working and the type of information was general. Hogström and Grigorjev had five meetings/interviews of this kind in the beginning of the thesis work process. It was after these meetings that it was decided that the research should be a case study and the focus should be on the AAA process. After this decision there was a need to interview a number of persons individually. During two days, 16th and 17th of October 2003, Hogström and Grigorjev were at the FNS office in Sätra, Sweden for interviewing. Most of the interviews were scheduled in advance. However, during the scheduled interviews, Hogström and Grigorjev realised that there was a need to interview other persons as well. All of them worked in Sätra and therefore Hogström and Grigorjev could arrange these interviews during those two days. Seven interviews were carried out during those two days and all of them were related to the mapping of the AAA process.

[189] Lekvall, P. and Wahlbin, C., 1993, page 186.

During the interviews, an interview guide has been used in order to secure that the information needs were obtained. Later during the research process, the interviews have become more specific because Hogström and Grigorjev's knowledge about the problem had increased. The interviews during 16th and 17th of October 2003 clarified what kind of internal information was possible to obtain from the company for the research process.

The interviews that were carried out in the beginning were tape recorded and notes were also taken. However, during the two days interview session in Sätra only notes were taken, since Hogström and Grigorjev were mapping the process and it was revised and modified after each interview. Both Hogström and Grigorjev were present at every interview in order to avoid misunderstandings and mistakes.

### 4.1.3 Research Evaluation

In this part validity and reliability will first be explained and then sources of errors in this thesis will be evaluated and afterwards it will be discussed if reliability and validity are reached in this thesis.

#### 4.1.3.1 Validity and Reliability

When a researcher designs the instrument that is used to collect information, the problems of uncertainty arise; is the information that is needed and wanted actually gathered? There is also uncertainty how reliable the gathered information is. Even if the intention is not to "measure", the researcher has to in some way make sure that there is knowledge about what has been done. The researcher has to make sure that the investigation examines what is supposed to be investigated, i.e. there has to be a good validity.[190]

It must also be known that the research is carried out in a trustworthy and reliable way, i.e. it has to be known that the reliability is good.[191] Instruments for measuring could be questionnaires. The questionnaire should produce trustworthy and stable results. Would other investigators reach the same result if they have used

[190] Patel, R., 1994, page 85.

[191] Ibid.

the same instrument and measures? If the research were done on another occasion on the same population, with the same purpose and method, it should generate the same result to have reliability.[192] A method or approach should in order to reach high reliability be independent of investigator. Reliability is a problem in investigations that should be interpreted.[193]

*Validity*

The difficulty with validity is that it is impossible with certainty to decide if a method used to measure is valid or not. There has to be a method of measuring that is known to give the real measure result. If this was the case it is better to use that method. Otherwise, the researcher has to use other methods, more or less subjective, to establish the validity of method used to measure.[194]

The link between the theory framework and the empirical framework is difficult, but without this link research will be useless. These kinds of links are called validity, meaning that what should be measured in fact is measured.[195] The internal validity is about the project and its links between theory and empirical evidence, how the project is planned in its parts. If different parts of the project do not reach validity, the project as a whole could not reach validity. The interviews should be conducted with relevant persons and experiments should have relevant population and the chosen persons should be able to answer the questions.[196]

The external validity is concerned that the project as a whole with its theory and empirical evidence could be valid in a wider setting. The external validity is concerned with the project as a whole, about the possibilities to generalise from a specific study. It is about the possibilities to generalise from the concrete sampling to a population, and somewhat more abstractly, if it is possible to generalise from a specific study to a general theory.[197]

[192] Svenning, C., 1996, page 64.
[193] Eriksson, L. and Wiedersheim-Paul, F., 1998, pages 39 and 40.
[194] Lekvall, P. and Wahlbin, C., 1993, page 211.
[195] Svenning, C., 1996, page 60.
[196] Svenning, C., 1996, page 62.
[197] Svenning, C., 1996, page 63.

*Reliability*

Different methods could be used in order to control the reliability in the investigation. Some authors mean that the same instrument for measuring should be able to be applied several times and give the same result while other mean that the same concept and framing for question/questions should give the same result.[198]

The requirement to use the same instrument for measuring should give the same result is more constrained. Using the same concept of framing for questions in two investigations with different questionnaires does not automatically reach the same result.[199] The reliability in a study could be secured through some simple methods. A definition that is clarified has to be used and it is also possible to use several indicators when measuring a phenomenon that is controversial. The possibility to secure reliability has to be considered in the stage when the instrument for measuring is constructed. Quantitative studies are more to exemplify than generalise. Therefore claims on a qualitative study is higher if it seeks to generalise.[200]

Errors in the measure arise through imperfection in the method of measuring, i.e. the tool for measuring and how it is used. Those imperfections could be of the kinds, low validity and low reliability.[201]

Validity and reliability are in a relationship to each other that stresses the fact that both of them have to be in focus. There are three rules:

- High reliability that does not automatically generate high validity
- Low reliability generates low validity
- Complete reliability is a presumption for a complete validity.[202]

Reliability is a contributor to validity and it is a necessary but insufficient condition for validity.[203]

198 Svenning, C., 1996, page 64.
199 Ibid.
200 Svenning, C., 1996, page 65.
201 Lekvall, P. and Wahlbin, C., 1993, page 211.
202 Patel, R., 1994, page 85.
203 Cooper, D. and Schindler, P., 1998, page 171.

#### 4.1.3.2 Sources of Possible Errors in This Thesis

Some areas that are critical when evaluating the validity and reliability in a research are as follows:[204]

*The wrong problem area is not unusual, since every problem within a organisation has to be interpreted. Sometimes it is difficult to reach the real problem since what is seen is only the symptom. It is not certain that the problem is captured and then transferred into something that could be measured. A mistake could be made already at this stage.*[205]

Since it was the company that selected the problem for investigation, the problem was already introduced to Hogström and Grigorjev. The question is, is the problem definition the real problem or is it just a symptom? Hogström and Grigorjev sought to keep an open mind about the problem definition since the knowledge they have gained from the course highlights that inventory could hide problems. During the early interviews/meetings, Hogström and Grigorjev experienced a feeling that there was something in the area of information that did not work correctly. Therefore the flow of material and information are to be investigated. Since Hogström and Grigorjev believe that they have kept an open mind about the problem in focus and that the inventory could just be a symptom, the possibility of investigating the wrong problem has been considerably reduced.

*Interpreted errors arise when investigating a smaller population and then drawing conclusions for a larger population.*[206]

The names of respondents for the interviews in the study were chosen for Hogström and Grigorjev by FNS. Are the chosen persons likely to be chosen by Hogström and Grigorjev as well? Probably, because Hogström and Grigorjev believe that the problem has been investigated in a correct manner. However, if Hogström and Grigorjev had used a questionnaire instead of interviews, information would have been missed and Hogström and Grigorjev wanted to have the possibility to be surprised by the information transferred at the interview. Therefore, the chosen method was interviews with different persons that work in different

[204] Eriksson, L. and Wiedersheim-Paul, F., 1998, pages 160 and 161.

[205] Ibid.

[206] Ibid.

departments. With an interview guide there was always a possibility for more informal discussions. Also, during these interviews it becomes obvious that there were other persons who needed to be interviewed.

The number of interviewed persons could also be too small. Hogström and Grigorjev realised at an early stage that there were several persons who had to be interviewed in order to be able to map the rigging part of AAA process. A single participant may have incorrect knowledge of the decision-making process in large organizations. The intention for Hogström and Grigorjev was to make sure that it was only the rigging part of the process that was described. In fact, this selection process took some time to separate other processes from the rigging process. The respondent had been describing what they believed to be a part of the actual process in focus. This also stresses the fact that no single participant has knowledge about the whole process. Hogström and Grigorjev are convinced that the number of people interviewed is the number of interviews needed to map the process.

*Errors when measuring could be due to the fact that the procedure is wrong or not appropriate to what is being measured. Errors in this case could be as follows:*[207]

- *Respondent errors, when the respondent cannot or will not give the right information.*
- *The instrument used maybe not is suitable to use in this situation; an example of this is poor quality in the questions asked.*
- *Effects of the interviewer since they could affect respondents' answer through the way they behave, in the way questions are asked, for example.* [208]

As mentioned before, during the interviews both Hogström and Grigorjev have been present in order to prevent any errors and mistake. Hogström and Grigorjev believe that by both being present when carrying out interviews have had a good influence on the interviews. Two different persons with different characteristics makes it easier to meet the respondent since it could be more comfortable for the respondent that hopefully one of the interviewers is more suitable to talk to. If the interviewer conducts the interview alone the situation could be that there is a total

[207] Lekvall, P. and Wahlbin, C., 1993, page 247.

[208] Lekvall, P. and Wahlbin, C., 1993, pages 247 and 248.

mismatch between the respondent and interviewer and no information is transferred at all. However, this is not the situation in this research since both Hogström and Grigorjev have been present.

The instrument used was an interview guide that provided the opportunity to have a discussion and not just answers to the questions from the interview guide. Hogström and Grigorjev believe that by using an interview guide the purpose of the interviews was served well. As has been mentioned before, there was information that became obvious during interviews that, otherwise, would have been missed.

*When working with the data gathered, errors could be made and because of this wrong conclusions drawn. An example of this is that errors could be punched in when registering answers from questionnaires.*[209]

In the thesis, mistakes could arise during the process of adaptation and revision of internal records and transformation of data into useful information. To prevent errors like this, Hogström and Grigorjev have checked the figures a number times and have asked the question if the answer is a probable outcome of the data used. Therefore Hogström and Grigorjev believe that the information has a good quality.

The tools for analysis used are from theory and Hogström and Grigorjev have good reason to believe that these are correct since the theory used is from published sources and some of the theory books are even used as course literature.

*For the researcher, criticism of sources is a method of selection. Constantly during the gathering of the material the researcher has to decide what is good enough to keep and what is not.*[210]

For the literature used in the thesis Hogström and Grigorjev have continuously made an evaluation of the literature. The theory framework has been rewritten several times. This is due to the fact of the data gathering and that Hogström and Grigorjev have worked with an open mind towards problem definition. Their belief is that the selected literature is an appropriate tool to solve the problem definition in the thesis.

[209] Eriksson, L. and Wiedersheim-Paul, F., 1998, pages 160 and 161.

[210] Eriksson, L. and Wiedersheim-Paul, F., 1998, page 153.

In the case of using articles, Hogström and Grigorjev have tried to find and use the original source. The information gathered from the Internet has to be used with a suspicion in mind. Therefore, to find the source of origin is a way to secure the used information. As a result, in this thesis the major part of literature used is from original sources.

#### 4.1.3.3 Validity and Reliability in This Thesis

Is the information that was needed gathered and how reliable is the gathered information? Hogström and Grigorjev believe that the information that is needed to propose a possible solution is gathered. The theoretical framework has been a useful tool for Hogström and Grigorjev while carrying out the empirical framework. There is a link between the theory and empirical part. With this link the investigation examines what it is supposed to be examined and, therefore the internal validity is good.

In this thesis the intention of the investigated process is the method used and the result should apply to another process within FNS. If this is the focus for external validity, then Hogström and Grigorjev believe that an external validity is reached. However, if the purpose is to generate a theory that could be applied in general, then external validity is not reached but Hogström and Grigorjev's opinion is that this kind of external validity is not relevant in the thesis, since the purpose of the thesis work is to suggest a solution to FNS.

Hogström and Grigorjev have been able to construct from the theoretical framework the measurement tool needed to gather information. After the measurement tool was constructed the fieldwork was carried out. The tools for measurement have been very useful during the fieldwork. The question of whether the same results should be reached if the same questions and same respondent was used is difficult to answer since the company works with infrastructure projects. Therefore the AAA process will not be possible to investigate again. Hogström and Grigorjev needed to work with clear definitions and therefore it was necessary to work with one process that was defined and also to work with two flows that also were defined. Hogström and Grigorjev are of the belief that the reliability is reached and it is good.

Hogström and Grigorjev believe reliability is reached but this does not automatically generate validity, although reliability is a contributor to validity. Hogström and Grigorjev are of the belief that validity in the different parts of the thesis has been reached and by this the thesis as whole has reached validity. This together with the evaluation of sources of possible errors in this thesis makes Hogström and Grigorjev convinced that both reliability and validity have been reached in this thesis.

# 5 Empirical Framework

*The aim of this chapter is to present the empirical investigation carried out in this thesis. The first and second research questions are covered in this chapter. At the same time, the third research question is placed in section 2.4 because it is a desktop study. The empirical data is based on interviews with persons with different areas of responsibility within FNS. The interviews were followed by collecting and processing internal data and information, so Hogström and Grigorjev could describe and map the AAA rigging process. Finally, the inventory management at FNS will be described which results in safety and cycle inventories tied up capital calculations for the AAA inventory.*

## 5.1 Flextronics Network Services Product Portfolio

Flextronics Network Services provides a set of integrated service offerings designed for operators and systems vendors to design, build, operate and maintain fixed and mobile networks.

### 5.1.1 Network Design

Network Design services includes two main areas of activity called Telecom Planning and Network Design.[211]

*Telecom Planning and Network Design:* In the area of Telecom Planning, Flextronics Network Services offers the following services: consulting, analysis and planning.

FNS proposes solutions in the design of fixed and mobile networks: from pre-study to final implementation in accordance with the requirements of customers and their design objectives.

### 5.1.2 Network Build

Network Build services include the following areas:[212]

[211] http://www.flextronicsnetworkservices.com

[212] Ibid.

*Site Development:* Once the planning and design processes are completed, FNS proceeds with site and material planning, the geographical location of masts and the technical parameters. Flextronics Network Services researches the requirements of local ordinances and develops strategies for site acquisition for each region of the project.

*Civil Works and Construction:* Flextronics Network Services provides a team of professionals to manage all aspects of the construction and civil works process - from site construction assessments to close-out, including subcontractor evaluation and coordination.

*Telecom Implementation:* Flextronics Network Services houses the following implementation services: site engineering and preparation, telecom equipment mounting and installation, site configuration data management, commissioning, procurement and logistics management, site acceptance testing and quality control, and project management.

*Network Integration:* Services performed within the integration field are: equipment integration, integration testing and system optimization.

### 5.1.3 Network Operation and Maintenance

The set of services in Network Operation & Maintenance area are:[213]

*Network Operations:* The Network Operations area activities are: surveillance, remote analysis and support, configuration management, performance management and activity management.

*Network Optimization and Network Maintenance:* FNS provides optimization services: periodic testing of network elements, tuning for peak performance and identification of upgrades to improve performance or migrate to next generation technologies.

[213] http://www.flextronicsnetworkservices.com

## 5.2 Market Introduction

The company and its historical background, corporate vision and values and what it offers have already been present in chapter one. In this section the market it is serving will be described.

### 5.2.1 Network Investments

On behalf of Swedish National Post and Telecom Agency, two investigations about 3G network investments in Sweden have been carried out. In the consultancy firm McKinsey's report, Sweden was referred to as one of the countries in Europe that would have the most expensive UMTS networks, where the cost for the Swedish UMTS rollout was estimated to exceed 30 billion SEK.[214]

Another independent assessment of the total investment has been performed by Björkdahl and Bohlin from Chalmers University of Technology, who declare the total amount of investments to 24,4 billion SEK. Furthermore, Björkdahl and Bohlin state in the report that the total investment could possibly be reduced by a further 5 billion SEK if the UMTS operators cooperated fully in accordance with the possibilities provided by the license conditions. [215]

The number of sites and the site distribution are dependent on the density of population. Björkdahl and Bohlin assume that a site in an urban area covers approximately 3.5 km² and a site in a rural area covers approximately 29 km².[216]

The results of Björkdahl and Bohlin's report are provided in Table 5.1. The total investment in Sweden is estimated as 24.4 billion SEK, and the total number of 3G sites as about 18 000. Surface coverage differs between the two consortia since Vodafone and 3 will build additional, individual networks.

[214] UMTS- en överblick av utbyggnaden, Delrapport, PTS-ER-2003:30, 2003.

[215] Ibid.

[216] Björkdahl, J. and Bohlin, E., 2003.

Table 5.1 Investments of 3G license holders in Sweden.

| | 3GIS | Vodafone (individual network) | 3 (individual network) | Svenska UMTS nät | Total |
|---|---|---|---|---|---|
| Number of sites | 7740 | 860 | 860 | 8600 | 18060 |
| Number of sites in urban/suburban areas | 2280 | 860 | 860 | 3140 | 7140 |
| Number of sites in rural areas | 5460 | 0 | 0 | 5460 | 10920 |
| Re-use of 2G sites | 1000 | 350 | 0 | 3100 | 4550 |
| Total investment (SEK billion) | 11.0 | 0.9 | 1.1 | 11.4 | 24.4 |
| Surface coverage ($km^2$) | 167 000 | 3000 | 3000 | 170 000 | - |

Source: Björkdahl, J. and Bohlin, E., 2003.

Table 5.2 provides information on how the investments are distributed per 3G actor, including Telia.

Table 5.2 Investment for all 3G consortia owners.

| | Telia | Tele2 | Vodafone | 3 | Total investment |
|---|---|---|---|---|---|
| 3G network investment (SEK billion) | 5.7 | 5.7 | 6.4 | 6.6 | 24.4 |

Source: 3G investments in Sweden, PTS-ER-2003:9, 2003.

As an alternative, Björkdahl and Bohlin provide a simulation based upon the possibility that the two consortia will completely share the rural network. Table 5.3 illustrates that the total investment level in this alternative will be 19 billion SEK.

Table 5.3 What if consortia will cooperate in rural areas.

| | **Telia** | **Tele2** | **Vodafone** | **3** | **Total investment** |
|---|---|---|---|---|---|
| 3G network investment (SEK billion) | 4.4 | 4.4 | 5.0 | 5.2 | 19.0 |

Source: 3G investments in Sweden, PTS-ER-2003:9, 2003.

Björkdahl and Bohlin estimate that the average cost per site (including the radio and core network) will be 1 250 000 SEK and that by re-using an existing 2G site 500 000 SEK will be saved. In the extreme case, the operators can only share the sites, and save around 10%.[217]

Due to all the facts that were mentioned above, the 3G rollout in Sweden is a very time and investment intensive process. During the short period of time (2000-2004), the operators have to install more than 18 000 3G sites and invest more, than 24 billion SEK, in the worst case scenario, according to Björkdahl and Bohlin. These conditions make Swedish 3G market very attractive for mobile network installation companies.

## 5.3 Mobile Network Service Market

There are at least five other companies that offer the same service as Flextronics Network Services. Hogström and Grigorjev will give short introduction of each of them.

### 5.3.1 ABB Group

ABB Group offers to its customer the full range of project management and installations for telecommunications networks that includes network planning, site acquisition, construction works, installation and commissioning. It has formed separate agreements with system providers such as Nokia and Ericsson to build 3G mobile communication networks in Europe.[218]

[217] Björkdahl, J. and Bohlin, E., 2003.

[218] http://www.abb.com

ABB states that the Nokia agreement covers Europe, the Middle East and Africa with full range of network implementation services. Ericsson has appointed ABB as the Global Authorized Service partner in the mobile communications field with similar network building responsibilities.

ABB has already designed and implemented telecommunications infrastructure in the Nordic countries, Australia, Austria, the Benelux countries, the Czech Republic, Germany, Poland, Switzerland and other countries in Europe. The company possesses several communication network service contracts in these countries.

In total, ABB has some 2 000 people working in the telecommunications area, generating revenues of approximately 500 million USD a year.

### 5.3.2 Ramboll Telecom Sweden

On 1st October 2002 Danish telecom service provider Ramboll opened an office in Stockholm, primarily with a view to serving clients within the telecom sector in Sweden. On the Nordic market Ramboll is represented by the consulting company ScandiaConsult that has experience of mobile network implementations in more than 25 countries. The company performs site acquisition, network design, project management and construction for mobile networks operators.

The company is involved in the 3G rollout in Denmark, Portugal and Sweden. Ramboll Sweden has received orders for UMTS design and production from Vodafone and Hi3G in Sweden.

The office in Stockholm had five engineers in 2002 plus 10 telecom engineers at ScandiaConsult. [219] There is no additional public information about the company's turnover on the Swedish market.

### 5.3.3 SAAB Contracting

SAAB Contracting belongs to the SAAB Group and has 40 years experience in the telecommunication field. The company delivers to the customers the broad variety of services such as system design, project management, site acquisition,

[219] http://www.ramboll.dk

construction work, material purchasing, logistics, installation, rollout, training, documentation, service and support.

SAAB Contracting acts on the telecommunication market as an independent service supplier that participates in construction and development of modern telecommunication systems. The company cooperates with other units within the SAAB Group in terms of technical support and service activities. SAAB Contracting sees Scandinavia as a home market with several projects in Europe.

SAAB Contracting has carried out several projects for Comviq GSM AB, Ericsson, Europolitan (Vodafone), Motorola Ltd. and Telia Mobile AB. The company was granted a contract for project management and installation of 3G systems on the current GSM sites for Telia Mobile networks.

SAAB Contracting has approximately 180 employees and the company is turnover 300 million SEK a year.[220]

### 5.3.4 Swedia Networks

Swedia Networks has experience in constructing, operating and servicing fixed and mobile networks in Sweden and other countries. The company is represented by its wholly owned subsidiaries' network in Sweden, Denmark, Germany, the UK, Austria, France, Switzerland and Malaysia and offers its customers network design, planning and construction, installation and, finally, network integration.

In the company's customer portfolio are more than 300 companies from Europe, as well as from other parts of the world. TeliaSonera, Tele2, 3GIS, Ericsson, Nokia, Nortel, Flextronics Network Services, Vodafone and others could be mentioned as Swedia Networks' customers in Sweden.

The company has approximately 2 500 employees and turnover around 328 million EUR. 49% of the shares are owned by TeliaSonera.[221]

All these companies have long-time experience in the telecom field and have entered the European telecom market, except for SAAB Contracting. Ramboll Swe-

[220] http://www.contracting.saab.se

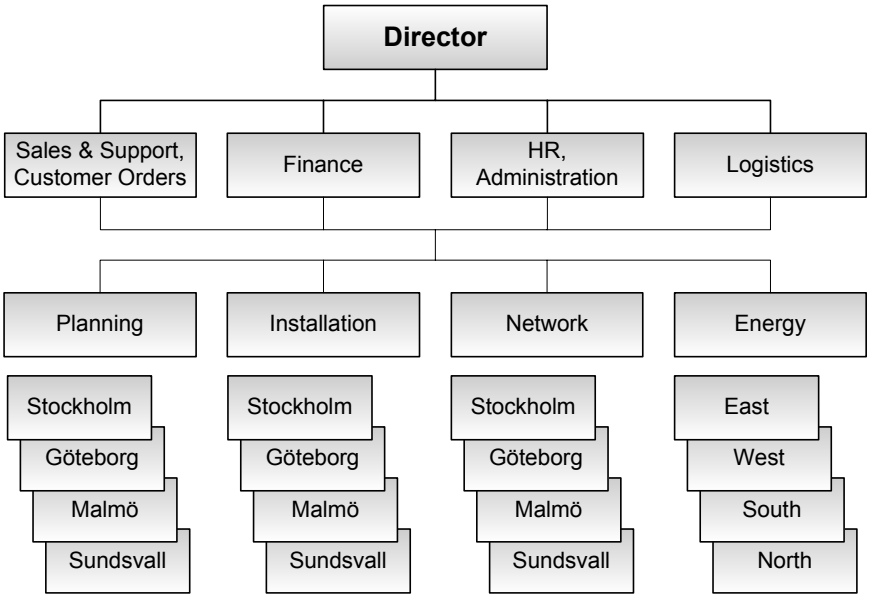
[221] http://www.swedianet.com

den is mostly concentrated on consulting services. In our view, Swedia Networks is the strongest player and competitor for FNS on the Swedish 3G market. However, Flextronics Network Services has succeeded in negotiating a collaboration agreement with TeliaSonera when it took over Orbiant Group in 2001. TeliaSonera guaranties to provide FNS with contracts until the end year 2004.

## 5.4 FNS Contracting Department

The figure below shows the organisation chart of the Contracting Department, which is one of the departments within the FNS organisation. The Contracting Department is considered as a region within the FNS Sweden organisational structure. The Supply Department that is discussed in this thesis is located in the box, "Logistics". The installation team and Zone Manager are located in the box, "Installation".

Figure 5.1 Contracting Department structure.




Source: Flextronics Network Services, 2003.

### 5.4.1 Contracting Department Guidelines

The Contracting Department has established policy for the following activities:

*Logistics and Service:* Logistics takes care of all material planning and efficiency control of material flow and the administrative flows from the material procurement

to the delivery and the goal is to minimise costs and improve service for the customer.

*Material planning:* The department for material planning has the following responsibilities: to perform the physical material planning as efficiently as possible, to cost efficient inventory, to offer quick and flexible solutions concerning transports and deliveries and statistical follow-ups, i.e. deviations and results.

*Logistics:* Logistics is responsible for planning of transports, coordination of deliveries towards the transporters and third parties, follow-ups for project costs and revenues, forecasts and follow-ups of pricing and delivery time frame.

*Procurement:* According to internal documents, the main goal for the Supply Department is to control in an efficient way, together with other departments, that requirements of service and products are up to standards.

The Supply Department product and service procurement policy consist of providing the right quantity and right quality at the required time, to the right place, for the right price and from the right supplier. The company is interested in developing and maintaining proper and trusting relations with suppliers.

Development of cooperation with other departments is concerns: new material, service, methods and material and flows.

The goals for the Supply Department are to develop and sustain good relationships with its suppliers; contribute to keep tied-up capital on a cost efficient level regarding other goals, for example, high delivery capacity, and in an active way, observe that material in inventory is useable and data concerning inventory is accurate and up to date.

*The overall goals for the Contracting Department are:*

- Deliver service and products to the customers at the right time with the right quality.
- Delivery precision: 98%
- Quality precision: 100%

## 5.5 AAA Business Process

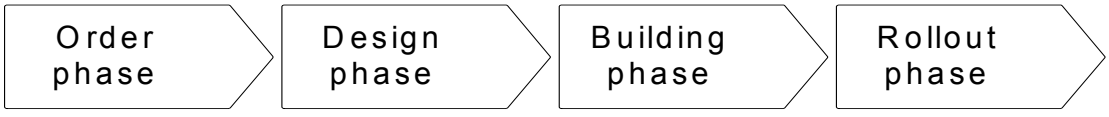
In order to monitor the information and material flows, Hogström and Grigorjev chose to map the AAA process. It is the current situation of the process that should be mapped, not the desired process. The time that is measured in the process is the passing through time for the activity at each department, not how long the activity takes. It has to be highlighted that the activities mapped are only activities that take place in the rigging process. There are other activities that could take place during this time window; however, these activities do not belong to the AAA rigging process.

According to FNS representatives, almost every 3G site is "tailored" after customer demand, and is unique, due to the technical, topographical and other reasons. However, in order to facilitate the 3G sites information handling, Hogström and Grigorjev with the company approval, made an attempt to simplify the AAA 3G sites variety. The attempt is resulted in the classification into four different categories of 3G sites that are rigged for AAA. The classification is based on the diameter of feeder cable. There are four dimensions of feeder cable and, therefore, four types of 3G sites are used: 1/2, 7/8, 1 1/4 and 1 5/8 inches.

When the process was mapped it was realised that the material specification was generated from the Zone Manager and this specification initiated the material flow. This specification also caused the choice of the articles to be investigated. At this point it was also possible to conduct a study of the current situation concerning the articles linked to AAA rigging process. This study is in section 5.7. The internal records are used as underlying data for the calculations made in thesis is are in Appendices 4 and 5.

The total rollout process of 3G mast consists of several phases, which are Order, Design, Building and Rollout.

Figure 5.2 UMTS rollout FNS.




Source: Flextronics Network Services, 2003.

Since the rigging process is carried out in the rollout phase, this is the only phase considered in this thesis. Other processes in rollout phase are civil works and installation of radio base station. These processes are carried out in sequences: first is civil work, second is the rigging process and third is the installation of radio base station. They must also be carried out in this sequence and there could be different contractors carrying out the processes. When the project is assigned to the Contracting Department, this is the start date and it is also used as a start for the rigging process. Before the work of rigging process begins, civil works have to be carried out. It has to be pointed out that civil works are not always necessary, but the rigging and radio base station installation process is always carried out. In the rigging process, antenna or antennas have to be rigged in a mast and feeder cable has to be installed. In this thesis the rigging process consists of masts that already exist i.e., GSM masts. The case could be that no mast exists at all in the area and has to be built before any other work could be carried out.

## 5.6 AAA Rigging Process at FNS

Mobile Network conducts a specification over the needs for the sites in order to answer the request from AAA. Mobile Network makes blueprints of the sites, determines what is needed to cover the area, applies for building permit and other kinds of requirements that have be to be done on each specific site. The time perspective that Mobile Network needs for this procedure is difficult to estimate because the time for the building permit application varies considerably from case to case. If there are any appeals against a site location, the whole procedure has to start all over again. When the specification of sites is ready, Mobile Network sends an offer to the Contracting Department. In the Contracting Department it is Sales and Support that negotiates the contract with Mobile Network. When an agreement is reached between both sides involved the contract is ready for rollout.

In the next step in the process, the Contracting Department takes over the operational work of the contract and the Project Administrator registers the project in the Project Management system and controls that all documents are included.

An e-mail is sent to the Zone Manager with the message that sites are registered in the Project Management system. The Zone Manager gathers documentation from

Project Management system and controls that all documents are included and determines it if any documentation is missing. The Zone Manager or someone else carries out a site inspection for each site in order to control if the blueprints are correct, makes a decision regarding what material (material specification) is needed for each specific site and carries out human resource planning. These activities start 5-10 working days before site rigging and the passing through time of these activities is 16-80 hours.

The Zone Manager forwards material specification to the Supply Department. The Supply Department registers the material specification in the system; this is mostly done at once or a maximum of one day after receiving the material specification. The feeder cable is ordered separately. Passing through time for this activity is 8 hours. Then, the material specification is sent to the purchaser who analyses the material requirements and orders articles if needed. Passing through time for this activity is 8 hours. Time for these activities is 24 hours and 8 hours for material transport to site.

The rigging takes about 40 hours for each of three technicians.

Under the installation process at site, the team has to register the performed work in a diary. When the rigging is completed, the team carries out an inspection to make sure that everything is according to requirements. The final documentation together with the material specification and working hours for the team is sent to the Zone manager.

There is also an independent inspection of the site. In the beginning, Mobile Network executed this inspection. However, at present Mobile Network has handed over this to Jan Mattsson, Contracting Department, who performs the inspection. Mattsson organizes the work so that an independent person executes this inspection. If the work is not performed according to instructions, a list of the faults that have to be corrected is prepared. Passing through time for this activity is 8 hours. If there are faults to correct on the site, the team has to adjust these faults within a week. When the correction is carried out, the passing through time is 8 hours.

The Zone Manager gathers the complete documentation of blueprints, material specification, working hours and invoices for the additional material bought for

site from the team. During the visit at Sätra on the 17th of October 2003 some sites installations had been completed five weeks earlier and the documentation was still missing. When the documentation is completed an internal invoicing is sent to Mobile Networks.

Below, the rigging process described according to the schedule from Theory Framework. FNS do not have information about the costs for each activity, and therefore no information is available in this column.

Table 5.4 AAA rigging process within Contracting Department.

| No. | Activity Description | Time, h | Value-Adding Activities | Cost |
|---|---|---|---|---|
| 1 | Project assignment to Project administrator | 8 | 0 | |
| 2 | Site inspection<br>Human resource planning<br>Material specification | 16-80 | +<br>+<br>+ | |
| 3 | Material order | 8 | + | |
| 4 | Purchasing | 8 | + | |
| 5 | Material picking, packing and delivery | 32 | + | |
| 6 | Rigging | 40 | ++ | |
| 7 | Documentation and First inspection | * | 0 | |
| 8 | Documentation posting to Zone manager | 8** | 0 | |
| 9 | Second and independent inspection of site | 8 | 0 | |
| 10 | Corrections (if needed) | 0-8 | 0 | |
| 11 | Final documentation to Zone manager | *** | 0 | |
| 12 | Final documentation to Project administrator | 8-200 | 0 | |
| | **Total:** | 136-400 | | |

* - Documentation gathering and First inspection are carried out during the rigging process, and therefore there is no passing through time for this activity.

**- Posting of the documentation to Zone Manager takes one day with mail (passing through time = 8 hours).

*** - The final documentation gathering process is similar to process 12, therefore the time is registered only once.

The activities are valued from the value-adding criteria used in theory, or also according to what does not add value. According to these criteria, activities like inspection, transport, storage and delay do not add any value to the product. The time measured is the passing through time for each activity in working days, i.e. 5 days a week and 8 hours per day, 136 / 8 = 17 days and 17 / 5 = 3,4 weeks.

Figure 5.3 AAA rigging process

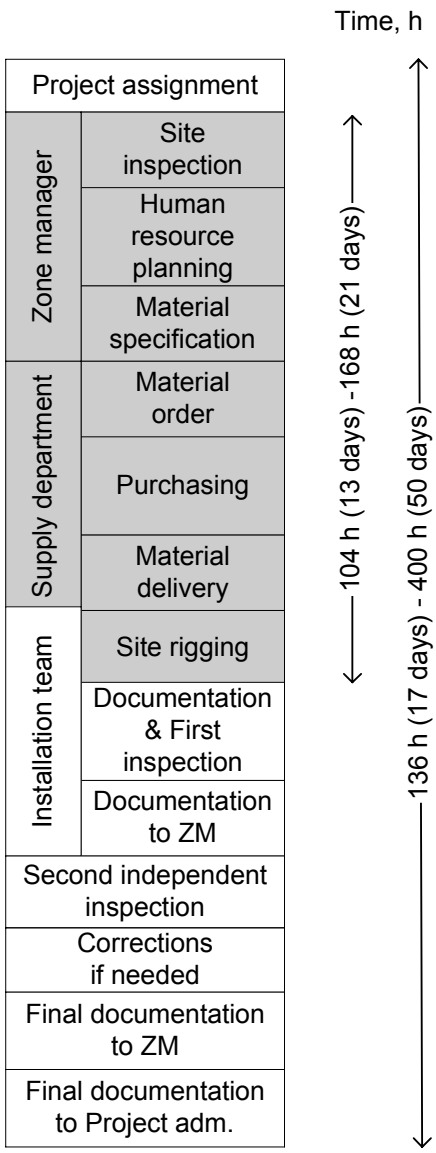



Figure 5.3 is an illustration of the Table 5.4 and the areas that are shaded grey are those that add value. According to the criteria of value-adding activities used in this thesis the total passing through time for these activities is 104 – 168 hours. The gap between 136 and 400 is caused by the gathering the final documentation that was delayed by 5 weeks (5*5*8=200 hours), when Hogström and Grigorjev were mapping the process. This might not always be the case, but the point of mapping a process is to depict the current situation.

Table 5.5 shows the number of departments or persons involved in the AAA rigging process. The following function-flow-schedule is particularly useful when

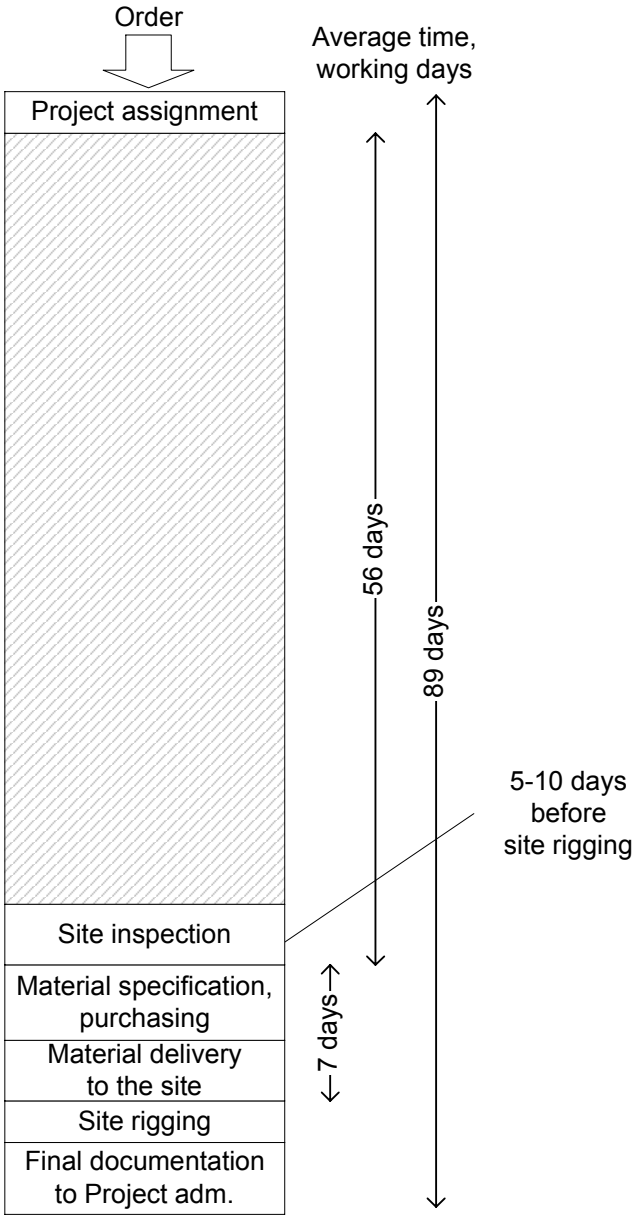
there is a need to map out how many individuals and departments are involved in a process.

Table 5.5 Functional flow chart of the activities within Contracting Department.

| **Departments** | **Activities** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project adm. | 1 | | | | | | | | | | | | | |
| ZM | | 2.1 | | | | | | | | | | | | |
| ZM | | | 2.2 | 2.3 | | | | | | | | | | |
| Supply dept. | | | | | 3 | | | | | | | | | |
| Purchaser | | | | | | 4 | | | | | | | | |
| Supply dept. | | | | | | | 5 | | | | | | | |
| Inst. team | | | | | | | | 6 | | | | | | |
| Inst. team | | | | | | | | | 7 | | | | | |
| Inst. team | | | | | | | | | | 8 | | | | |
| Quality manager | | | | | | | | | | | 9 | | | |
| Inst. team | | | | | | | | | | | | 10 | | |
| ZM | | | | | | | | | | | | | 11 | |
| Project adm. | | | | | | | | | | | | | | 12 |

The result of investigation of internal order processing information is presented in Figure 5.4. If the time that is presented in Figure 5.3 above is based on the interviewees' personal assumptions, then the timing in Figure 5.4 is entirely founded on a number of revised Excel tables for AAA orders from various departments and persons (see Appendix 3). The figure shows the time periods on average between different points of time.

Figure 5.4 AAA rigging process analysis based on empirical data




Figures 5.3 and 5.4 present an important view on the total AAA order processing process and will be analysed later on in the thesis.

## 5.7 Inventory Management for AAA 3G sites

The inventory building is located in the neighbourhood of FNS office building in Sätra outside of Stockholm. Flextronics Network Services utilizes three different types of inventory: cycle inventory, safety stock and inventory in-transit. All these types of inventories are located in the same building. The inventory has a capacity

of approximately 700 euro-pallets and has as its purpose the provision of installation teams with material and serve FNS' external customers. Also, the company leases out the inventory space to some customers for their spare parts.

### 5.7.1 Inventory Management at Flextronics Network Services

The chief of the Supply Department, Magnus Rickman is in charge of inventory management and purchasing process. The operational task of the Supply Department is to manage inventory, order components from suppliers according to material specification provided by Zone Manager and to ensure the components delivery to the installation place on agreed dates. There is a rule, as mentioned in the previous section, that the Zone Manager has to place an order with material specification for sites at least five working days in advance before the start of site rigging process. The "five days practice" is based, as explained by Rickman, on the following time distribution: one day for Purchaser, one day for Material administrator, three days for material picking, packing and, finally, one additional day for transport. All required components are delivered to site installation place in batches after they have been kitted in Sätra.

FNS manages inventory with the help of ERP system Movex (Intentia Ltd.), which was launched on 1st September 2003. Before this date, the company had utilized ERP system from IFS. According to the Material administrator, Björn Hallgren, the company uses Material Requirement Planning (MRP) system for purchasing components, managing and handling inventory. FNS does not use any demand forecasts for their purchasing activities. The company uses 12% interest rate for the capital tied up calculations.

The company strives to establish deeper relationship with its suppliers in order to decrease and eliminate uncertainties in the order processing. Furthermore, FNS plans, in cooperation with its suppliers, to offer the customers the total solution of mobile networks installation with better quality and control over installation process for lower costs.

### 5.7.2 AAA 3G Sites

As was mentioned in the previous section, there are four dimensions of feeder cable and, therefore, four types of 3G sites are used: 1/2, 7/8, 1 1/4 and 1 5/8 inches. Each type of 3G site consists approximately of over 20 various articles, which are standard articles for mobile network sites. Some of these articles are used for all four site variations. For example, Article A1 is utilized in every type of site. However, due to the certain degree of site uniqueness, the total number of articles that are used for AAA is 110. In fact, 47 of them are used more frequently than others. The material specification and material costs for different 3G sites are presented in Appendix 4. The articles in the tables are distributed after their costs per site. Article A1 is a most expensive article for 1/2 and 7/8 inches site variations, while Article F1 costs are highest for two other remaining types of sites.

### 5.7.3 Demand Distribution of 3G Sites

Flextronics Network Services received its first 3G site order from AAA on 10th April 2003. The time period that is covered in the thesis extends until 31st October 2003. Hogström and Grigorjev were given the statistical information about AAA sites for this time period.

One order from AAA may include several 3G sites. FNS has rigged 124 3G sites for AAA during the time period.[222] The total material expenses for rigged sites exceeded 8 million SEK. With the help of Table 5.6, it could be seen that the site type 1 5/8 inches had greater demand than other site variations and it stands for almost 50% of material costs for the time period.

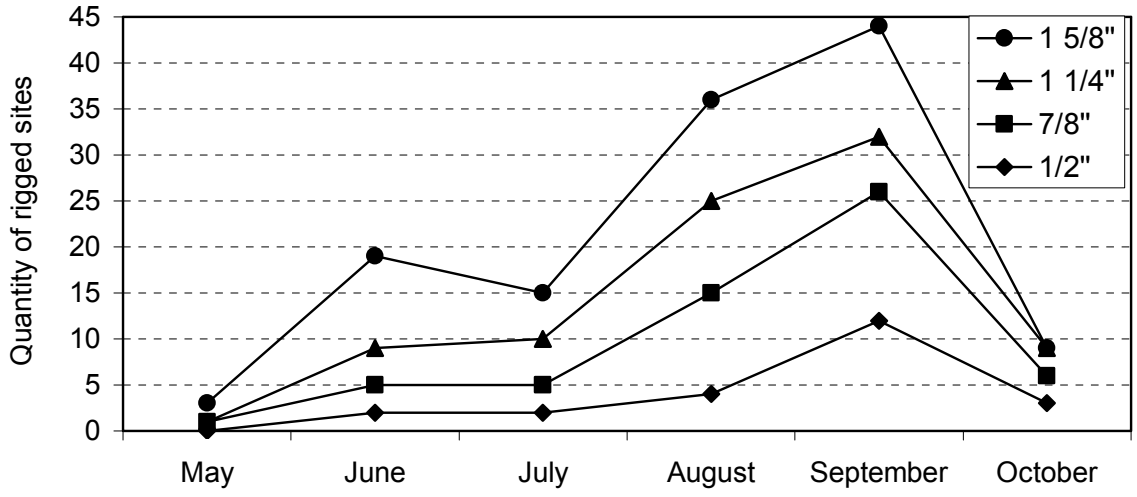
[222] Due to unclear site division in the company's performance statistics for the total number of rigged sites, the company's figures may not correspond to figures in the thesis in some cases.

Table 5.6 Demand statistics and material costs per type of site.[223]

| | 1/2" | 7/8" | 1 1/4" | 1 5/8" | Total |
|---|---|---|---|---|---|
| Quantity of ordered sites | 23 | 35 | 28 | 40 | 124 |
| % of the total quantity | 17 | 28 | 23 | 32 | 100 |
| Material costs per site, SEK | | | | | |
| Material costs for time period, SEK | | | | | 8 334 568,6 |
| % of the total costs | | | | | 100,00 |

The Figure 5.5 shows demand distribution during the time period. As could be seen from the figure and as it was acknowledged by FNS' employees, there is no stable pattern in demand for AAA business sector.

Figure.5.5 AAA 3G sites demand variations.




## 5.7.4 Suppliers

For the AAA business sector, FNS purchases components from several suppliers, which are mostly situated in Sweden. The Purchaser orders articles from suppliers via e-mail or/and telephone. The list of suppliers is provided by the customer (AAA) that made a contract with suppliers regarding delivery preconditions,

[223] "Quantity of ordered sites" statistics is based on the sales figures for feeder cable (05.05-31.10.2003) that were presented by cable purchaser M. Radisevic.

prices, and other related matter. Therefore, FNS has almost no option for further negotiations with suppliers in terms of prices and order quantities. Due to these reasons and the uniqueness of every order, the relations between FNS and suppliers are established on the contractual base.

There are two purchasers for AAA business sector in the company: Milos Radisevic, who is responsible for ordering feeder cable and Lea Piltorn, who orders the remaining material for 3G sites. According to feeder cable purchaser, Milos Radisevic, FNS established a wide network of feeder cable suppliers and, therefore cable lead times are not the critical one among other articles. There is always an option to deliver feeder cable in one or five working days, depending on order urgency. There are no available statistics about suppliers' delivery performance in terms of quantity and lead-times variations. According to Piltorn, suppliers' delivery lead-times for AAA articles are from 5 up to 20 working days plus additional transportation time of one-two days. However, there were some cases when the delivery time from suppliers extended up to 30 working days depending on demand from other companies. Due to the lack of suppliers' performance information, Hogström and Grigorjev will assume that all lead times and quantities are fixed and stable.

### 5.7.5 Cycle Inventory

The AAA cycle inventory is estimated to 403 258 SEK without interest rate. However, the value of cycle inventory in reality is somewhat higher since Hogström and Grigorjev's calculations are based on the 47 most frequently used articles. The information about item prices, order quantities and cycle inventory is presented in Appendix 5. For example, the highest order value has Article A1 with an order size of 15 units and a value 165 000 SEK. The high order value is a consequence of the high item price and large order size. As a result, the percentage of two highest order values (Articles A1 and A2) of the total cycle inventory costs is respectively 21% and 14%. It may even be said that only two articles of 110 represent 35% of cycle inventory value in AAA case.

### 5.7.6 Safety Stock

According to Material administrator Hallgren, the selection of articles and quantities in the safety stock are based on manual analysis with the help of MRP system. Demand frequencies, suppliers' lead-times and minimal order size for purchasing are major considerations in this selection. As Hogström and Grigorjev have previously mentioned, the demand pattern of AAA 3G sites is uneven. Therefore, Hogström and Grigorjev believe that the company has applied a strategy of utilising a safety stock in order to avoid site installation interruptions, as well as to secure and improve its service level for the customers. As Magnus Rickman admitted, the higher level of inventory has contributed to winning new orders from customers due to the short material delivery time.

There are 61 items that are placed in the safety stock for AAA sites. The value of safety stock for AAA orders is estimated by Hogström and Grigorjev to 943 208 SEK (without interest rate). There are three articles (3%) that represent 53% of safety stock tied up capital: A1 (35%), A2 (12,3%) and A3 (5,9%). These articles are used in all four 3G site variations and only for AAA 3G sites.

### 5.7.7 Tied Up Capital in Inventory

Hogström and Grigorjev will use the Equation 2-2 and focus only on tied up capital in Cycle and Safety inventories, not including Inventory in transit. The result of tied up capital estimation is presented in Appendix 5.

The total cost of tied up capital including interest rate today for AAA 3G sites is:

$$Tied\ up\ capital = Cycle\ stock + Safety\ stock = 406\ 168 + 943\ 208 = 1\ 349\ 377\ \text{SEK}$$

$$Cost\ of\ capital = Cycle\ stock \times I + Safety\ stock \times I = 27\ 213 + 63\ 194 = 90\ 408\ \text{SEK}$$

$$Total\ cost = Cost\ of\ capital + Tied\ up\ capital = 90\ 408 + 1\ 349\ 377 = 1\ 439\ 785\ \text{SEK}$$

The time period from 10th of April 2003 until 30th of October 2003 consists of 201 days, and therefore, rate is calculated to 6,7%.

# 6 Analysis

*In this chapter, Hogström and Grigorjev will analyse their findings from the previous chapter. Firstly, after discussion with the company and evaluation of required information about inventory analysis, Hogström and Grigorjev come to a decision to attempt implementation of the Lead-time analysis approach in order to reduce inventory tied up capital for Flextronics Network Services. Secondly, analysis of inventory management will be carried out, which includes the examination of possible alternative models for safety and cycle inventories using modified various inventory variables. Comparison and analysis of different values for tied up capital will be presented. The analysis of the desktop study about Competitive advantage for FNS is located in the last section of Analysis chapter.*

FNS' business area is network projects. The word "project" points out that the work performed at FNS has a time limit, since projects always have fixed date of beginning and ending. This indicates that the environment, where FNS has its business, is in constant change. There will always be different customers with different demands. In the past, a company could compete with the physical product; the quality and the functionality of the product was enough to win a customer. This has changed since, if a company wants to be an order winner, the offer has to include a service that will make a product competitive.

One important part of the service offered, together with the physical product, is the activities related to logistics. It may even be said that the physical product has lost its significance. There are other companies on the market that can offer the same products/services as FNS. For FNS to be an order winner, it has to set up and utilise the superior logistics service and offer the best product/service to its customers. FNS has to concentrate on its core business and to perform its core activities in more cost-efficient way in the future.

## 6.1 AAA Rigging Process

In order to find out what articles were linked to the AAA rigging process, the process was mapped and the information flow was traced. When the information flow was outlined, the material flow was mapped as well.

The situation at FNS reflects that management of material and information flows is a cross-functional and the difficulties of information sharing among different internal functions/departments were discovered at FNS. The negative effect of information hoarding within FNS resulted in the inventory build-ups. The situation, which is described in Analysis chapter, confirms what theory framework states about information flow: information flow has become vital to a company because it enables a company to respond in real time and with accurate data. When information is treated as an asset, it is possible to have efficient and secure material flow. It also confirmed that if a company wants to reduce uncertainty of the required articles, the material flow cannot be isolated from the information flow.

There is no doubt that information flow is important and it is important to evaluate what kind of information adds value to the FNS logistics system. The ability to change data into useful information is essential; otherwise it will only be data and it has no value for managers in the decision-making process. To transform data into information that is of no use only costs money. Therefore, the departments within FNS have to agree about what kind of information adds value before taking decision regarding what information should be produced and shared.

As could be seen from the AAA process description, the useful information is generated at different occasions within the process. This information, in fact, is already available early in the process and could be useful for the Supply Department in their approach to reducing tied up capital in inventory.

If FNS uses the available information in a correct manner it could be more as an asset and vital to the Contracting Department. Some of the information, regarding what articles are needed, is available today to the Supply Department, but is not utilised until late in the process. The challenge for FNS is how to set up new guidelines for communication and co-operation in order to achieve a higher degree of information visibility in the internal supply chain.

Hogström and Grigorjev have evaluated the activities that are taking place in the AAA process according to value-adding criteria described in the theory framework. The management at FNS has to decide what criteria should be used for ac-

tivities classification in value-adding context. Since FNS has not defined the criteria for value-adding activities within the process, Hogström and Grigorjev will not perform the further analysis of activities according to questions mentioned in section 2.2.3.2.

The Figure 5.3 illustrates the AAA rigging process and the areas that are shaded in grey are value-adding activities. The activities that add value, according Hogström and Grigorjev, are at least 42% (=168 working days / 400 working days) and at the most 76% (=104 working days / 136 working days) of the total time. It is important to reduce the time that does not add any value, since the customer will not pay for these activities. If the customer is not willing to pay for these activities, this will only be a cost for FNS and in the end this will negatively affect the profit for FNS. Another way to dispose of non-value adding activities is to transform those activities into value-adding and be paid by the customers.

According to Hogström and Grigorjev, the activities such as site inspection, human resource planning and material specification are regarded as activities that add value to the process. The Zone Manager is responsible for all three activities. These activities are also important for the information flow regarding what and when material is needed. The reason material specification is delivered at least five days in advance is that the Supply Department (according to their explanation) needs at least five days to carry out the purchasing, picking, packing and additional time (one working day) for the material delivery to the site. Hogström and Grigorjev consider that there is no logic behind "five days' practice", since all articles have longer than five days' lead time. Furthermore, the employees at the Contracting Department just follow the established practice without questioning it. As a result, the Supply Department has kept high levels of inventory.

Furthermore, when the Contracting Department receives an order, it is not clarified what type of site is to be rigged. However, some of the articles are used in all sites variations and the information of sites ordered quantity is, actually, the real demand for these articles. Hence, Hogström and Grigorjev believe that some kind of categorisation of material is necessary for the material handling improvement. This could simplify the Supply Department articles' demand estimation. As it is today, the information regarding articles for purchasing is sent by the Zone Man-

ager to the Supply Department five days before they are needed. In reality, according to Figure 5.4, the material specification is handled over to the Supply Department within 56 working days on average after the order was received at the Contracting Department. In the illustration there is a time window between the Order assessment and Site inspection stages. It could look like there were no activities at all are performed. However, the work that might be carried out is called civil works. The civil works have to be performed before the rigging process takes place. The question is how is it possible to benefit from the time window in the rigging process (this will be analysed later in this chapter).

When site orders quantity is received, this is will be the real time demand. To utilise the real time demand for site specific articles, the site inspection and human resource planning has to be performed earlier in the process compared to when it is carried out today. The site inspection gives the information of what articles are needed and the human resource planning contributes with the information of when the articles are needed. These two activities produce the information flow and as a natural step this is also a link to the material flow. Furthermore, this also points out that the Zone Manager is the key to the information that the Supply Department needs. In order to have inventory of required articles in terms of type and quantity, the changes of how AAA process is carried out are needed. However Hogström and Grigorjev believe that these changes will lead to lower levels of inventory in the long time perspective and thereby possibly more savings concerning tied up capital in inventory.

As depicted in Table 5.4, the total lead time of AAA process is extended due to the extensive time (up to 50% in the worse case) for gathering the documentation that is needed to carry out an internal invoicing. When the mapping process was conducted, there were several sites that were finished five weeks earlier but the final documentation was still not gathered. This affects FNS' order fulfilment processes in a negative way, since the final internal invoicing could not be sent. The financial flow is disregarded in this thesis, however, although this is an important part in the order fulfilment process, vital to the company and also a part of FNS' financial management.

The customer order sets the logistics function in motion, but the logistics function could be set in motion earlier in the process. In order to reduce the tied-up capital in inventory, the generation of material specification in the process that has to be changed. Hogström and Grigorjev believe that the time between Project assignment and Material specification could be utilised in better way.

## 6.2 Inventory Management Analysis

Hogström and Grigorjev will carry out an analysis of inventory management at FNS that is based on empirical data. The aim is to create a model with guidelines of FNS inventory management in order to develop a base for conclusions and recommendations.

FNS employs inventory because of the following reasons:

- To act as a buffer between supply and uneven demand;
- To allow for demands that are larger than expected, or at unexpected times (Zone managers processes an order that can include several sites at once);
- To allow for deliveries that are delayed or too small;
- To take advantage of price discounts on large orders; and
- To give cover for emergencies.

### 6.2.1 Inventory Turnover Rate

As previously mentioned, FNS has presented the site rollout statistics for the last six months. Therefore, the turnover rate for AAA inventory (Equation 2-1) is:

$$Inventory\ turnover = \frac{8\ 341\ 086{,}20}{1\ 439\ 785{,}6} = 6{,}2\ times/half\ a\ year$$

In another way, this means that the average time for the goods in store is 29 days.

### 6.2.2 Demand, Supply Quantity and Timing Uncertainty

In order to analyse the current situation with tied up capital in cycle and safety inventories, the authors have decided to observe three articles which are accountable for the major part of safety stock tied up capital: A1 - 35%, A2 - 12,3% and A3 - 5,9% (see Table 6.1).

Table 6.1 Articles for further investigation.

| Article number | Safety stock, units | Batch size, units | Price, SEK | Cycle inventory, SEK | Safety stock, SEK | % of safety stock | Supplier | Lead time, days* |
|---|---|---|---|---|---|---|---|---|
| A1 | 30 | 15 | 11 000,0 | 82 500,0 | 330 000,0 | 35,0 | | 5 |
| A2 | 45 | 45 | 2 574,0 | 57 915,0 | 115 830,0 | 12,3 | | 10 |
| A3 | 20 | 10 | 2 770,0 | 13 850,0 | 55 400,0 | 5,9 | | 10 |
| TOTAL | | | | 154 265,0 | 501 230,0 | 53,1 | | |

* - plus additional time for transport (1-2 days)

With the purpose of reproducing as closely as possible the real situation with uncertainties in FNS inventory management, the statistics for demand quantity and timing variations plus additionally suppliers' quantity and timing variations are needed. However, Hogström and Grigorjev have only received demand quantities and timing statistics from the company. At present, there are no available statistics about suppliers' performance in terms of timing and quantity. Therefore, Hogström and Grigorjev will use the model for safety stock calculation for demand variations and constant replenishment cycle and, finally, will analyse AAA inventory by using only available information. Unfortunately, the result of the analysis will not fully reproduce the reality of inventory management at FNS.

### 6.2.3 Demand Variations

For calculating demand variations Equation 2-6 will be used. The time period is based on feeder cable demand and is estimated to 130 working days.

*Demand variations of Article A1*:

Table 6.2. The standard deviation of daily demand of Article A1.

| Quantity of ordered A1 units per day | Frequency *(f)* | Deviation from Mean *(d)* | Deviation squared $(d^2)$ | $fd^2$ |
|---|---|---|---|---|
| 0 | 77 | -4 | 16 | 1232 |
| 1 | 21 | -3 | 9 | 189 |
| 2 | 12 | -2 | 4 | 48 |
| 3 | 8 | -1 | 1 | 8 |
| 4 | 5 | 0 | 0 | 0 |
| 5 | 2 | 1 | 1 | 2 |
| 8 | 1 | 4 | 16 | 16 |
| 9 | 4 | 5 | 25 | 100 |
| 4 | 130 | | | 1595 |
| $\hat{S}$=4 | $n$=130 | | $\sum fd^2$=1595 | |

The standard deviation of daily demand of A1:

$$\sigma_s = \sqrt{\frac{\sum fd^2}{n-1}} = 3{,}51 \approx 4 \text{ units}$$

*Demand variations of Article A2*:

Table 6.3. The standard deviation of daily demand for Article A2.

| Quantity of ordered A2 units per day | Frequency *(f)* | Deviation from Mean *(d)* | Deviation squared $(d^2)$ | $fd^2$ |
|---|---|---|---|---|
| 0 | 77 | -12 | 144 | 11088 |
| 3 | 21 | -9 | 81 | 1701 |
| 6 | 12 | -6 | 36 | 432 |
| 9 | 8 | -3 | 9 | 72 |
| 12 | 5 | 0 | 0 | 0 |
| 15 | 2 | 3 | 9 | 18 |
| 24 | 1 | 12 | 144 | 144 |
| 27 | 4 | 15 | 225 | 900 |
| 12 | 130 | | | 14355 |
| $\hat{S}$=12 | $n$=130 | | $\sum fd^2$=14355 | |

The standard deviation of daily demand of A2:

$$\sigma_s = \sqrt{\frac{\sum fd^2}{n-1}} = 10{,}54 \approx 11 \text{ units}$$

*Demand variations of Article A3*:

Table 6.4 The standard deviation of daily demand for Article A3.

| Quantity of ordered A3 units per day | Frequency *(f)* | Deviation from Mean *(d)* | Deviation squared $(d^2)$ | $fd^2$ |
|---|---|---|---|---|
| 0 | 77 | -4 | 16 | 1232 |
| 1 | 21 | -3 | 9 | 189 |
| 2 | 12 | -2 | 4 | 48 |
| 3 | 8 | -1 | 1 | 8 |
| 4 | 5 | 0 | 0 | 0 |
| 5 | 2 | 1 | 1 | 2 |
| 8 | 1 | 4 | 16 | 16 |
| 9 | 4 | 5 | 25 | 100 |
| 4 | 130 | | | 1595 |
| $\hat{S}$=4 | $n$=130 | | $\sum fd^2$=1595 | |

The standard deviation of daily demand of A3:

$$\sigma_s = \sqrt{\frac{\sum fd^2}{n-1}} = 3{,}51 \approx 4 \text{ units}$$

### 6.2.4 Safety Stock Service Level for Chosen Articles

*Current Service Level*

The current service level for chosen articles is calculated with a help of Equation 2-5, where Z is a safety factor which is associated with Service Level:

$$SS = Z\sigma_s \sqrt{R} \qquad Z = \frac{SS}{\sigma_s \sqrt{R}}$$

The interrelation between safety factor and service level is based on Figure 12-10, Lumsden 2003.

A1: Safety factor Z = 3,06; Current service level SL ≈ 99,8%

A2: Safety factor Z = 1,23; Current service level SL ≈ 89,8%

A3: Safety factor Z = 1,5; Current service level SL ≈ 93,1%

As could be seen from the examined service levels, there is no established service policy for the articles at FNS, which results in an uneven distribution of service level among these articles. 99,8% service level for A1 is a very capital intensive commitment for FNS. On the other hand, other articles are experiencing service level of around 90%. This is, in Hogström and Grigorjev mind, inadequate to their importance for the AAA process. Hogström and Grigorjev's propose to increase the service level of A2 and A3, and at the same time decrease the A1's service level.

*Customized Service Level*

Due to the fact, that these three articles are important for the AAA process, Hogström and Grigorjev make an assumption that the articles will receive the highest service level, i.e. 98%. The safety stock quantity for 98% service level is calculated according to Equation 2-5 with Z=2,05[224]:

$$SS = Z\sigma_s \sqrt{R}$$

A1: Service level SL ≈ 98%, Safety stock quantity ≈ 20 units

A2: Service level SL ≈ 98%, Safety stock quantity ≈ 75 units

A3: Service level SL ≈ 98%, Safety stock quantity ≈ 28 units

All articles should be classified after various characteristics such as their importance for business process, profit contribution, price, order size and lead time, for example. There is always the possibility to decrease or increase service level for certain articles; however the company should follow an established policy for inventory management and purchasing.

[224] Figure 10-12. Interrelation between safety factor and service level, Lumsden, K., 2003, page 176.

### 6.2.5 Safety Stock Tied Up Capital

*Tied up capital after service level improvement*

If FNS would accept the proposed service level adjustment (98% service level) for chosen articles, it certainly will affect the amount of tied up capital. The financial consequences of safety stock adjustment are depicted in Table 6.5.

Table 6.5 Safety stock tied up capital for 98% service level.

| Article number | Safety stock, units | Price, SEK | Current safety stock, SEK | % of current safety stock | Adjusted safety stock, SEK | % of adjusted safety stock |
|---|---|---|---|---|---|---|
| A1 | 20 | 11 000,0 | 330 000,0 | 35,0 | 220 000,0 | 23,6 |
| A2 | 75 | 2 574,0 | 115 830,0 | 12,3 | 193 050,0 | 20,7 |
| A3 | 28 | 2 770,0 | 55 400,0 | 5,9 | 77 560,0 | 8,3 |
| TOTAL | | | 501 230,0 | 53,1 | 490 610,0 | 52,6 |

The purpose of calculations above is to evaluate the cost of service level improvement, not the lowering of safety stock value. Therefore, it could be seen that reducing with 1,8% of Article A1 service level costs to company 110 000 SEK in safety stock per year without interest rate. The total tied up capital for these three articles has decreased by 10 620 SEK.

*Tied up capital after 50% decreased suppliers' lead time*

There are several methods to decrease tied up capital in safety stock. Hogström and Grigorjev will apply some of them that are suitable for FNS current situation, and imitate safety stock performance. Hogström and Grigorjev make an assumption that it is possible to reduce suppliers' total lead times (through reduced order sizes, preference of faster transport modes, utilisation of IT or improved relationship with suppliers) for the articles with 50%. The results of this assumption are shown in Table 6.6.

Table 6.6 Safety stock after reduced suppliers' lead time (with service level 98%).

| Article number | New lead time, days | Current safety stock, units | Adjusted safety stock, units | Price*, SEK | Current safety stock, SEK | Adjusted safety stock, SEK | % of adjusted safety stock |
|---|---|---|---|---|---|---|---|
| A1 | 3 | 20 | 15 | 11 000,0 | 330 000,0 | 165 000,0 | 20,9 |
| A2 | 5 | 75 | 50 | 2 574,0 | 115 830,0 | 128 700,0 | 16,3 |
| A3 | 5 | 28 | 19 | 2 770,0 | 55 400,0 | 52 630,0 | 6,7 |
| TOTAL | | | | | 501 230,0 | 346 330,0 | 43,9 |

* - Purchasing prices and transport costs could increase to some extent due to more flexible purchasing policy.

The saving of 154 900 SEK is not so striking; however Hogström and Grigorjev's intention was to demonstrate possible solutions for FNS' safety stock simulation. There is a possibility to decrease even further the tied up capital of safety stock if the company will revise other articles service levels, their lead times and influence the demand distribution.

### 6.2.6 Cycle Inventory Tied Up Capital

There are two possible ways of decreasing the cycle inventory tied up capital: reduce batch sizes or articles' prices. On the other hand, the gained flexibility with smaller order sizes could negatively affect purchasing prices and transportation costs. It may even be said, that the increase in purchasing prices and transport costs is a trade-off of the company's gained flexibility. Obviously, the company has to balance between flexibility and its costs. Hogström and Grigorjev will not go further into the second way of decreasing the cycle inventory, which is reducing article prices.

Hogström and Grigorjev would like to examine two alternatives for AAA cycle inventory: 50% decreased batch size and, as the second alternative, the possibility to buy articles lot-for-lot with 15% increased purchasing prices (see Table 6.7).

Table 6.7 Two alternatives for AAA cycle inventory .

| Article number | Current batch size | Alt. 1 batch size | Price, SEK | Alt.2 batch size | Alt. 2 price, SEK | Current cycle stock, SEK | Alt.1 cycle stock, SEK | Alt .2 cycle stock, SEK |
|---|---|---|---|---|---|---|---|---|
| A1 | 15 | 8 | 11 000 | 1 | 12 650 | 82 500,0 | 44 000,0 | 6 325,0 |
| A2 | 45 | 23 | 2 574 | 3 | 2 960 | 57 915,0 | 29 601,0 | 4 440,2 |
| A3 | 10 | 5 | 2 770 | 1 | 3 186 | 13 850,0 | 6 925,0 | 1 592,8 |
| TOTAL | | | | | | 154 265,0 | 80 526,0 | 12 357,9 |

The results of simulation provide with a contribution for further cycle inventory tied up capital investigation. There is a possibility to decrease considerably the value of cycle inventory, even with increased purchasing prices. On the other hand, the improvement for inventory tied up capital has to be seen in the total logistics cost concept. For example, decreasing order size for articles will negatively affect transport and ordering costs. For this reason, the investigation of company's financial management has to cover all departments that are involved in the process.

### 6.2.7 Modelling of Inventory Tied Up Capital

In order to summarize all alternatives, which are mentioned above, and compare them with the current situation, Hogström and Grigorjev have chosen an adjusted alternative for FNS inventory. The results of the adjusted alternative are shown in Table 6.8.

The adjusted solution for FNS' safety stock: service level for three chosen articles is 98% (other articles' service level is unchanged), suppliers' lead time is 50% shorter. Cycle inventory is lot-for-lot with 15% increased purchasing prices. The financial consequences are presented in Table 6.8.

Table 6.8 Comparison between current inventory status and adjusted alternative.

| | Cycle stock tied up capital, SEK | Cycle stock cost of capital (6,7% interest rate) | Safety stock tied up capital, SEK | Safety stock cost of capital (6,7% interest rate) | Total cost, SEK |
|---|---|---|---|---|---|
| Current situation | 406 168,4 | 27 213,3 | 943 208,9 | 63 195,0 | 1 439 785,6 |
| Adjusted alternative | 38 593,2 | 2 585,7 | 906 555,2 | 60 739,2 | 1 008 473,3 |

The total difference between the current situation and adjusted alternative is 431 312,3 SEK (-30%). According to calculations, the cycle inventory has been considerably decreased due to lot-for-lot policy with following low capital costs, only 2 585 SEK. At the same time, the safety stock has been improved only four percent. This could be explained with increased purchasing prices by 15% (according to the chosen alternative). Hogström and Grigorjev believe that there is a potential for further decreasing tied up capital in the safety stock because if FNS purchases per unit, the suppliers' lead time will be much shorter followed by lower levels of safety stock.

As a result of improvement, the turnover rate will increase with assumption of the same material costs for half a year:

$$Inventory\ turnover = \frac{8\ 341\ 086,2}{1\ 008\ 473,4} = 8,8\ times/half\ a\ year$$

In another way, this means that the average time for the goods in store is 20 days.

However, Hogström and Grigorjev have previously mentioned that the pure savings should be estimated in the total cost concept context, i.e. transport costs, order processing costs, inventory carrying and lot quantity costs. Plus, the financial Department has to adjust its way of invoicing customers, i.e. from 30 days to 15 days.

## 6.3 Competitive Advantage through Logistics

In the new organisational structure, the logistics management is presented on strategic level as well as on operational level (see Figure 1.1). This indicates that FNS has realised that logistics is an important tool of the strategy and opportunity for FNS to design a logistics system that can fulfil the customer service objectives.

If FNS can perform its core activities in a more cost-effective way than the competitors, the company will gain the advantage in the marketplace. The Total cost concept is a tool to increase the overall logistics cost efficiency in the company. One of major objectives of FNS logistics service is to reduce the total costs of logistics activities rather than to focus on each activity in isolation. Effective logistics management and real cost savings can be achieved only by considering logistics as an integrated system. Therefore, all possible suggestions for FNS logistics system improvement, proposed by Hogström and Grigorjev and the company's employees in the future, have to be evaluated in the total cost concept context.

Hogström and Grigorjev have mapped the internal AAA business process by identifying participants who are involved, activities that are carried out, and measured passing through times of each activity. The results of this investigation are presented earlier in the section and include suggestions for process improvement. Hogström and Grigorjev believe that if FNS will apply using time-based management, the company will reduce its costs indirectly through compressing activities' lead times. Eliminating non-value adding activities, decreasing lead time of other activities, eliminating waiting times, and lowering overheads costs will lead to improved flexibility, decreased tied up capital in inventory and work-in-progress and, finally, to enhanced customer service and FNS' profitability.

Another finding that Hogström and Grigorjev would like to highlight is the possibility of applying the process perspective of business process. Process perspective means organising resources and responsibility around core business processes instead of around tasks and functions. In the statements from FNS, the responsibility is defined for each function/department, which indicates that a more process-oriented view is needed in order to focus on the total output. The evidence that FNS is organised through functions/departments is apparent by the processes

that are carried out in sequences and information communicated in batches between departments instead of by a constant flow. During the interviews, Hogström and Grigorjev were directed to different persons since none of the respondents had the knowledge about the AAA rigging process in total. This indicates that FNS is organised through functions. Companies that are organised according to functions are deliberately focused against effective administrative management of the company's resources rather than on creating value-adding flow. This creates barriers between the functions/departments and also adds time to the process as a whole. If FNS would be organised according to process perspective, the activities within the process could be performed in parallel manner. The process perspective creates awareness of the customers, the product, the information flow and the resource consumption. It also points out the efficiency of the organisation in focus. The process view appears as cross-functional flow and it overcomes the gap between functional units of an organisation.

### 6.3.1 Strategy and Planning

Logistics is a planning concept that seeks to develop a system wide view of the firm's performance. There has to be a strategy for logistics in order to fulfil a company's goals. If there is no strategy for the logistics within the company, there will be a sub-optimisation. The Contracting Department's guidelines provide the foundation from which a company develops strategies, plans and tactics. It also provides a direction and control for tactical plans and daily operations.

The logistics planner can only configure the logistics system that satisfies the customer requirements at the lowest total cost after the overall corporate strategies and marketing plans have been determined. The point of the logistics system is to make it possible for a company to achieve the desired customer service.

It is not possible for the logistics management to design an efficient and effective logistics system without the knowledge of the firms' objectives regarding customer service. When setting the objectives for customer service, the following has to be considered: specific requirements of customers, competitive service levels, changing environmental conditions and the amount of service that FNS is willing to offer. Hogström and Grigorjev believe that there is no clear strategy for the logistics

within FNS. Before any decision is taken regarding the inventory, decisions have to be taken about FNS wants to achieve with their customer service level. The decision taken concerning the inventory has to correspond to the logistics strategy of FNS. Consideration should also be taken on what influences the decision has on FNS' total cost for the logistics.

### 6.3.2 Supply Chain Optimisation

When analysing what stage is FNS positioned in, when one is considering the supply chain optimisation according to Poirier, Hogström and Grigorjev believe that FNS is positioned on level one because of FNS' focus at the present is more on inventory, logistics, transport and order fulfilment. The effort with the progress at FNS is still at the internal level. Since FNS has put the inventory and logistics in focus, the company has also realised that the main pathway is to construct a supply chain. The company strives to establish the supply chain via deeper relationships with various suppliers in order to create a complete product for network operators. However, FNS has to realise that the road to a leading edge position will require focus, dedication, creativity and hard work. Poirier's research is based on experience of many companies, and there is no way that FNS can avoid this hard work moving through the levels of development.

Firms that have decided to work on their supply chain both internally and externally are the ones today that have gained competitive advantage. Companies only assemble the product on customers' demand and suppliers deliver the components to the location for assembly, when it is needed. In this way companies do not need to keep any inventory, and components used are always up-to-date, which decreases risk of obsolete material for a company. The enabler for supply optimisation is the IT platform that company uses in order to share needed information. During the fall 2003 FNS has implemented MOVEX, an ERP system, which could be used as the IT platform and the enabler for FNS integration and information sharing. The logistics management is primarily concerned with optimizing flows. The benefit for companies with higher internal collaborative integration is proved to have higher logistics performance compared with less integrated firms. Supply chain management considers that internal integration by itself is not sufficient; the benefits of external collaboration are potentially even higher com-

pared to internal collaborative integration. For FNS to reach the competitive advantages as they seek, the progress of optimisation has to continue from internal optimisation to external optimisation.

In order to reach the competitive advantage, FNS has to cooperate with valued suppliers and distributors, since no firm as an individual can manage this alone. In the guidelines from FNS, it is written that the company should seek to build sustainable relationships with suppliers and this in turn should contribute to keeping tied up capital on a cost efficient level. FNS has to be careful in trying to only cut costs. According to Poirier, firms can become very skillful at cutting costs through the leveraging of their volume and buying positions with suppliers. No supplier will in the long run take over costs from FNS. The real value is created when the inventory is reduced within the whole supply chain and the profit gained is also shared within the chain.

According to Poirier, one of the most obvious factors for less successful organisation stands out; it is a lack of trust and sincere effort among necessary participants in the chain and a narrow-minded view focusing only on the internal gains that could be reached. These firms have also failed to develop cross-functional trust. To develop the trust is regarded as a crucial success factor when optimising the supply chain. In order not to fail, FNS has to develop the cross-functional trust within the firm. Early efforts at supply chain optimisation have proved that the difficulties are typical within the organisation. Thus, if FNS should continue with optimisation of the supply chain and succeed, the internal barriers have to be torn down. For the work to have success it is good to begin with a small project to prove the concepts and discover complexities, and to develop answers before proceeding to larger and more complex situations.

If FNS wants to achieve a real competitive advantage, further progress might require redesigning the total supply chain system. Standing in the way are several pitfalls. In reaching advanced levels FNS has to identify these obstacles and overcome them. Most firms continue to find other projects that will enhance internal supply chain performance but never really move on to higher-order efforts and benefits.

The future competition will not be through single firms. It will be through supply chains. To reach competitive advantage, FNS has to seek co-operation with valuable partners in order to be the market leader. For FNS to be a global provider, there is a need to be within a supply chain that is competitive. This will help FNS to enter new markets and launch new products. Time to market is crucial when introducing new products and with a good supply chain the time to market will be shorter.

# 7 Conclusions

*The aim of this chapter is to draw conclusions that are founded on the results of empirical chapter analysis.*

## 7.1 Research Question 1

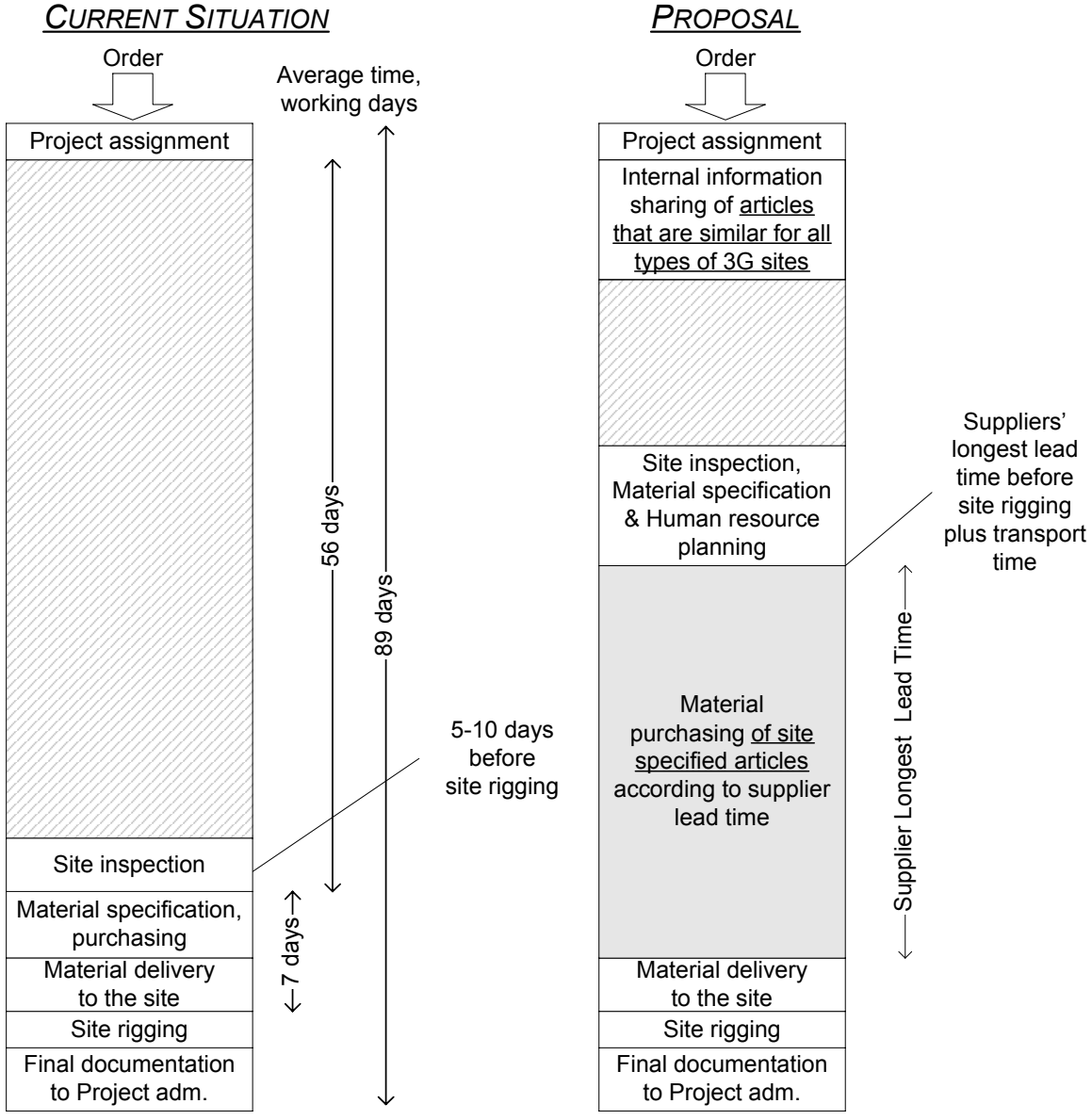
*Mapping a business process: How does the information and material flows stream within the business process?*

Before any decision regarding inventory management is taken, a strategy concerning logistics has to be established. Logistics does not live its own life. It is a tool for FNS to fulfil the objectives the company has. If there is a lack of planning, the managers will spend their time reacting to crises. If the strategy exists, the managers could anticipate changes and develop guidelines to deal with changes. It is necessary for FNS to develop a logistics strategy since, the business environment that FNS work in is characterized as volatile. FNS' business environment in itself indicates that the organisation has to build in the ability to change. For FNS to cope with these changes, the organisation of the company has to be according to processes, because the process perspective organises resources and responsibility around core business processes and not around tasks and functions. When FNS will organise through process, the ability to change is adopted and the output of the process will be in focus. This will result in a strong customer focus and the cross-functional activities will be easier to manage.

Concerning the AAA rigging process that is in focus in this thesis, Hogström and Grigorjev have come to the following conclusions: the information is available but it not used in the appropriate way. Therefore, information has to be shared internally earlier in the process. When the information about number of sites is available, the real demand for articles that are similar for all types of 3G sites is also available. Therefore, there is a possibility for the Supply Department to reveal the uncertainty concerning these articles. In order to decrease the uncertainty for the site specific articles, Hogström and Grigorjev suggest performing the site inspection at least 20 days (or longest supplier lead time plus transport time) before site

rigging date. This will cover the time needed for the supplier to deliver the material required and eliminate insecurities in the purchasing process (see Figure 7.1). The human resource planning and the start date for site installation will dictate the date for purchasing material.

Figure 7.1 The current situation and proposal for the AAA rigging process.




Hogström and Grigorjev believe that the information and material flows within the business process were mapped thoroughly in this thesis. The information is generated at different occasion during the business process, although it is not utilised as it could be. If the Supply Department takes advantage of early generated information this could improve the performance of the internal supply chain. If

changes proposed for the rigging process are to be followed, improvements regarding tied up capital in inventory are possible (research question number 2). By this Hogström and Grigorjev believe that the research question number 1 has been answered.

## 7.2 Research Question 2

*Inventory tied up capital: How is it possible to reduce tied up capital in inventory and with what methods?*

Due to the fact that inventory is a major use of capital, the objectives of inventory management are to increase company's profitability, to predict the impact of corporate policies on inventory levels, and to minimize the total cost of logistics activities. In order to manage the inventory in an appropriate way, the logistics objectives for inventory have to be set up and a strategy for how to reach them has to be worked out. Efficient inventory management will benefit the company's profitability. As Hogström and Grigorjev have mentioned above, there is no well-defined inventory strategy at FNS. This statement could be proven by the examination of service levels for several articles in Analysis chapter. Therefore, FNS needs to work out an inventory strategy that will cover all processes within inventory management.

In the shorter time perspective, FNS has to revise its inventory through articles categorization with defined articles service levels, order sizes, safety stock levels, and standardisation of the articles. Of course, due to short-term deals with customers and suppliers, FNS should frequently apply inventory revisions and the following possible corrections. Categorization of articles could be carried out after various characteristics, such as their importance for business processes, profit contribution, price, order size, and lead time. FNS has to follow up its suppliers' performance for efficient inventory management. The most important articles (highest service level) need a special management, such as improved relations with suppliers, shorter lead times, smaller order sizes, and advanced transport modes. The statistics for suppliers' quantity and timing variations are needed for calculating the accurate safety stock levels. For the future, the information about suppliers' performance will contribute to designing a leading supply chain.

Today, FNS does not have any freedom in choosing a supplier for the AAA 3G sites. Such relations with suppliers are characterised by short time relations, higher risk of obsolete articles in the inventory, information hoarding, lack of trust and co-operation. In the longer perspective, FNS has to seek ways for removing uncertainties in its inventory management by establishing collaboration with its strategic suppliers. Information sharing, trust between partners, early warning systems, superior quality with shorter lead times and smaller order sizes, and usage of IT are the right features for FNS future inventory management.

Hogström and Grigorjev believe that in order to decrease tied up capital in cycle inventory, articles' order sizes have to be decreased, and/or the best alternative is to purchase articles on lot-for-lot principle. On the other hand, the smaller order sizes will cause an increase in purchasing prices and transportation costs and could be seen as trade-offs against the company's increased flexibility. There is, also, a possibility to decrease even further the safety stock tied up capital, as was presented in the Analysis chapter. FNS can revise other articles service levels, negotiate with its suppliers' shorter lead times and influence the demand distribution.

Even process improvements, such as the possible early release of material specification, could lower inventory tied up capital. The articles that are part of all four site variations could be ordered earlier in the process despite the results of site inspection carried out by Zone manager. However, Hogström and Grigorjev have previously mentioned the savings should be estimated in the total cost concept context, i.e. transport costs, order processing costs, inventory carrying and lot quantity costs. It has to be mentioned that all improvements for inventory will lose their effect without co-operation with other departments, especially the Financial Department. For example, if FNS decreases its average time for goods in store to 20 days and, at the same time, the Financial Department still applies for 30 days credit time for the FNS' customers, the whole importance of inventory improvement will be lost. Lower tied up capital and shorter delivery times demand a reduced time horizon for customers invoicing in order to experience the improvements in the logistics system.

Hogström and Grigorjev have presented these organisational, financial and technical recommendations in order to achieve inventory tied up capital reduction.

Therefore, Hogström and Grigorjev consider the Research question number 2 is answered.

## 7.3 Research Question 3

*Competitive advantage: What can be done in order to gain competitive advantage for the company in the future?*

Hogström and Grigorjev believe that Flextronics Network Service needs a well-defined logistics strategy, which is evolves from overall corporate strategy. The logistics strategy should contain clear objectives for each area of logistics, i.e. inventory policy in terms of tied up capital in safety and cycle inventories, and articles service levels.

FNS should apply the Total cost concept for managing the overall logistics in the company. All decisions should be to be evaluated in the Total cost concept context in order to gain the real savings.

FNS need also to define the criteria for which activities add value to the processes that are carried our in the company. The definition should be associated with the overall business strategy for FNS. When there is an understanding of the value-adding criteria at the corporate level, these can be translated into value-adding criteria at the operational level. When value is added, the customers are willing to pay for the activities carried out and this will in the end benefit FNS.

For FNS to gain a competitive advantage, the work of optimising its supply chain has to continue. In order for FNS to manage the cross functional activities, the trust within the company has to be developed. The capability for developing cross-functional trust, both internally and externally, is considered as a crucial success factor. If trust is not developed, FNS will never reach the stage of an integrated supply chain. The most common obstacles for sharing trust is within the company. If FNS fail to identify these obstacles, it will never reach the advanced levels of the supply chain. For FNS, the optimisation of the supply chain should be the main pathway, since the competition in the future will be through supply chains and not between single firms. To be an order winner, FNS needs to create and be a member of an excellent supply chain. This will be a competitive advan-

tage for FNS and this will also benefit the customers and company's shareholders. In the future, FNS will need continuously to update its strategy of how to reach a total integrated supply chain because the progress of supply chain will not continue by itself. A well defined strategy of how to move through the different stages from the model used by Poirier will help FNS to reach a fully integrated supply chain. Hogström and Grigorjev believe that Research question number 3 is answered.

The research questions should give the purpose a concrete form and should provide a guide to the required information. The purpose was to investigate the current situation regarding tied up capital in the inventory and to formulate proposals that will contribute to reductions of the inventory tied up capital. A proposal should also be given as to how the company could gain a competitive advantage with its project logistics in the future. Hogström and Grigorjev have answered the research questions and by this also fulfilled the purpose of this thesis.

# 8 Recommendations

*The aim of this chapter is to come up with practical recommendations for FNS that are based on empirical studies and the analysis.*

The recommendations are separated into two groups: strategic and operational. The division of recommendations is based on status of involved activities and level of decision-making process.

*Strategic:*

- Clarify FNS' logistics objectives and strategy according to corporate strategy.
- Decide what kind of supply chain FNS seeks to be a member of and formulate a strategy for how to accomplish this task.
- Work out inventory strategy according to logistics strategy.
- Identify core processes and redesign the company around processes.
- Formulate criteria of value-adding activities and examine all activities of FNS processes in value-adding context.
- Use the Total cost concept for evaluation and decision-making process regarding changes in FNS' logistics system.
- Redesign the AAA rigging process in order to generate real time demand in order to reduce uncertainty for demand.
- Establish or improve relations with strategic suppliers in order to reduce uncertainty from suppliers' side.
- Investigate further possibilities for standardisation of components.
- Improve usage of Movex ERP system for strategic and operational decisions.

- Improve internal integration between departments.

*Operational:*

- Carry out suppliers' evaluation in terms of their performance (quality, timing and willingness for cooperation).
- Constantly inspect type and quantity of articles in safety stock.
- Revise the activities and duties of Zone Manager in order to decrease lead times.
- Improve quality of the installation process in order to avoid rework (non value-adding time).
- Investigate the possibility of decreasing purchasing material order sizes.
- Improve communication channels between the Zone Manager and Installation team in order to decrease the time of document transmission within AAA process.
- Put efforts into eliminating unplanned articles buying by installation team since the invoices for those articles have a tendency to delay the total internal invoicing process.

# 9 Suggestions for Further Research

*In this chapter Hogström and Grigorjev will state suggestions for further research that would be valuable to conduct for Flextronics Network Services in order to continue developing the company's logistics system.*

Due to time limitation Hogström and Grigorjev could not investigate several potential solutions for FNS logistics' performance improvement. Therefore, Hogström and Grigorjev would like to present in the thesis some suggestions for further research.

- Activity Based Costing (ABC)

During the research, Hogström and Grigorjev have revealed that the managers at FNS had difficulties with cost estimations for different functions/activities. In order to reach the goal of lowest total cost, the process performance data and cost is needed. To overcome this situation, further research of how all resources are allocated among process or departments is needed. Hogström and Grigorjev believe that one of the potential solutions to the problem is carrying out Activity Based Costing analysis at FNS.

- Vendor Managed Inventory (VMI)

In order to decrease inventory carrying costs and administrative work, the implementation of VMI could be suitable for FNS. Hogström and Grigorjev believe that inventory management at FNS needs new suggestions that are adapted for the company for lowering its tied up capital. Further research of possible VMI implementation, for example, for consumption articles in inventory, needs to be carried out.

- Outsourcing of inventory

Finally, when everyone in business is trying to concentrate on core activities and outsource the support processes, the further investigation of inventory outsourcing is necessary.

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Matti Sjöfält, Material and Logistics, FNS

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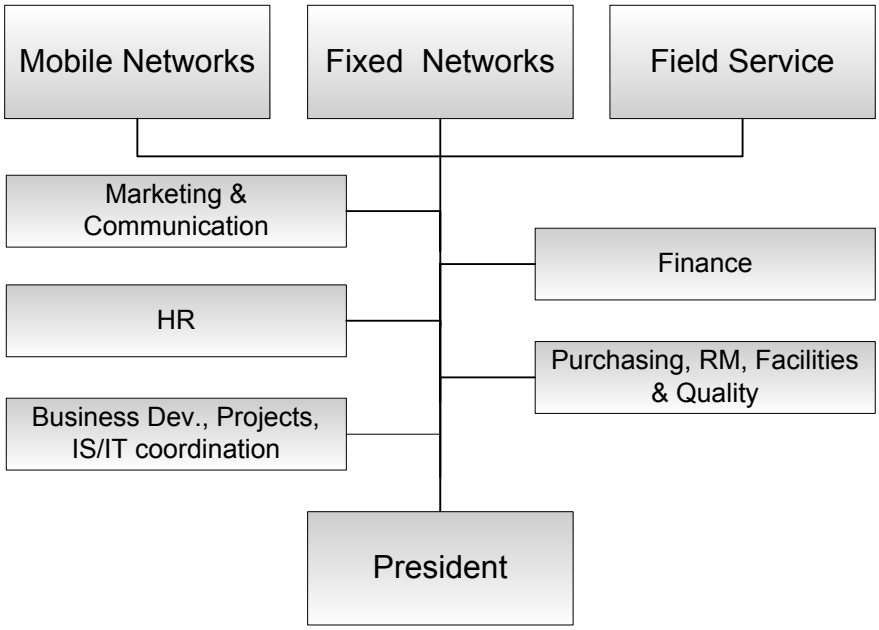
# 11 Appendix 1 – FNS Previous Structure

Figure 11.1 Previous organisational structure.

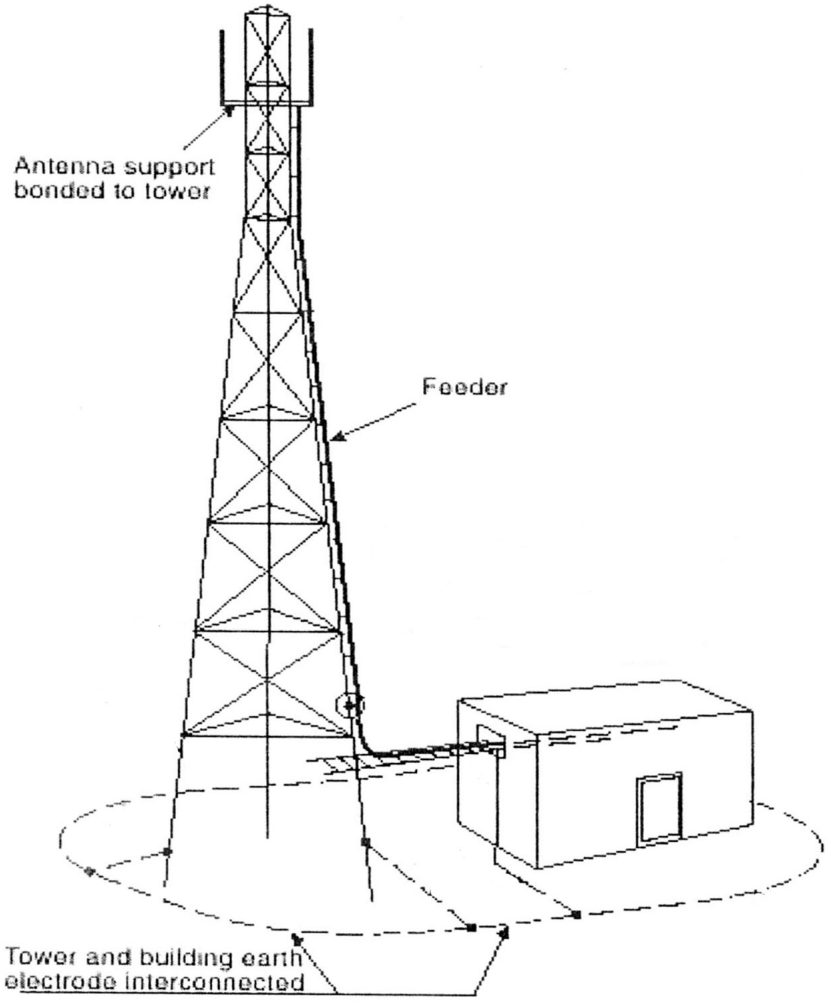
Source: Flextronics Network Services, 2003.



# 12 Appendix 2 – 3G Mobile Networks

Figure 12.1 Example of 3G site.

Source: Flextronics Network Services, 2003.




3G is the next generation of wireless network technology that provides high speed bandwidth (high data transfer rates) to handheld devices. The high data transfer rates will allow 3G networks to offer multimedia services combining voice and data.[225]

3G wireless networks support the following maximum data transfer rates:

[225] Third Generation (3G) Wireless, Technology Brief, Silicon Press, 2002.

- 2.05 Mbits/second to stationary devices.
- 384 Kbits/second for slowly moving devices, such as a handset carried by a walking user.
- 128 Kbits/second for fast moving devices, such as handsets in moving vehicles.

*3G standards*

The International Telecommunication Union (ITU) is responsible for standardizing 3G. After trying to establish a single 3G standard, ITU finally approved a family of five 3G standards:[226]

- Three standards based on CDMA, namely CDMA2000, WCDMA, and TDSCDMA.
- Two standards based on based on TDMA, namely, FDMA/TDMA and TDMA-SC (EDGE).

Europe, Japan, and Asia have agreed upon a 3G standard called the Universal Mobile Telecommunications System (UMTS), which is WCDMA operating at 2.1GHz. Note that UMTS and WCDMA are often used as synonyms. In the USA and other parts of Americas, WCDMA will have to use another part of the radio spectrum. Incidentally, most of the world's wireless operators have chosen to use UMTS.[227]

*3G development worldwide:*[228]

- 1999 Beginning of 3G radio interface standardization First demonstrations of 3G infrastructure
- Device prototypes demonstrated

[226] Third Generation (3G) Wireless, Technology Brief, Silicon Press, 2002.

[227] Ibid.

[228] 3G White Paper, Gemplus, 2001.

- 2000 Standardization process underway for network architectures and device requirements
- European governments to award 3G licenses by auctions or Beauty contests
- 2001 3G initial trials of services to begin in Europe
- NTT DoCoMo to launch first commercial 3G services in Japan
- 2002 3G services to be officially launched in European Union countries
- 2003 3G devices to be readily available
- Mobile subscribers set to exceed fixed-line subscribers worldwide
- 2004 European critical network coverage to be achieved
- 2005 3G set to have wide influence in US.

# 13 Appendix 3 - 3G Orders

Table 13.1. 3G orders

Source: FNS internal records, 2003.

| Project nr. | Order date | Purch. receives material spec. from ZM | Material picking date | Material delivery to site location date | Order closing date | Time between Order receiving and ZM orders material | Time be-tween Purch. order and Material delivery to site | Project total time |
|---|---|---|---|---|---|---|---|---|
| | 10-apr | 01-sep | 01-sep | | 26-sep | 103 | | 122 |
| | 28-apr | 09-maj | 14-maj | 16-maj | 12-sep | 10 | 6 | 100 |
| | 28-apr | 03-sep | 04-sep | 04-sep | | 93 | 2 | |
| | 07-maj | 26-maj | 28-maj | 02-jun | 12-sep | 14 | 6 | 93 |
| | 07-maj | 13-maj | 15-maj | 19-maj | 26-sep | 5 | 5 | 103 |
| | 07-maj | 03-sep | 29-aug | 29-aug | 26-sep | 86 | | 103 |
| | 07-maj | 23-jun | 03-jul | 07-jul | 26-sep | 34 | 11 | 103 |
| | 07-maj | 23-jun | 03-jul | 07-jul | 12-sep | 34 | 11 | 93 |
| | 07-maj | 26-sep | 30-sep | 02-okt | | 103 | 5 | |
| | 07-maj | 25-jun | 10-jul | 14-jul | 12-sep | 36 | 14 | 93 |
| | 07-maj | 01-jul | 10-jul | 14-jul | 12-sep | 40 | 10 | 93 |
| | 07-maj | 27-maj | 12-jun | 16-jun | 12-sep | 15 | 15 | 93 |
| | 07-maj | 03-sep | 04-sep | 04-sep | 26-sep | 86 | 2 | 103 |
| | 07-maj | 03-sep | 04-sep | 04-sep | 03-okt | 86 | 2 | 108 |
| | 07-maj | 03-sep | 04-sep | 04-sep | 03-okt | 86 | 2 | 108 |
| | 07-maj | 27-maj | 12-jun | 16-jun | 26-sep | 15 | 15 | 103 |
| | 07-maj | 27-jun | 10-jul | 14-jul | 26-sep | 38 | 12 | 103 |
| | 07-maj | 14-aug | 27-aug | 29-aug | 03-okt | 72 | 12 | 108 |
| | 07-maj | 23-sep | 30-sep | 02-okt | | 100 | 8 | |
| | 07-maj | 08-sep | 08-sep | | 26-sep | 89 | | 103 |
| | 07-maj | 04-jul | 21-jul | 23-jul | 03-okt | 43 | 14 | 108 |
| | 07-maj | 04-jul | 22-jul | 24-jul | 26-sep | 43 | 15 | 103 |
| | 07-maj | 04-jul | 17-jul | 21-jul | | 43 | 12 | |
| | 07-maj | 04-jul | 17-jul | 22-jul | 03-okt | 43 | 13 | 108 |
| | 07-maj | 26-maj | 28-maj | 02-jun | 12-sep | 14 | 6 | 93 |
| | 07-maj | 04-sep | 13-sep | 15-sep | | 87 | 8 | |
| | 13-maj | 04-jun | 12-jun | 16-jun | 19-sep | 17 | 9 | 94 |
| | 13-maj | 05-jun | 12-jun | 16-jun | 19-sep | 18 | 8 | 94 |
| | 13-maj | 04-sep | 09-sep | 11-sep | | 83 | 6 | |

| Project nr. | Order date | Purch. receives material spec. from ZM | Material picking date | Material delivery to site location date | Order closing date | Time between Order receiving and ZM orders material | Time be-tween Purch. order and Material delivery to site | Project total time |
|---|---|---|---|---|---|---|---|---|
| | 13-maj | 04-sep | 08-sep | | 26-sep | 83 | | 99 |
| | 13-maj | 03-sep | 04-sep | 04-sep | 03-okt | 82 | 2 | 104 |
| | 13-maj | 09-sep | 17-sep | 22-sep | | 86 | 10 | |
| | 13-maj | 09-sep | 11-sep | 15-sep | 03-okt | 86 | 5 | 104 |
| | 13-maj | 05-jun | 12-jun | 16-jun | 19-sep | 18 | 8 | 94 |
| | 14-maj | 08-sep | 09-sep | 11-sep | 12-sep | 84 | 4 | 88 |
| | 14-maj | 08-jul | 23-jul | 25-jul | 12-sep | 40 | 14 | 88 |
| | 14-maj | 03-sep | 04-sep | 04-sep | 03-okt | 81 | 2 | 103 |
| | 15-maj | 04-sep | 13-sep | 15-sep | | 81 | 8 | |
| | 17-maj | 18-aug | 28-aug | 01-sep | 26-sep | 66 | 11 | 95 |
| | 17-maj | 22-sep | 02-okt | 06-okt | | 91 | 11 | |
| | 17-maj | 09-sep | 15-sep | 18-sep | | 82 | 8 | |
| | 20-maj | 03-sep | 01-sep | 01-sep | 03-okt | 77 | | 99 |
| | 20-maj | 11-sep | 17-sep | 19-sep | | 83 | 7 | |
| | 20-maj | 12-jun | 19-jun | 23-jun | 19-sep | 18 | 8 | 89 |
| | 21-maj | 08-jul | 23-jul | 25-jul | 26-sep | 35 | 14 | 93 |
| | 21-maj | 22-sep | 26-sep | 30-sep | | 89 | 7 | |
| | 21-maj | 03-jun | 12-jun | 16-jun | 19-sep | 10 | 10 | 88 |
| | 21-maj | 03-sep | 04-sep | 04-sep | 19-sep | 76 | 2 | 88 |
| | 21-maj | 03-sep | 04-sep | 04-sep | 19-sep | 76 | 2 | 88 |
| | 21-maj | 02-sep | 04-sep | 08-sep | | 75 | 5 | |
| | 21-maj | 22-aug | 25-aug | 26-aug | 19-sep | 68 | 3 | 88 |
| | 21-maj | 08-okt | 15-okt | 16-okt | | 101 | 7 | |
| | 21-maj | 25-sep | 01-okt | 03-okt | | 92 | 7 | |
| | 26-maj | 02-jun | 05-jun | 10-jun | 12-sep | 6 | 7 | 80 |
| | 28-maj | 18-sep | 18-sep | 19-sep | 03-okt | 82 | 2 | 93 |
| | 28-maj | 13-jun | 19-jun | 23-jun | 19-sep | 13 | 7 | 83 |
| | 03-jun | 11-jul | 24-jul | 28-jul | 26-sep | 29 | 12 | 84 |
| | 04-jun | 25-aug | 03-sep | 05-sep | | 59 | 10 | |
| | 04-jun | 11-jul | 24-jul | 28-jul | 26-sep | 28 | 12 | 83 |
| | 04-jun | 11-jul | 24-jul | 28-jul | 12-sep | 28 | 12 | 73 |
| | 04-jun | 15-aug | 27-aug | 29-aug | 26-sep | 53 | 11 | 83 |
| | 04-jun | 04-sep | 13-sep | 15-sep | | 67 | 8 | |
| | 05-jun | 09-sep | 16-sep | 19-sep | | 69 | 9 | |
| | 05-jun | 09-sep | 17-sep | 22-sep | | 69 | 10 | |
| | 05-jun | 26-sep | 30-sep | 02-okt | | 82 | 5 | |

| Project nr. | Order date | Purch. receives material spec. from ZM | Material picking date | Material delivery to site location date | Order closing date | Time between Order receiving and ZM orders material | Time be-tween Purch. order and Material delivery to site | Project total time |
|---|---|---|---|---|---|---|---|---|
| | 06-jun | 23-sep | 30-sep | 02-okt | | 78 | 8 | |
| | 06-jun | 23-sep | 30-sep | 02-okt | | 78 | 8 | |
| | 06-jun | 18-jun | 26-jun | 30-jun | 19-sep | 9 | 9 | 76 |
| | 06-jun | 12-jun | 19-jun | 23-jun | 19-sep | 5 | 8 | 76 |
| | 06-jun | 03-sep | 01-sep | 01-sep | 03-okt | 64 | | 86 |
| | 06-jun | 04-sep | 05-sep | | | 65 | | |
| | 06-jun | 22-sep | 29-sep | 01-okt | | 77 | 8 | |
| | 06-jun | 05-sep | 05-sep | 09-sep | | 66 | 3 | |
| | 06-jun | 12-sep | 17-sep | 19-sep | | 71 | 6 | |
| | 06-jun | 10-sep | 16-sep | 19-sep | | 69 | 8 | |
| | 06-jun | 01-jul | 03-jul | 07-jul | 12-sep | 18 | 5 | 71 |
| | 12-jun | 22-sep | 02-okt | 06-okt | | 73 | 11 | |
| | 12-jun | 09-sep | 17-sep | 22-sep | | 64 | 10 | |
| | 12-jun | 23-sep | 30-sep | 02-okt | | 74 | 8 | |
| | 12-jun | 04-sep | 13-sep | 15-sep | | 61 | 8 | |
| | 12-jun | 14-aug | 18-aug | 20-aug | 19-sep | 46 | 5 | 72 |
| | 12-jun | 05-sep | 13-sep | 15-sep | | 62 | 7 | |
| | 12-jun | 06-aug | 11-aug | 13-aug | 19-sep | 40 | 6 | 72 |
| | 12-jun | 31-jul | 07-aug | 11-aug | 19-sep | 36 | 8 | 72 |
| | 12-jun | 13-aug | 18-aug | 20-aug | 19-sep | 45 | 6 | 72 |
| | 12-jun | 14-jul | 17-jul | 21-jul | 19-sep | 23 | 6 | 72 |
| | 12-jun | 18-jul | 24-jul | 28-jul | 19-sep | 27 | 7 | 72 |
| | 12-jun | 05-sep | 10-sep | 12-sep | 03-okt | 62 | 6 | 82 |
| | 12-jun | 05-aug | 07-aug | 11-aug | 19-sep | 39 | 5 | 72 |
| | 12-jun | 07-aug | 11-aug | 13-aug | 19-sep | 41 | 5 | 72 |
| | 17-jun | 19-sep | 29-sep | 01-okt | | 69 | 9 | |
| | 17-jun | 10-sep | 11-sep | 15-sep | 26-sep | 62 | 4 | 74 |
| | 17-jun | 04-sep | 08-sep | | | 58 | | |
| | 17-jun | 05-sep | 05-sep | 09-sep | 03-okt | 59 | 3 | 79 |
| | 17-jun | 15-sep | 22-sep | 24-sep | | 65 | 8 | |
| | 17-jun | 16-sep | 22-sep | 24-sep | | 66 | 7 | |
| | 17-jun | 05-sep | 08-sep | 10-sep | | 59 | 4 | |
| | 18-jun | 03-sep | 04-sep | 04-sep | 03-okt | 56 | 2 | 78 |
| | 19-jun | 03-sep | 20-sep | 25-sep | | 55 | 17 | |
| | 19-jun | 15-okt | 16-okt | 20-okt | | 85 | 4 | |
| | 19-jun | 04-sep | 08-sep | | 03-okt | 56 | | 77 |

| Project nr. | Order date | Purch. receives material spec. from ZM | Material picking date | Material delivery to site location date | Order closing date | Time between Order receiving and ZM orders material | Time be-tween Purch. order and Material delivery to site | Project total time |
|---|---|---|---|---|---|---|---|---|
| | 23-jun | 15-sep | 18-sep | 22-sep | | 61 | 6 | |
| | 26-jun | 11-sep | 22-sep | 25-sep | | 56 | 11 | |
| | 26-jun | 04-sep | 13-sep | 15-sep | | 51 | 8 | |
| | 26-jun | 26-sep | 30-sep | 02-okt | | 67 | 5 | |
| | 26-jun | 04-sep | 13-sep | 15-sep | | 51 | 8 | |
| | 26-jun | 25-aug | 02-sep | 04-sep | | 43 | 9 | |
| | 26-jun | 03-sep | 04-sep | 04-sep | | 50 | 2 | |
| | 26-jun | 04-sep | 08-sep | | | 51 | | |
| | 26-jun | 09-sep | 16-sep | 19-sep | | 54 | 9 | |
| | 26-jun | 26-sep | 30-sep | 02-okt | | 67 | 5 | |
| | 26-jun | 26-sep | 30-sep | 02-okt | | 67 | 5 | |
| | 26-jun | 03-sep | 04-sep | 04-sep | | 50 | 2 | |
| | 26-jun | 09-sep | 17-sep | 22-sep | | 54 | 10 | |
| | 26-jun | 22-sep | 02-okt | 06-okt | | 63 | 11 | |
| | 30-jun | 15-sep | 17-sep | 22-sep | | 56 | 6 | |
| | 30-jun | 08-sep | 09-sep | 11-sep | 03-okt | 51 | 4 | 70 |
| | 30-jun | 16-sep | 22-sep | 24-sep | | 57 | 7 | |
| | 01-jul | 17-jul | 24-jul | 28-jul | 12-sep | 13 | 8 | 54 |
| | 02-jul | 03-okt | 08-okt | 10-okt | | 68 | 6 | |
| | 02-jul | 11-sep | 15-sep | 16-sep | | 52 | 4 | |
| | 02-jul | 25-sep | 30-sep | 30-sep | | 62 | 4 | |
| | 02-jul | 04-sep | 08-sep | | | 47 | | |
| | 03-jul | 25-aug | 27-aug | 29-aug | | 38 | 5 | |
| | 04-jul | 04-sep | 04-sep | | | 45 | | |
| | 04-jul | 15-sep | 18-sep | | | 52 | | |
| | 04-jul | 15-sep | 18-sep | | | 52 | | |
| | 08-jul | 01-okt | 07-okt | 10-okt | | 62 | 8 | |
| | 10-jul | 11-sep | 15-sep | 17-sep | | 46 | 5 | |
| | 10-jul | 11-sep | 15-sep | 17-sep | | 46 | 5 | |
| | 11-jul | 10-sep | 12-sep | 16-sep | | 44 | 5 | |
| | 11-jul | 11-sep | 15-sep | 17-sep | | 45 | 5 | |
| | 15-jul | 12-sep | 17-sep | 19-sep | | 44 | 6 | |
| | | | | | SUM | 7449 | 877 | 5718 |
| | | | | | Average | 56 | 7 | 89 |

# 14 Appendix 4 - Material Specifications for 3G Sites

Table 14.1. Material specification for site 1/2 inches.

Source: FNS internal records, 2003.

| Article no. | Denomination | Qty | Unit | Price, SEK | Costs per site, SEK |
|---|---|---|---|---|---|
| | | | st | 11 000,0 | |
| | | | st | 2 574,0 | |
| | | | m | 19,9 | |
| | | | st | 2 770,0 | |
| | | | st | 6,0 | |
| | | | st | 99,9 | |
| | | | st | 92,0 | |
| | | | st | 715,0 | |
| | | | st | 500,0 | |
| | | | st | 494,0 | |
| | | | st | 446,4 | |
| | | | m | 9,1 | |
| | | | m | 11,7 | |
| | | | m | 9,9 | |
| | | | m | 4,8 | |
| | | | st | 50,5 | |
| | | | st | 3,1 | |
| | | | st | 2,6 | |
| | | | st | 0,3 | |

Table 14.2. Material specification for site 7/8 inches.

Source: FNS internal records, 2003.

| Article no. | Denomination | Qty | Unit | Price, SEK | Costs per site, SEK |
|---|---|---|---|---|---|
| | | | pcs | 11 000,0 | |
| | | | m | 39,8 | |
| | | | pcs | 2 574,0 | |
| | | | pcs | 168,0 | |
| | | | pcs | 4 920,0 | |
| | | | pcs | 2 770,0 | |
| | | | pcs | 138,4 | |
| | | | pcs | 24,8 | |
| | | | pcs | 222,0 | |
| | | | pcs | 165,8 | |
| | | | pcs | 103,5 | |
| | | | pcs | 715,0 | |
| | | | st | 446,4 | |
| | | | pcs | 60,5 | |
| | | | pcs | 25,4 | |
| | | | pcs | 122,4 | |
| | | | m | 11,7 | |
| | | | m | 9,9 | |
| | | | m | 4,8 | |
| | | | m | 9,1 | |
| | | | st | 50,5 | |
| | | | pcs | 3,1 | |
| | | | pcs | 0,3 | |

Table 14.3 Material specification for site 1 1/4 inches.

Source: FNS internal records, 2003.

| Article no. | Denomination | Qty | Unit | Price, SEK | Costs per site, SEK |
|---|---|---|---|---|---|
| | | | m | 78,8 | |
| | | | st | 11 000,0 | |
| | | | st | 2 574,0 | |
| | | | st | 365,5 | |
| | | | st | 26,0 | |
| | | | st | 2 770,0 | |
| | | | st | 222,0 | |
| | | | st | 166,0 | |
| | | | st | 147,6 | |
| | | | st | 446,4 | |
| | | | pcs | 61,5 | |
| | | | st | 27,4 | |
| | | | m | 11,7 | |
| | | | m | 9,9 | |
| | | | m | 4,8 | |
| | | | st | 2,6 | |
| | | | st | 50,5 | |
| | | | st | 50,5 | |
| | | | m | 9,1 | |
| | | | st | 0,6 | |
| | | | st | 3,1 | |
| | | | m | 4,7 | |

Table 14.4 Material specification for site 1 5/8 inches.

Source: FNS internal records, 2003.

| Article no. | Denomination | Qty | Unit | Price, SEK | Costs per site, SEK |
|---|---|---|---|---|---|
| | | | m | 103,9 | |
| | | | st | 165,8 | |
| | | | st | 11 000,0 | |
| | | | st | 2 574,0 | |
| | | | st | 514,5 | |
| | | | st | 32,0 | |
| | | | st | 168,0 | |
| | | | st | 2 770,0 | |
| | | | st | 250,0 | |
| | | | st | 195,8 | |
| | | | pcs | 98,5 | |
| | | | st | 500,0 | |
| | | | st | 494,0 | |
| | | | st | 227,8 | |
| | | | st | 446,4 | |
| | | | st | 6,0 | |
| | | | st | 31,0 | |
| | | | m | 9,1 | |
| | | | m | 9,9 | |
| | | | m | 4,8 | |
| | | | m | 11,7 | |
| | | | st | 50,5 | |
| | | | st | 3,1 | |
| | | | st | 2,6 | |
| | | | st | 0,3 | |

# 15 Appendix 5 – Cycle Inventory and Safety Stock

Table 15.1 Cycle and safety stocks value for AAA business area

Source: FNS internal records, 2003.

| Article number | Safety stock | Batch size | Price, SEK | Cycle inventory costs, SEK | Safety stock, SEK | % of safety stock |
|---|---|---|---|---|---|---|
| | 30 | 15 | 11 000,0 | 82 500,0 | 330 000,0 | 35,0 |
| | 45 | 45 | 2 574,0 | 57 915,0 | 115 830,0 | 12,3 |
| | 20 | 10 | 2 770,0 | 13 850,0 | 55 400,0 | 5,9 |
| | 10 | 5 | 4 920,0 | 12 300,0 | 49 200,0 | 5,2 |
| | 75 | 80 | 514,5 | 20 580,0 | 38 587,5 | 4,1 |
| | 200 | 200 | 168,0 | 16 800,0 | 33 600,0 | 3,6 |
| | 75 | 80 | 365,5 | 14 620,0 | 27 412,5 | 2,9 |
| | 150 | 100 | 165,8 | 8 287,5 | 24 862,5 | 2,6 |
| | 600 | 500 | 32,0 | 8 000,0 | 19 200,0 | 2,0 |
| | 30 | 10 | 500,0 | 2 500,0 | 15 000,0 | 1,6 |
| | 30 | 10 | 494,0 | 2 470,0 | 14 820,0 | 1,6 |
| | 20 | 50 | 715,0 | 17 875,0 | 14 300,0 | 1,5 |
| | 60 | 60 | 195,8 | 5 874,0 | 11 748,0 | 1,2 |
| | 45 | 30 | 250,0 | 3 750,0 | 11 250,0 | 1,2 |
| | 25 | 40 | 446,4 | 8 928,0 | 11 160,0 | 1,2 |
| | 20 | 1 | 528,4 | 264,2 | 10 567,4 | 1,1 |
| | 400 | 600 | 26,0 | 7 800,0 | 10 400,0 | 1,1 |
| | 75 | 80 | 138,4 | 5 536,0 | 10 380,0 | 1,1 |
| | 400 | 400 | 24,8 | 4 964,0 | 9 928,0 | 1,1 |
| | 60 | 60 | 147,6 | 4 428,0 | 8 856,0 | 0,9 |
| | 30 | 15 | 278,0 | 2 085,0 | 8 340,0 | 0,9 |
| | 30 | 30 | 222,0 | 3 330,0 | 6 660,0 | 0,7 |
| | 5 | 1 | 1 265,0 | 632,5 | 6 325,0 | 0,7 |
| | 60 | 60 | 103,5 | 3 105,0 | 6 210,0 | 0,7 |
| | 3 | 3 | 1 900,0 | 2 850,0 | 5 700,0 | 0,6 |
| | 5 | 1 | 1 064,0 | 532,0 | 5 320,0 | 0,6 |
| | 5 | 1 | 1 047,0 | 523,5 | 5 235,0 | 0,6 |
| | 12 | 12 | 425,0 | 2 550,0 | 5 100,0 | 0,5 |
| | 50 | 15 | 99,9 | 748,9 | 4 992,5 | 0,5 |
| | 50 | 60 | 98,5 | 2 955,0 | 4 925,0 | 0,5 |
| | 5 | 1 | 964,0 | 482,0 | 4 820,0 | 0,5 |
| | 12 | 1 | 385,0 | 192,5 | 4 620,0 | 0,5 |

| Article number | Safety stock | Batch size | Price, SEK | Cycle inventory costs, SEK | Safety stock, SEK | % of safety stock |
|---|---|---|---|---|---|---|
| | 50 | | 92,0 | 0,0 | 4 600,0 | 0,5 |
| | 6 | 1 | 750,0 | 375,0 | 4 500,0 | 0,5 |
| | 200 | 1 | 22,2 | 11,1 | 4 440,0 | 0,5 |
| | 16 | 1 | 238,0 | 119,0 | 3 808,0 | 0,4 |
| | 30 | 1 | 110,0 | 55,0 | 3 300,0 | 0,3 |
| | 50 | 60 | 61,5 | 1 845,0 | 3 075,0 | 0,3 |
| | 25 | 40 | 122,4 | 2 448,0 | 3 060,0 | 0,3 |
| | 50 | 60 | 54,0 | 1 620,0 | 2 700,0 | 0,3 |
| | 100 | 100 | 25,4 | 1 267,5 | 2 535,0 | 0,3 |
| | 5 | 1 | 411,0 | 205,5 | 2 055,0 | 0,2 |
| | 400 | 400 | 4,8 | 968,0 | 1 936,0 | 0,2 |
| | 5 | 1 | 368,0 | 184,0 | 1 840,0 | 0,2 |
| | 6 | 12 | 306,0 | 1 836,0 | 1 836,0 | 0,2 |
| | 8 | 10 | 227,8 | 1 139,1 | 1 822,5 | 0,2 |
| | 200 | 1000 | 9,1 | 4 550,0 | 1 820,0 | 0,2 |
| | 50 | 100 | 32,6 | 1 628,5 | 1 628,5 | 0,2 |
| | 30 | 1 | 48,0 | 24,0 | 1 440,0 | 0,2 |
| | 50 | 100 | 27,4 | 1 370,0 | 1 370,0 | 0,1 |
| | 20 | 15 | 60,5 | 453,8 | 1 210,0 | 0,1 |
| | 2 | 1 | 463,0 | 231,5 | 926,0 | 0,1 |
| | 20 | 40 | 38,0 | 760,0 | 760,0 | 0,1 |
| | 20 | 1 | 18,9 | 9,5 | 378,0 | 0,0 |
| | 100 | 200 | 3,1 | 310,0 | 310,0 | 0,0 |
| | 10 | 20 | 31,0 | 310,0 | 310,0 | 0,0 |
| | 500 | 1000 | 0,6 | 300,0 | 300,0 | 0,0 |
| | 5 | 10 | 50,5 | 252,5 | 252,5 | 0,0 |
| | 500 | 1000 | 0,3 | 145,0 | 145,0 | 0,0 |
| | 40 | 100 | 2,6 | 127,5 | 102,0 | 0,0 |
| | 0 | 438 | 103,9 | 22 754,1 | 0,0 | 0,0 |
| | 0 | 192 | 19,9 | 1 910,4 | 0,0 | 0,0 |
| | 0 | 500 | 9,9 | 2 470,0 | 0,0 | 0,0 |
| | 0 | 10 | 50,5 | 252,5 | 0,0 | 0,0 |
| | 0 | 500 | 11,7 | 2 925,0 | 0,0 | 0,0 |
| | 0 | 354 | 78,8 | 13 947,6 | 0,0 | 0,0 |
| | 0 | 210 | 39,8 | 4 179,0 | 0,0 | 0,0 |
| | 0 | 15 | 166,0 | 1 245,0 | 0,0 | 0,0 |
| | | | 4,66 | 0,0 | 0,0 | 0,0 |
| | 0 | 1 | 156,0 | 78,0 | 0,0 | 0,0 |
| | 0 | 1 | 6 631,0 | 3 315,5 | 0,0 | 0,0 |

| Article number | Safety stock | Batch size | Price, SEK | Cycle inventory costs, SEK | Safety stock, SEK | % of safety stock |
|---|---|---|---|---|---|---|
| | 0 | 1 | 102,5 | 51,3 | 0,0 | 0,0 |
| | 0 | 1 | 135,0 | 67,5 | 0,0 | 0,0 |
| | 0 | 1 | 362,0 | 181,0 | 0,0 | 0,0 |
| | 0 | 1 | 510,0 | 255,0 | 0,0 | 0,0 |
| | 0 | 1 | 100,0 | 50,0 | 0,0 | 0,0 |
| | 0 | 1 | 1 575,0 | 787,5 | 0,0 | 0,0 |
| | 0 | 1 | 2 574,0 | 1 287,0 | 0,0 | 0,0 |
| | 0 | 1 | 2 574,0 | 1 287,0 | 0,0 | 0,0 |
| | 0 | 1 | 3 765,0 | 1 882,5 | 0,0 | 0,0 |
| | 0 | 1 | 2 556,0 | 1 278,0 | 0,0 | 0,0 |
| | 0 | 1 | | 0,0 | 0,0 | 0,0 |
| | 0 | 1 | 16,6 | 8,3 | 0,0 | 0,0 |
| | 0 | 1 | 15,9 | 8,0 | 0,0 | 0,0 |
| | 0 | 1 | 19,0 | 9,5 | 0,0 | 0,0 |
| | 0 | 1 | 21,0 | 10,5 | 0,0 | 0,0 |
| | 0 | 1 | 19,7 | 9,8 | 0,0 | 0,0 |
| | 0 | 1 | 19,1 | 9,6 | 0,0 | 0,0 |
| | 0 | 1 | 25,3 | 12,7 | 0,0 | 0,0 |
| | 0 | 1 | 27,0 | 13,5 | 0,0 | 0,0 |
| | 0 | 1 | 21,7 | 10,9 | 0,0 | 0,0 |
| | 0 | 1 | 10,2 | 5,1 | 0,0 | 0,0 |
| | 0 | 1 | 7,0 | 3,5 | 0,0 | 0,0 |
| | 0 | 1 | 13,6 | 6,8 | 0,0 | 0,0 |
| | 0 | 1 | 230,8 | 115,4 | 0,0 | 0,0 |
| | 0 | 1 | 34,6 | 17,3 | 0,0 | 0,0 |
| | 0 | 1 | 22,4 | 11,2 | 0,0 | 0,0 |
| | 0 | 1 | 71,5 | 35,8 | 0,0 | 0,0 |
| | 0 | 50 | 4,0 | 100,0 | 0,0 | 0,0 |
| | 0 | 1 | 303,8 | 151,9 | 0,0 | 0,0 |
| | 0 | 1 | 340,2 | 170,1 | 0,0 | 0,0 |
| | 0 | 1 | 632,1 | 316,1 | 0,0 | 0,0 |
| | 0 | 1 | 112,0 | 56,0 | 0,0 | 0,0 |
| | 0 | 1 | 2 895,0 | 1 447,0 | 0,0 | 0,0 |
| | 0 | 1 | 55,0 | 27,5 | 0,0 | 0,0 |
| | 0 | 1 | 55,0 | 27,5 | 0,0 | 0,0 |
| | | | | 406 168,4 | 943 208,9 | 100 |
| | | | +6,7% | 433 381,7 | 1 006 403,9 | |
| Cycle inventory + Safety stock | | | | 1 439 785,6 | | |