SELECTING THE RIGHT SUPPLY CHAIN FOR A CUSTOMER IN PROJECT BUSINESS

An Action Research Study In The Mobile Communications Infrastructure Industry

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Dissertation for the degree of Doctor of Science in Technology to be presented with due permission of the Department of Industrial Engineering and Management, for public examination and debate in Auditorium Luna in Spektri at Helsinki University of Technology (Espoo, Finland) on the 8th of January, 2003, at 12:00.

ABSTRACT

This thesis is about integrating a supply chain to a customer's implementation project. The study is to identify and describe key factors that influence supply chain choices for project businesses. The aim is to explain the selection criteria for the right chain for an individual customer under different circumstances. The research problem, a highly relevant theme in the Internet age, is how to select the most appropriate supply chain for a customer in different business conditions. In addition to contributing to the scientific literature, this research also aims to support practical business situations in the industry by creating a normative decision-making model.

The scope of this study is, thus, restricted to supply chains in project businesses where the success of logistics processes is largely dependent on how well physical deliveries are integrated into the implementation schedules of a project. The focused product type is typical of high-tech and innovative products with relatively short life cycles. Furthermore, the business environment of the scope is characterised by fast-growing turbulent markets.

This study is an action research conducted in the GSM network business in Europe during 1999 and 2000. The research is an inductive, theory-building multiple-case study. The supplier case company is Nokia Networks, one of the leading suppliers of fixed and mobile telecommunication systems, and the customers consist of major European mobile phone operators, which however are anonymous in the thesis for the sake of business confidentiality. The research material was collected from customer-specific implementation projects that were individually carried out as part of an extensive supply chain re-engineering program inside the case company. The program, called BIRD (Breakthrough Inventory Rotation Days), aimed to streamline the process for high-volume base station deliveries and implement one of alternative supply solutions for a customer to best fit its individual needs. An individual process implementation for a customer (N=11) is considered to be the unit of analysis in this study.

The basic axiom in the thesis is the Contingency Theory of Organisations that briefly says: "There is not one best way to organise something, but rather it depends on the environment". A customer's environmental requirements should determine the appropriate structure for the supply chain. The study maintains that there are two effective means to differentiate supply chain solutions for an individual customer. The first means is the well-known concept of Order Penetration Point (OPP). The second one is the value offering point (VOP), which is still a rather fresh and theoretical concept in the supply chain management literature. The study demonstrates how the positioning of these two points impact on the three dimensions of supply chains, i.e. on customer service, capital employment and total costs.

The research results drawn from the in-depth case analysis are as follows:

- Three types of customer demand chains, distinguished by the position of the value offering point, can be identified among customers in project business. These are (1) call for project planning, (2) call for project execution and (3) call for project inventory management.
- Alternative supply chains are being used in different customer projects, quite intuitively, without a proper justification for the choices made. This is mainly due to contradictory target setting in project and supply chain systems (e.g., time buffers vs. material buffers) that makes it extremely complex to find the "right" supply chain solution for a customer.
- The accuracy of project planning and the implementation of a pre-defined execution trigger for ordering are actually sufficient selection factors to specify the right combination of value offering and order penetration points. However, as these selection factors are on a highly operational level, it is difficult to estimate their behaviour in a project beforehand.
- The technology life-cycle stage (which in this instance is represented by GSM penetration) and the level of the customer-supplier process collaboration are business conditions that can be used to estimate the behaviour of the selection factors in a project beforehand. Furthermore, these are considered to be necessary conditions in moving the value offering point further downstream in the chain.

As a conclusion this study provides companies with a useful model to implement successful supply solutions for individual customers, especially applicable in the project business environment for innovative and high tech products. The study provides a set of normative rules to specify the right supply chain for a customer and defines the underlying pre-conditions to apply the rules. In addition to these normative results, the study provides new insight on the existing body of knowledge on integrating equipment deliveries into a customer's implementation project – which seems to be a fairly untouched area in the literature. According to the selected research approach, these conclusions are valid within the case study settings and their generalisation to a wider context should be further studied.

Key words: demand chain, supply chain, project management, value offering point, order penetration point

“You have your way. I have my way.
As for the right way, the correct way,and the only way, it does not exist.”

Friedrich Nietzsche

FOREWORD

This dissertation represents an important milestone in my personal life. Already as a teenager I realised that I want to be involved in making science in some particular research area. At that time I believed the research area is physics, but it turned out to be industrial management – perhaps reflecting my pragmatic worldview. To achieve this milestone I am very grateful to my supervising professor Eero Eloranta for his professional guidance and feedback throughout the whole research process of the thesis. His valuable contribution and strong commitment have a significant impact to the outcome.

ExIMa doctoral program in the Helsinki University of Technology (HUT) provided me an excellent opportunity to conduct the research besides my work at Nokia. I want to thank the whole ExIMa team and all the research follows for a stimulating environment in doing this study. I received lots of valuable support from Prof. Eila Järvenpää, Prof. Jukka Ranta, Dr. Jan Holmström, Dr. Jussi Heikkilä and Dr. Mikko Junttila. I very much appreciate Prof. Harri Haapasalo and Prof. Anita Lukka for the valuable and insightful comments during the preliminary inspection. I am also grateful to Helsinki University of Technology, Suomen Akatemia, Tekniikan Edistämissäätiö and Wallenberg Institute that practically made it possible for me to finalise the thesis during a study leave.

Great thanks belong to a number of my Nokia colleagues who I closely worked with during 1999 and 2000 in doing the action research across Europe. Special acknowledgement goes to my ex-superior Mr. Eero Virros for supporting and giving me the opportunity to conduct doctoral studies besides my daily work. Likewise, I am very grateful to Mr. Pekka Vartiainen for his contribution and to his whole Europe Area team in implementing customised supply solutions. Special thanks belong to my colleague Mrs. Tiina Tissari for planning, collecting and sharing the same research material base. I also want to present my sincere thanks to Mr. Tapio Karjalainen, Mr. Matti Franck, Mrs. Hille Korhonen, Mr. Thomas Müller, Mr. Ari Kurikka, Mr. Antti Hietala, Mr. Esa Vilminko, Mr. Mikko Kosonen, Mr. Jaakko Laine and Mr. Timo Hänninen for their managerial support and contribution in doing the research.

It was important for me to have a possibility to discuss the usefulness of the research results with representatives from other industries. Therefore, I want to express my sincere appreciation to Mr. Tuomo Rönkkö (ElTel Networks), Mr. Jarkko Muurimäki (Skanska), Mr. Jukka Siren (SCC/Viatek), Mr. Harri Länsiö (Kone) and Mr. Samu Salmelin (Kone) for the fruitful discussions.

I would also like to express my gratitude to my parents, brother and other close relatives and friends for their many encouragements during the work.

Finally, I have to admit that this thesis would not exist without my great love Satu and her strong commitment to this work during the last four years. I admire her patience for being so supportive and her ability to constantly be involved in my (sometimes agonized) creation process. Satu and Rasmus practically gave me the needed energy to finalise this work.

Helsinki, December 2002

Jari Collin

ABBREVIATIONS

AR	Action Research
ARPU	Average Revenue Per User
ATO	Assemble-To-Order
AuC	Authentication Centre
BCG	Boston Consulting Group
BIRD	Breakthrough Inventory Rotation Days
BPR	Business Process Re-engineering
BSC	Base Station Controller
BSS	Base Station Subsystem
BTS	Base Station
CLM	Council of Logistics Management
CRM	Customer Relationship Management
DA	Delivery Accuracy
DOS	Days of Supply
EIR	Equipment Identity Register
EMC	European Mobile Communications
GIT	Goods In Transit
GIWU	GSM Inter-Working Unit
GSM	Groupe Spécial Mobile (or Global System for Mobile communications)
HLR	Home Location Register
JIT	Just-In-Time
MSC	Mobile Switching Centre
MTO	Make-To-Order
MTS	Make-To-Stock
MWR	Microwave Radios
NMT	Nordisk Mobiltelefon
NSS	Network and Switching Subsystem
OPP	Order Penetration Point
OPT	Optimised Production Technology
OSS	Operation and Support Subsystem
PISM	Pre-Installation Site Meeting
PMBOK	Project Management Body of Knowledge
PS	Physical Stock
PTO	Pack-To-Order
PTT	Post Telephone and Telegraph
RDC	Regional Distribution Centre
ROI	Return on Investment
SiSo	Site Solution Material
STO	Ship-To-Order
TOC	Theory of Constraints
TQM	Total Quality Management
TRX	Transceiver Unit
UMTS	Universal Mobile Telecommunication System
VLR	Visitor Location Register
VOP	Value Offering Point
WIP	Work In Process

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1. INTRODUCTION

1.1. Supply chains and the new economy

At the turn of the millennium we are witnessing a process of fundamental change in industries, economies, national societies and cultures globally. This transformation process, which is also referred to as informationalism among social scientists, has substantially been boosted by new innovations in information technology and communication systems. One of the today's recognised sociologists, Manuel Castells (2000), compares the significance of the ongoing changes to the previous two industrial revolutions in the western world. The first started in the last third of the eighteenth century, and was characterised by new technologies such as the steam engine, the spinning jenny, Cort's process in metallurgy, and, more broadly, by the replacement of hand-tools by machines. The second industrial revolution, about 100 years later, featured the development of electricity, the internal combustion engine, scientifically-based chemicals, efficient steel casting, and the beginning of communications technology, with the diffusion of the telegraph and the invention of the telephone (Castells, 2000).

These two periods of industrialisation undoubtedly have fundamentally changed the way people live. Today, again around a hundred years after the second industrial revolution, we are on our way towards a mobile information society where existing business laws and manners will be replaced with new ones for the Internet Age. In addition, the changes will not only occur in global structures; including the networking of nations and enterprises that the new information technology will provide on a conceptual level, but they will also bring about a totally new way of living, working and communicating for people. Already during the last decades we have seen a rapid development of digital communication technologies resulting in various technical devices like portable computers and mobile phones for consumers. These new technical innovations have enabled people to remotely access a global market place, the Internet, which forms the core of the new economy. According to Tapscott (1996), this new information technology gives rise to a new kind of economy, which in turn drives new kinds of enterprises. The new technology, the new economy and the new enterprise are inextricably linked (Tapscott, 1996).

We presumably have only seen the dawn of this information revolution. Today, we are still, more or less, in the building phase of the technological infrastructure of the new economy. In fact, there are only a handful of enterprises that have been able to essentially add more value for their customers by using the new economy's innovative business models. However, there is no doubt that these innovations will gradually be implemented on a larger scale as an effective technological infrastructure is put in place. Third generation cellular networks, based on globally accepted UMTS-standards, can be considered to be this kind of improvement to the existing mobile communication infrastructure as they enable new kinds of value innovations for many industries. These new cellular networks will be able to transfer data (text, speech and image) up to hundreds of times faster than existing technologies. Combined with the constant development of personal computers, mobile phones and other wireless devices, this should provide industries and companies a sufficient infrastructure to really reassess their existing business models. Totally new types of business opportunities will rise in each industry when people are no longer dependent on their physical location, but rather can easily work, shop, pay bills, entertain themselves, socialise and so forth basically everywhere in the world. This is a real revolution for humanity.

This ongoing development on a large scale provides us with two important perspectives that are closely linked to this study. First, this work's case studies are taken from a pioneering mobile communications infrastructure industry that is, obviously, building a platform for the new information societies. During the 1990s this industry had already been in the middle of a turbulent restructuring-process and faced a period of rapid growth, as the new digitally-based communications technology (GSM networks) expanded the business opportunities for telecom operators. This study of the industry contains an in-depth analysis of the architecture and performance of the supply chains of individual operators. The research material is collected from 38 different GSM network building projects in Europe in 1999 and 2000. In order to explain the dynamics of these supply chains, it is first essential to understand the underlying phenomena that led mobile telecommunications to rapidly become one of the most attractive and fast growing industries world-wide in the late 20th century.

Currently, at the dawn of the third generation cellular networks, the attractiveness of the telecom markets has increased the competition to a level of madness. In a number of UMTS-license auctions telecom operators paid national governments enormous amounts of money for radio bandwidth just to ensure that they were also one of the players in the 3rd generation markets. European governments alone have already collected over 100,000 MEUR from license fees (21.10.2001/www.cellular-news.com)! In addition to these investments, the operators naturally have to invest in building new cellular networks before they can start offering new services to consumers. This has lead to financial problems. Therefore, it is quite evident that an operator's main focus in building the networks will be speed and cost-efficiency. In this project, traditional management doctrines, especially within project management practises and efficient supply chain solutions, will again play a central role in company strategies.

We can say that these rapid changes in the telecom industry have been revolutionary. The new innovations in technology created new business opportunities in the markets. The potential for exponential market growth attracted new players to the business, which in turn led competition to dramatically increase. This put pressure on speed and product margins, which drove companies to find the most effective and cost-efficient business solutions via partnerships and re-structuring. This series of actions already took place with GSM technology, but it is expected to be even more tangible with UMTS-technology – as partly witnessed already in the markets. This work considers informationalism to be an impetus for this series of actions. As the wave of informationalism moves further, the implementation of similar turbulent processes (followed by new technology innovations, huge potential for market growth, stiff competition with new players and focus on cost-efficiency and re-structuring) is also expected in other industries.

The second perspective that connects this study closely to informationalism is related to the research problem and its relevancy in the new economy, where global markets are basically accessible to everyone on the Internet. This work maintains that finding the right supply chain for a customer is actually a pre-requisite for being a successful player in these Internet-based markets. This assumption is also supported by a number of adventurous trials during the late 1990s among companies, which failed to shift their operations to the new e-business models. They explicitly revealed the great importance of supply chain management as an effective way to differentiate and customise a product for individual customers. Indeed, a successful entry point to the new e-business mode for companies is primarily not about having a "killer software application", but rather about the ability to create a totally new business model that enables reliable, customised supply solutions for individual customers.

Product differentiation and customisation through supply chain management is not a new phenomenon; several related concepts and practical applications are already available in the literature. For instance, concepts like mass-customisation, manufacturing postponement and customer order decoupling points have been widely studied in a number of scientific articles (see

Lampel and Mintzberg, 1996; Gilmore and Pine II, 1997; Feitzinger and Lee, 1997; Van Hoek, 1998 for examples). However, this work maintains that there still is a significant gap in the supply chain literature, as it does not provide companies enough information to make successful business decisions in selecting a supply chain for an individual customer. This is a highly relevant theme for high-tech products with short life cycles, especially in a project business environment.

There are two essential studies from the late 1990s that are used as a main framework in the thesis on top of which the research problem is built on. The first one is an empirical study by Fisher (1997) that provides companies with a normative decision-making model to match their supply chains with different types of products. According to that study, the supply chain for innovative products - which is also the focus of this thesis - should be responsive to better meet the requirements of individual customers. However, it does not clearly suggest how companies should differentiate their supply chains for different customers. This aspect is examined in a more conceptual study by Holmström et al. (1999), which introduces a new implementation method for companies to systematically improve their value offering to individual customers via supply chains. Although that study gives us a framework to develop customised supply solutions, it does not provide any normative model of how companies should select the right supply chain for a customer. Furthermore, both studies are more focused on wholesaler-retailer supply chains in a consumer business, whereas the main interest of this thesis is explicitly on supply chains in project businesses.

1.2. Research problem and research questions

The purpose of this study is to identify and describe key factors that influence supply chain choices for project businesses. Furthermore, this study aims to explain the selection criteria for the right chain for a customer under different circumstances. In addition to contributing to the scientific literature, this research also aims to support practical business situations in the industry by creating a normative decision-making model.

The research problem is as follows:

How to select the most appropriate supply chain for a customer in different business conditions?

This research problem is explicitly studied from a supplier company's standpoint. It can be divided into the following key questions:

1. What types of demand chains can be identified among customers? *(identification)*
2. How are alternative supply chains being used, and why? *(description)*
3. Which selection factors actually specify the most appropriate supply chain for a customer? *(prescription)*
4. How, and under which conditions, should the selection factors be used? (*use criteria)*

The fundamental axiom of this thesis is the well-known Contingency Theory of Organisations by Lawrence and Lorsch (1967). Briefly, this theory says that there is not one best way to organise something, but rather it depends on the environment. Under different environmental conditions, different states of differentiation and integration are related to effective performance. To be effective, internal states and processes of organizations need to be contingent upon environmental characteristics. The contingency theory is applied in the study as follows: "There is not a single supply chain mode that suits all customers; rather, the selection of the right chain depends on the customer's business environment." A customer's environmental requirements should determine the appropriate structure for a supply chain.

1.3. The scope of research

The scope of this study is restricted to supply chains in project businesses where the success of logistics processes is largely dependent on how well physical deliveries are integrated into the implementation schedules of a project. The focused product type is typical of high-tech and innovative products with relatively short life cycles. Furthermore, the business environment of the scope is characterised by fast-growing turbulent markets inside Europe.

This thesis consists of empirical research conducted as a multiple-case study in the GSM network business during 1999-2000. It covers the process implementation of supply chains for high-volume base station equipment and radio links plus related site solution material that is needed for installing complete base station sites in a network. The process implementation was implemented as customer specific re-engineering projects. The case company is Nokia Networks, one of the leading suppliers of fixed and mobile telecommunication systems, and the customers consist of major European mobile phone operators, which however are anonymous in the thesis for the sake of business confidentiality. Nokia represents a supplier company in this study.

The research material was collected from those customer-specific implementation projects that were individually carried out as part of an extensive supply chain re-engineering program inside Nokia Networks. The program, called BIRD (Breakthrough Inventory Rotation Days), aimed to streamline the process for high-volume base station deliveries and implement one of several alternative supply solutions for a customer to best fit its individual needs. The main objective was to provide the operators the fastest time to profit with the GSM network and, at the same time, to improve the process cost-efficiency by radically reducing inventories in the whole end-to-end supply chain. The BIRD program covered 38 different customer process implementations inside Europe in total. Eleven of those customer projects were selected for in-depth case analysis for this thesis. An individual process implementation for a customer is considered to be the unit of analysis in this study.

1.4. Thesis composition

This thesis consists of nine chapters. The first chapter is an introduction to the thesis. It introduces the reader to the study, presenting the research problem and questions. In addition, the scope of the study is presented in this chapter. The second chapter consists of a literature review. It covers the most relevant theories and concepts for this study. This section is also used as a basis in creating ‘a priori’ research constructs. The third chapter explains the scientific research methods. The research strategy, the reasoning and the detailed design of the actual research process are described in this chapter. Furthermore, the chapter includes descriptions of the research material. The fourth chapter introduces the reader to the BIRD re-engineering program and to the general business environment of the customers. This section focuses on explaining the characteristics of GSM building projects and describing the alternative supply chains in use. The fifth chapter builds the ‘ a priori’ research constructs for operational study propositions. These study propositions are to direct attention in individual customer cases to items that are examined within each unit of analysis. The sixth chapter includes the analysis of customer case studies. The eleven in-depth cases are individually described and analysed in detail. Furthermore, this section includes a cross-case analysis to find common characteristics. The next chapter presents the research results and the main findings that were drawn based on the eleven in-depth case studies. This section answers the particular research questions presented in the first chapter. The final conclusions of the study and the presentation of a new theory are done in the eighth chapter. The new theory about customised supply solutions in project businesses is presented in this chapter. This is explicitly done based on the eleven selected in-depth case studies (N=11). The ninth and final chapter is reserved for further validation and discussion on the applicability of the results. It includes a validation of the conclusions against all the customer cases in the BIRD program (N=38) and discussion on applicability in other project business industries. It also includes a brief exploration about the need for further studies.

2. LITERATURE REVIEW

This chapter presents the basic management concepts and theories that are essentially linked to the research problem and questions. The chapter is composed of three sub-chapters. It starts with an introduction to the concept of supply chain management and its main objectives in microeconomics. The purpose is to create a solid base for judging the successful elements of the supply chains. The second sub-chapter deals with the various means, or ways, to differentiate supply chains. The most significant concepts that make supply chain customisation easily achievable are discussed in this sub-chapter. The third sub-chapter focuses on reviewing the business conditions that are determinant factors in selecting a supply chain for a customer in project businesses.

2.1. The ends of successful supply chains

2.1.1. Preface

Over the past decade, there has been an increasing emphasis on supply chain management as a vehicle through which firms can achieve competitive advantage in markets (Dyer, Cho and Chu, 1998). A large number of examples in the 1990s, both successful and abortive, show how companies have made large investments to streamline their supply chains in order to improve customer satisfaction and increase their internal productivity. As Christopher (1998) states, it is not actually individual companies that compete with each other nowadays; rather, the competition is between rival supply chains. Those supply chains that add the most value for customers with the lowest cost in the chain make up the winning network of individual companies.

According to Mentzer et al. (2001a), supply chain management is, still in the early 2000s, a very popular development area among companies. Its importance is especially significant in the area of high-tech industry where product life cycles are short and product values are relative high. Likewise, the management of end-to-end supply chains in a business environment like the mobile communications infrastructure business has a major financial impact on all parties involved in the chain. Just thinking about the current industrial dynamics of the hi-tech information technology markets it is relatively easy to argue that today the management of supply chains is actually not a competitive advantage anymore; rather, it is a condition of being in the business for companies.

However, although the importance of supply chain management is widely recognised, its explicit meaning is often blurred among companies (e.g., Mentzer at al., 2001a). Therefore, it is now necessary to take a closer look at the concept of supply chain management and its key objectives. Moreover, we need a solid conceptual basis for drawing any conclusions about the phenomena studied in this thesis.

What is supply chain management?

All too often in the literature the term *supply chain management* is narrowly understood to be the same as *logistics management*. Although these terms basically represent the same management discipline, this work, however, maintains that there are fundamental differences between these two concepts (similar to, e.g., Mentzer et al., 2001; Bowersox et al., 1999; Christopher, 1998, Lambert et al., 1998). The concept of supply chain management has been derived from logistics management and it has a broader scope than tradition logistics within companies. In order to really understand the meaning of supply chain management and the differences between these two concepts, it is useful to shortly review the development of logistics in microeconomics over the past decades.

According to Ballou (1992), logistics management, as a discipline in management science and practice, has its roots back in the United States in the 1950-60s when the potential of efficient material distribution to decrease companies' direct product costs was realised. He (1992) continues that, at that time, there were four key conditions that encouraged the development of physical distribution models: (1) shifts in consumer demand patterns and attitudes toward more demanding needs for high availability and variety of products, (2) cost pressures on industry, (3) progress in computer technology and (4) the influences of the military experience. Physical distribution, according to Gattorna and Walters (1996), was considered to be a dominant theme in those days to respond to growing demand by companies to decrease costs in the logistics chain.

Mainly due to the oil crises in the 1970s, when both transportation costs and interest rates – and thus also inventory carrying costs - rose at the same time, the importance of logistics to a company's profits was really understood by top management (Ballou, 1992). It was then soon realised that optimisation of physical distribution alone was not good enough, but rather purchasing and material handling should be integrated very tightly into it. This integration process was leading to an evolution of logistics management that according to many sources (e.g., Langley and Holcomb, 1992; Ballou, 1992; Gattorna & Walters, 1996) can be considered to be the combination of two management disciples: physical distribution and materials management. Gradually, logistics management was understood as a cross-functional activity affecting the whole organisation, instead of optimising logistics separately in each functional column (Christopher, 1998). The rapid development in information technology, at the same time, was significantly speeding up this integration process.

Until the early 1980s the development of logistics systems in companies, however, was very much a cost-driven activity and the potential for customer satisfaction and new value creation were not fully understood. As Bowersox et al. (1999) point out, the full appreciation of logistical performance as a way to sustain customer relationships, while already introduced in the 1950s, was widely neglected until the mid-1980s. At that time, Professor Michael Porter of the Harvard Business School argued that a company is able to gain a competitive advantage over its rivals in the same markets only by providing more value to its customers. In his famous book, Competitive Advantage (Porter, 1985), he introduced the new concept of *value chain* - and *value system* – that rapidly became a famous doctrine in management studies worldwide. Each activity in a company should add value to the value chain of a customer and, similarly, each company in a particular industry should add value to the value system (Porter and Millar, 1985). In the value concept, logistics plays a central role in creating value for the customer, as both inbound and outbound logistics are represented as primary activities in the chain. At that moment, logistics was also seen as an activity that could greatly help companies in improving customer value, not only internal cost-efficiency.

Thus it was in the late 1980s that supply chain management really started to be utilized in the literature. In addition, according to Cooper et al. (1997), supply chain management has risen to prominence over the last ten years. This work maintains that the value chain concept was an impetus for the development of supply chain management, which has its roots in the basic logistics management theories.

The definitions of logistics and supply chain management vary somewhat in the literature. The Council of Logistics Management (CLM), an international organisation of logistics professionals, has defined logistics (or logistics management) as:

"The process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods and related information from point of origin to point of consumption for the purpose of conforming to customer requirements."

According to Christopher (1998) logistics management is:

"*The process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and the related information flows) through the organisation and its marketing channels in such a way that current and future profitability are maximised through cost-efficient fulfilment of orders."*

This work maintains that there are two essential aspects in both definitions (like many others in the literature) that distinguish logistics management from supply chain management. First, logistics management primarily focuses on a company's internal processes and second, profitability targets are pursued through cost-efficiency. Supply chain management goes much beyond this in terms of objective setting and scope. Therefore, it can be explicitly distinguished from traditional logistics management.

Supply chain management, as a more holistic concept, is a collaborative-based strategy to link inter-organisational business operations to achieve a shared market opportunity (Bowersox, Closs and Stank, 1999). The objective setting in supply chain management is twofold. First, the goal of an integrated supply chain is to enhance end-customer value (Bowersox et al., 2000). Second, the focus, at the same time, still greatly remains on the cost-efficiency targets throughout the whole supply chain (e.g., Christopher, 1998). Furthermore, the scope, obviously, is not restricted to a single value chain in one company, but rather it covers a number of value chains within a value system that makes up the inter-organisational supply chain for the end-customer. According to LaLonde and Masters (1994), a supply chain strategy should always include two or more firms in a supply chain entering into a long-term agreement.

Many attempts in the literature to define supply chain management are often long, confusing statements that are clumsily derived from the concept of logistics management. It is, thus, no wonder that these two concepts are often mixed. However, the definition applied in this thesis is taken from Christopher (1998) who has defined supply chain management as follows:

"The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole."

This definition concisely points out the two main aspects that distinguish it from logistics management. The first aspect is the objective of providing enhanced customer value with minimum costs in the whole chain. In other words, the definition says that the focus should be on creating superior customer value and to do this at the lowest cost to the whole supply chain. The second aspect deals with the inter-organisational relationships in a chain that consists of a number of companies both upstream and downstream.

In the literature the concept of supply chain management has also been referred to as a management philosophy (e.g., Ellram and Cooper, 1990; Mentzer et al., 2001). According to Mentzer et al. (2001), the concept as a management philosophy has the following characteristics:

1. A systems approach to viewing the supply chain as a whole, and to managing the total flow of goods inventory from the supplier to the ultimate customer.

2. A strategic orientation toward co-operative efforts to synchronise convergence of intra-firm and inter-firm operational and strategic capabilities into a unified whole.

3. A customer focus to create unique and individualised sources of customer value, leading to customer satisfaction.

In recent years the term supply chain management was confronted with some criticism that the notion does not describe its customer-oriented focus well enough (e.g., Christopher, 1998; Volman and Berry; 2000). Therefore, the term demand chain management has been used alongside supply chain management in the literature to stress the importance of customer-oriented thinking. However, this work maintains that a demand chain is not the same as a supply chain, and therefore demand chain management and supply chain management are not synonymous. According to Eloranta (1999), a demand chain transfers demand information from end customer markets to suppliers, whereas a supply chain creates products and services that are transferred from suppliers to end customers. Working together, the demand and supply chains create the demand-supply chain. A demand-supply chain is an end-to-end network where demand knowledge is passed from markets to supply sources and value offerings are passed from supply sources to consumers (Eloranta, 1999). This approach is also illustrated in Figure 1.

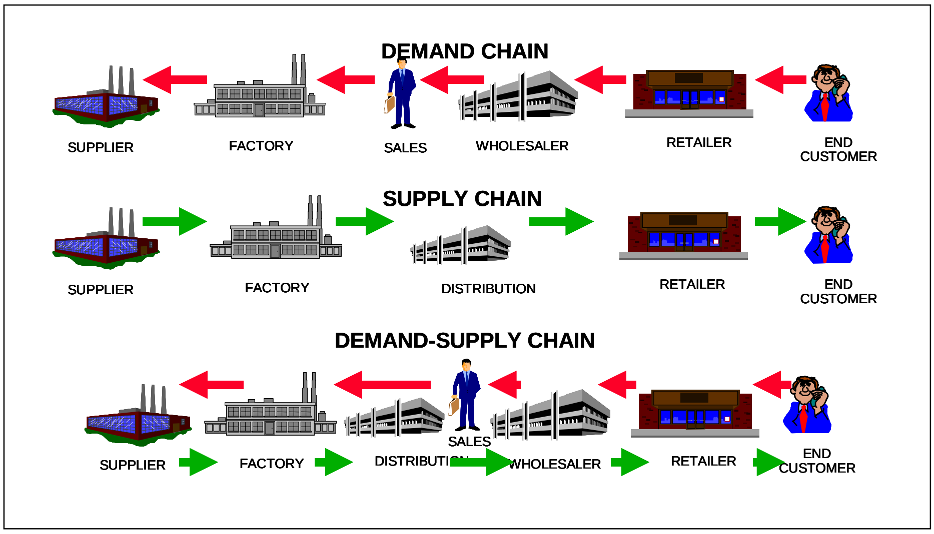


Figure 1: Demand-supply chain (Eloranta, 1999)

Key principle in this demand-supply chain framework is to identify customers' demand chain and to integrate suppliers' supply chain into it.

Dimensions of supply chain management

The goal of an integrated supply chain, as mentioned above, is primarily to enhance the value for end-customers. Adding customer value through supply chain management, however, is not that straightforward, because it includes different dimensions or perspectives. According to Bowersox et al. (2000), there are at least three different perspectives on creating value for customers through supply chains: economic value, market value and relevancy value. They are defined as follows:

1. ***Economic value*** is the first and perhaps the most traditional way to perceive customer value. Economic value deals with economies of scale to generate efficiency in logistics operations. Efficiency refers to the organisation's ability to provide the desired product and service mix at a level of cost that is acceptable to the customer (Langley and Holcomb, 1992). In other words, the economic value is about achieving a suitable solution for the customer with minimised total costs in the supply chain. The value for customers, naturally, is a low price.

2. The second value perspective, ***market value***, builds upon the effectiveness of supply chains. This value perspective focuses on economies of scope to achieve product service positioning. Effectiveness refers to issues of performance, and whether the logistics function meets customer requirements in a critical result area (Langley and Holcomb, 1992). The

effectiveness of supply chains, in practical terms, deals very much with product availability versus effective capital employment (for instance, inventory levels). The market value for customers is assortment (for instance, product portfolio) and convenience (for instance, lead-time).

3. The third value perspective, as Bowersox et al. (2000) call it, is the ***relevancy value***. This is about doing things for individual customers that make a real difference in the way the company works. This kind of differentiation or customisation of supply chains can be understood as being a vehicle to improved customer service. Differentiation manifests itself in the ability of logistics to create value for the customer through the uniqueness and distinctiveness of the logistics service (Langley and Holcomb, 1992).

Bowersox et al. (2000) continue that the value proposition to end-customers is always a combination of these three value perspectives. For suppliers, these value dimensions create a triangle of financial trade-off questions between (1) total costs [economic value], (2) capital employment [market value] and (3) customer service [relevancy value]. These three dimensions are also considered to be the ends of a successful supply chain. They are embedded in the Return on Investment (ROI) measurement that is widely used in the literature to indicate the ultimate financial performance of supply chains (e.g., Christopher, 1998; Gattorna and Walters, 1996). ROI is the ratio between the net profit and the capital that was employed to produce the profit, thus:

$$ROI = \frac{Profit}{Capital\ employed} = \frac{Sales - Total\ costs}{Capital\ employed} \qquad \text{(Christopher, 1998)}$$

The ratio can be further expanded:

$$ROI = \frac{Sales - Total\ costs}{Sales} * \frac{Sales}{Capital\ employed} = Margin * Asset\ turn$$

The ROI measurement represents a product of profitability and asset rotation. The dimensions of a supply chain that have an impact on the measurement are also illustrated in Figure 2.

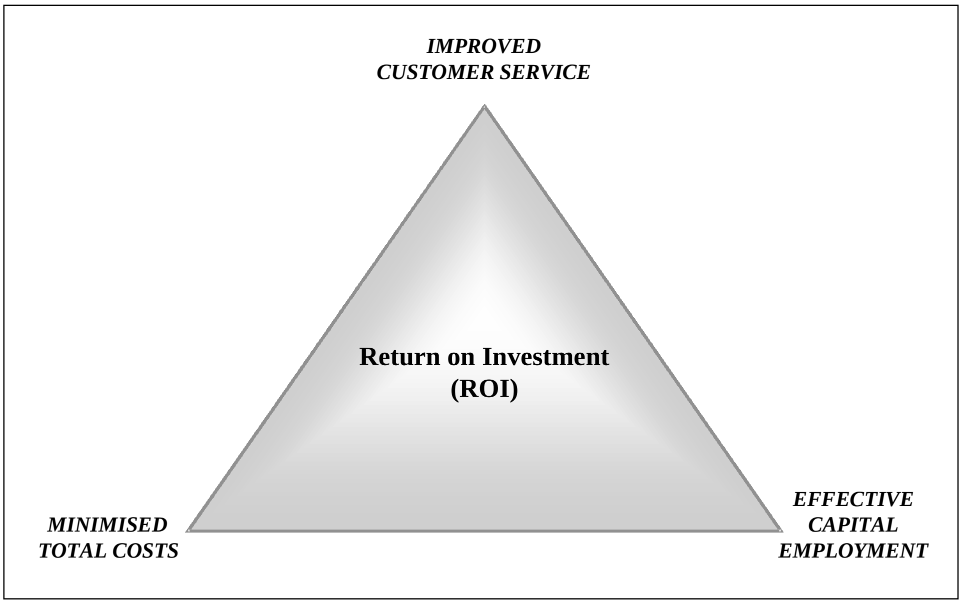


Figure 2: Supply chain dimensions and ROI (adopted from Christopher, 1998)

For example, if a supplier wanted to increase economic value for its customers (reduce customer prices), the supply chain would have to work more cost-efficiently (cut costs). One way to improve the efficiency is to make compromises with the existing service levels for customers. This would immediately decrease the relevancy value to the customers (for example, the removal of customer specific package labelling). Another way to improve efficiency would be to better utilise the benefits of economies of scale; for instance, by increasing delivery lot sizes. This would probably prolong the order fulfilment times, and thus decrease the market value for customers.

Another example would be if a supplier wants to increase customer market value; for instance, the supply chain has to meet customer requirements more effectively. In practice, it would mean shorter lead-times and better product availability for customers. However, this would be done without building extra buffers in the chain. To meet these requirements, additional costs are typically needed to make the delivery process work faster (for instance, the use of expensive express transportation). Furthermore, increasing effectiveness also creates pressures to reduce the level of differentiation (relevancy value and customer service), since product buffering is often needed downstream in the chain where customisation is not possible anymore without expensive investments.

In a third alternative, a supplier wants to increase the relevance value to its customers, and thus improve the level of customer service. These improvements in customising logistics solutions for individual customers are normally not possible without raising total supply chain costs. Moreover, when the level of customisation is increased, the capital tied up in the supply chain also gradually increases.

In other words, there is not one best solution to increase customer value via supply chains; rather, it is always a trade-off between improved customer service, effective capital employment and minimised total costs. These three ends of successful supply chains are separately discussed in the next sections.

2.1.2. Improved customer service

The concept of customer service has traditionally been considered to be an integral link between logistics and marketing management. According to many sources in the literature, customer service represents the 'Place' dimension in the well-known "Four P's Marketing Mix"– **P**roduct, **P**rice, **P**romotion and **P**lace (e.g., Christopher, 1998). Christopher (1998) continues that in recent years there are signs of increased potential for seeing logistics customer service as a means of product and service differentiation. According to Ross (1998), customer service was earlier associated mainly with the old cliché of logistics to "get the right product to the right place at the right time at the right price". Although the old marketing utilities of time, place and price have not lost their importance, the meaning of "right" to the customer has significantly changed over the past decades. The "right" supply chain solution, nowadays, refers to a service that really makes a difference for customers allowing them to run their business more efficiently. Instead of building supply channels to achieve volume and throughput (from the perspective of a supplier), responsiveness to the customer, no matter what the cost, has become the fundamental principle in channel design (Ross, 1998).

According to Novack et al. (1994), the term customer service is associated with so many kinds of services offered to customers that it would be better to use the term logistics service to describe the outputs of logistics related processes. There are many ways in the literature to identify and classify logistics or customer service elements. One of the studies most referred to, conducted in the mid-1970s by LaLonde and Zinszer (1976), suggests that customer service should be understood as being composed of pre-transaction, transaction and post-transaction elements. The pre-transaction elements form the basis for good customer service. They relate to supplier policies or programmes, like written statements on service policy, organisational structure, system flexibility and technical services. The transaction elements are those customer service variables directly involved in performing the physical distribution function. These include lead-time, availability, order convenience, and product and delivery reliability. The post-transactional elements of customer service are generally supportive of the product while in use; including product warranty, installation, parts and repair service, procedures for customer complaints and product replacement. According to the study, the most important elements for customers were product availability (order completeness, order accuracy and stocking levels) and order cycle time (order transit time, and time for assembly and shipping) in those days (LaLonde and Zinszer, 1976).

Another more recent study in the early 1990s by Parasuraman et al. (1991) distinguished the service elements by customer expectations. The study reveals that customers expect more and more customised and personalised solutions. The more they pay, the better the service they should get. The study indicates how the logistics service is not limited, at all, to straightforward actions; rather, it is a long-term process with highly personal relationships with the supplier. Many customers wanted ongoing, personalised relationships with the same representatives. The study suggests that five overall customer service dimensions that customers expect can be identified: reliability, tangibles, responsiveness, assurance and empathy, which by Parasuraman et al. (1991) define as follows:

1. ***Reliability*** is largely concerned with service outcome; the ability to perform the promised service dependably and accurately. The other dimensions are more concerned with the service process. Reliability of service permits suppliers to lock in their customers, who will gladly pay premium prices for perceived quality. The study revealed that reliability of service comes in first regardless how its salience is measured or which specific service is analysed.

2. ***Tangibles*** refer to the appearance of physical facilities, equipment, personnel and communication material. Tangibles are designed to give customers a sense of confidence and assurance that the logistics services they are receiving are truly world class. The term also refers to the appearance a firm’s service value capabilities project to the customer. In other words, this is about giving the professional image of a supplier.

3. ***Responsiveness*** deals with the willingness to help customers and to provide prompt service. It includes the supplier's ability to respond to the needs of the customer quickly and concisely letting customers know that their time and costs are important. A helpful attitude and timely service will always leave the customer with the sense of dealing with a winner.

4. ***Assurance*** is about the knowledge and courtesy of employees and their ability to convey trust and confidence. When customers purchase goods or services, they need to feel assured that the supplier possesses the required competence, skills and knowledge to assist them when some product issues arise. Security and the overall courtesy of people in a supplier's organisation, in all possible ways, are also essential parts of creating assurance.

5. ***Empathy***, the last dimension, refers to more human aspects, like caring, individualised attention provided to the customer. It is about understanding the customer situation and its varying needs. It also deals very much with communicating politely and effectively in different situations.

The findings from the study also suggested that customer service expectations have two levels: desired and adequate. The desired service level is the service the customer hopes to receive. The adequate service level is that which the customer finds acceptable. Service level expectations are, thus, somewhere between the adequate and desired levels. This zone of tolerance, as it is called, tends to vary from customer to customer. This is also why customised logistics services are needed for customer value creation (Parasuraman et al., 1991).

Only during the past decade has the great importance of a logistics service for companies as a tool of revenue and profit generation really been understood (e.g., Novack et al. 1994; Mentzer et al. 2001). There is anecdotal evidence from firms such as Dell Computer Corporation, Hewlett-Packard, Cisco Systems and Nokia Mobile Phones that logistics services can provide a powerful possibility to gain market share. Thus, supply chain management is not understood anymore as only a cost cutting activity, rather, it is a good way to increase customer value through differentiated products and services solutions for customers. According to Mentzer et al. (2001), logistics service capabilities can be leveraged to create customer and supplier value through service performance, increase market share, enable mass customisation, create effective customer response-based systems, positively affect customer satisfaction, provide differentiating competitive advantage and segment customers. Mentzer et al. (2001) also suggest that logistics services, as a powerful source of customisation, can efficiently be implemented per customer segment.

2.1.3. Effective capital employment

During the last few decades the importance of shareholder value as a performance measure for a corporation has substantially increased. According to Christopher and Ryals (1999), the supply chain strategy has a central position in shareholder value creation. The more money investors put in a company, the faster they expect to profit from the investment. Briefly defined, shareholder value indicates the net present value of future cash flow; that is, expected profit after tax minus the cost of capital employed in the future. It is therefore sensible that top management is often being driven by the goal of enhancing shareholder value; thus, monitoring closely both the 'profit and loss statement' and the 'balance sheet'. Many companies have come to realise the (negative) effect that lengthy pipelines and highly capital-intensive logistics facilities can have on shareholder value (Christopher, 1998).

It is a well-known fact that effective logistics, or supply chain management, has a major influence on a company's balance sheet in several ways. Christopher (1998) has discovered a set of logistics variables that influence different items in a balance sheet. The way the variables impact on assets and liabilities are listed below:

- ***Cash and receivables***, as components of current assets, are crucial to the liquidity of the business. Short *order cycle times*, from when the customer places an order to when goods are delivered, also enable fast issuing of invoices, which then contributes to early payments from the customer. Likewise, a high *completion rate* enables fast payments. The *accuracy of invoicing* process, which clearly is one of the logistics processes, also influences whether the customer pays the bill on time or not.

- ***Inventories*** belongs to a company's current assets including raw materials, subassembly or bought-in components, through work-in-progress to finished goods. According to Christopher (1998), fifty percent or more of a company's current assets will often be tied up in inventory. Company policies about *inventory and service levels* clearly influence the size of total inventories.

- ***Properties, plant and equipment*** represent the fixed assets items in the balance sheet, influenced by the *distribution facilities and transportation equipment* of the supply chain. The plant, depots and warehouses form a substantial part of the total capacity employed, if the company owns them. Material handling equipment, vehicles and other equipment involved in storage and transport can also add to the total sum of fixed assets.

- ***Current liabilities*** of the business are short-term debts, which must be paid in cash within a specified period of time. A company's *purchasing policies* have a big impact on the elements of accounts payable for bought-in materials, components and other kinds of raw materials. This is the area where greater integration of purchasing with operations management can yield dividends. For instance, economies of scale have traditionally been considered to be a key driver for purchasing decisions, which often leads to excessive levels of raw-material inventories. If premature commitment of materials can be minimised, this should lead to an improved position for current liabilities.

- ***Debts and equity*** are balance sheet items that represent the way fixed and current assets are financed. These liability decisions can substantially be influenced by the *financing options for inventory, plant and equipment*. The ratio of debt to equity, referred to as 'gearing' or 'leverage' in the literature, influences the return on equity and has implications for cash flow in terms of interest payments and debt repayment. The trend seems to be that more companies are leasing plant facilities and equipment and thus converting a fixed asset into a continuing expense.

The way these logistics have a variable impact on a balance sheet is also illustrated in Figure 3.

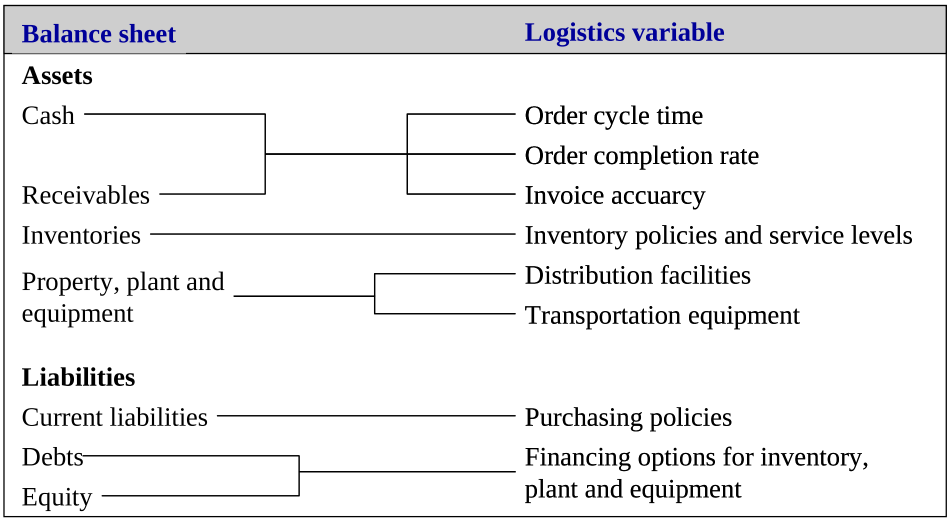


Figure 3: Logistics management and balance sheet (Christopher, 1998)

In many companies top management often monitors inventory development because it typically includes an easy potential to improve ROI and inventories also include a significant amount of obsolescence risk that directly affects the bottom line. Ross (1998) states that the management and strategic deployment of supply chain inventories is one of the essential pillars of channel competition strategy. It is therefore often justified to concentrate on the inventories.

According to Ballou (1992), there are three general classes of costs that are important in determining inventory policy: (1) procurement costs, (2) inventory carrying costs and (3) out-of-stock costs. These costs are more or less in conflict, or trade-off, with each other. Actually, this classification is an analogue to the three dimensions of a supply chain that were discussed earlier. *Procurement costs*, which are associated with the acquisition of goods for the replenishment of inventories, are strongly linked to the efficiency of a supply chain. By minimising the procurement costs, the efficiency of a supply chain is also improved. *Inventory carrying costs* are closely linked to the effectiveness of a supply chain. The more effectively a supply chain works, the less capital is tied up in inventories and the less the carrying costs. *Out-of-stock costs* are incurred when an order is placed but cannot be filled from the inventory to which the order is normally assigned. These kinds of costs, which are composed of either lost sales or delays in fulfilling the order, are closely connected to customer service aspects. Inventory management involves balancing product availability and costs. The business environment greatly determines what kind of inventory strategy to apply (Ballou, 1992).

Inventory carrying costs result from storing, or holding, goods for a period of time. The costs are roughly proportional to the average quantity of goods on hand. As a rule of thump, having inventories on hand can on average cost between 20 and 40 percent of their value per year (e.g., Ballou, 1992). These costs can be divided into four classes as follows:

1. *Storage space costs* represent the rental or space-related operating costs of the storage building. When space is rented from a logistics service provider, which often is the case nowadays, storage rates are typically charged for by volume or weight for a period of time, representing operating costs in the ‘profit and loss’ statement.

2. *Capital costs* refer to the cost of the money tied up in inventory in the supply chain. According to a study by Landeros and Lyth (1989), these costs may represent over 80 percent of total inventory costs, still being the most intangible and subjective of all the carrying cost elements. The cost of capital may vary from the prime rate of interest to the opportunity cost of capital.

3. *Inventory service costs* include insurance and taxes, which often are proportional to the amount of inventory. Insurance coverage is needed as protection against losses from theft, fire, storm or other kinds of environmental catastrophe. Based on the assessments of prevailing inventory levels, local authorities levy taxes that typically represent only a small portion of total carrying costs.

4. *Inventory risk costs* are associated with deterioration, damage, shrinkage (theft) and obsolescence risks. There are certain groups of products that are more vulnerable to these risk costs than others. For instance, products like groceries and agricultural products can be easily spoiled or contaminated in a short period of time. Another group of products, which has to tackle these problem on a larger scale, is hi-tech equipment like mobile phones or laptops. These items are especially vulnerable to pilferage and obsolescence as product life cycles are relatively short.

As one can easily conclude from the discussion above, the holding of inventory is only costly and risky because of the capital investment and the potential for obsolescence. However, this is not the whole truth Although holding inventories has major cost elements associated with it, inventory commitments are often needed to guarantee product availability and lead-time requirements from customers. Thus, this is a very important aspect of customer service. Moreover, inventories can indirectly also reduce operating costs in other activities and may more than offset the carrying costs.

According to Bowersox and Closs (1996), there are four prime functions for having inventories in the supply chain. These are geographic specialisation, decoupling, balancing demand and supply and buffering uncertainties with safety stock.

- *Geographic specialisation* deals with processes for creating market assortments economically by collecting and combining components, which are manufactured in various locations, at a single warehouse for final-product shipments. The economies gained through geographic specialisation are expected to more than offset increased inventory and transportation costs.

- A second function of inventories, *decoupling,* provides maximum operating efficiency within a single process (for instance, a manufacturing facility) in the chain. Decoupling can also act as a "buffer" between sequential processes, and thus decrease the number of uncertainty factors in the whole chain.

- *Balancing supply and demand*, as a third function of inventories, is concerned with time requirements between consumption and manufacturing. It very much deals with managing the lead-time gap. The concept of the lead-time gap, according to Christopher (1998), is defined as the time between the logistics lead-time (the time taken to complete the process from goods inwards to deliver product) and the customer's order cycle (the period they are prepared to wait for delivery). Inventories thus might be needed to provide a short enough lead-time for customers.

- The fourth function of inventories is to *buffer uncertainties* by having a safety (or buffer) stock in place. This safety stock requirement results from uncertainty concerning future sales and inventory replenishment. The stock can protect against two types of uncertainty: the first type is concerned with excess demand compared to forecasts and the second one is to protect against delays in the process during the performance cycle.

One of the most used performance indicator to analyse the effectiveness of a supply chain is the inventory rotation that, in practical terms, indicates how fast material is moving further in the supply chain.

2.1.4. Minimised total costs

The concept of total costs has its roots back in the mid-1960s when Le Kashman and Stolle (1965) introduced a new cost approach to distribution and illustrated how costs incurred in one part of the supply chain can be compensated for, and even exceed, by savings elsewhere in the chain. For many industries it was only after many years that the importance of logistics management (the combination of physical distribution and materials management) was really understood as a cross-functional activity inside companies and as was as the need for related logistic costing techniques. The total cost concept, according to Ross (1998), assumes that the operating costs of each of the logistics functions were inversely proportional and that management should strive to minimise the total costs of the logistics chain, rather than focusing on reducing the costs of one or two specific logistics functions. Simply reducing costs in only one area of the supply chain may lead to an increased total cost for the chain. This is the opposite approach to conventional accounting, which allocates costs to a few volume drivers, often based on functional organisation dimensions.

The basic idea behind the total cost concept may be simply explained by using a practical example of such a trade-off situation. For instance, when a transportation service is being selected, the direct costs of transportation and the indirect costs effect on inventory levels in the supply chain are in cost conflict with each other. Economically, the best solution occurs at the point where the sum of both cost elements is at its lowest. This is a very simplified example, as it covers only two variables; i.e., transportation cost and inventory carrying costs, but in real life the number of variables is often much larger. However, the objective clearly is to manage this kind of conflict by balancing the activities so that they are collectively optimised.

In the literature, there are various attempts to create a comprehensive approach to the total cost concept. One of these attempts in the early 1990s was developed by Cavinato (1992), who argued that traditional total cost systems are not sufficient and total product costs are not visible or easily usable by managers on a daily basis. Therefore, he introduced a supply chain total cost/value hierarchy model as a management tool that presents a total cost view from materials to the ultimate customer. The model provides a hierarchy of costs and other factors that build upward from raw materials through manufacturing, distribution, to final marketing and selection and use by the ultimate customer. It is composed of twenty basic cost and value elements that combine into ten key strategic and management areas (Cavinato, 1992).

This hierarchy model is presented in Figure 4.

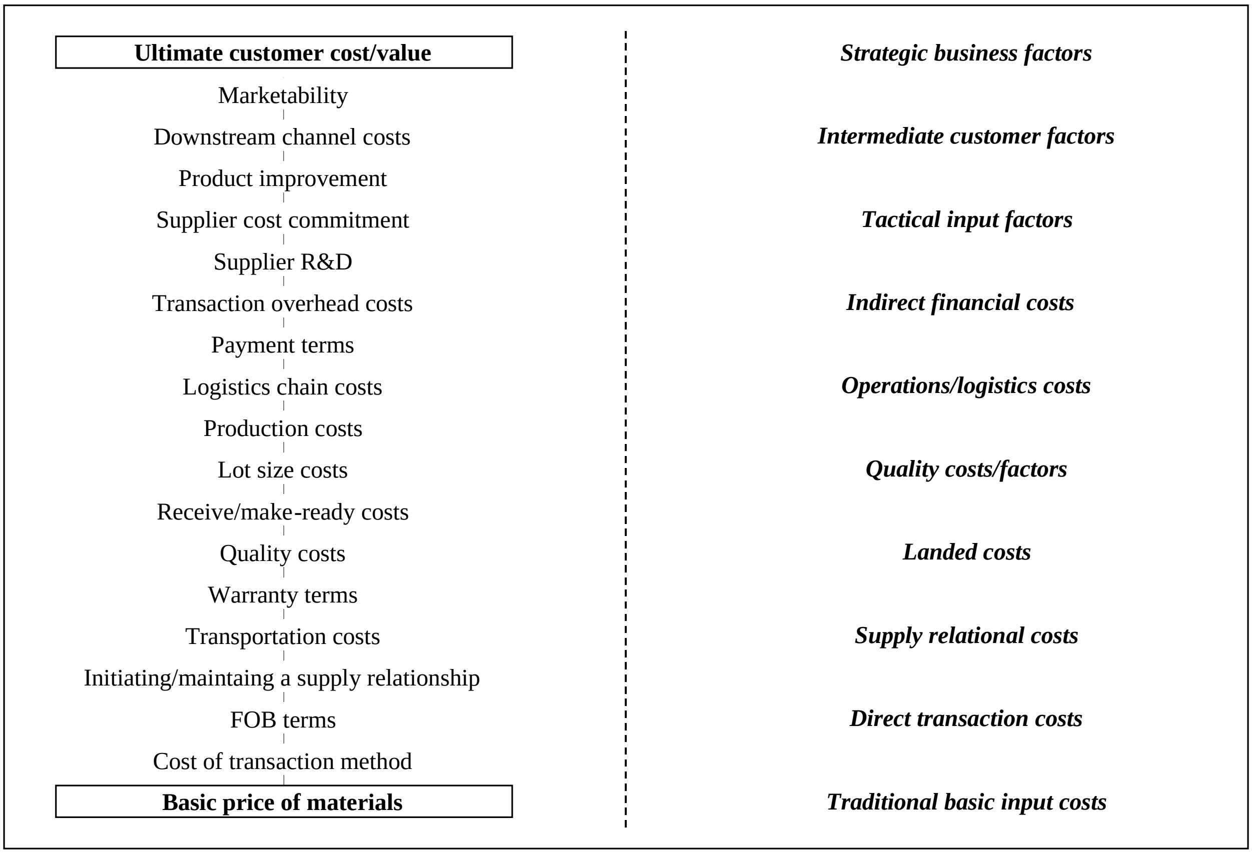


Figure 4: Total cost/value hierarchy model (Cavinato, 1992)

Cavinato (1992) defines the cost factors as follows:

1. *Traditional basic input costs* form the primary price of products or materials paid to the supplier.

2. *Direct transaction costs* are the costs of detecting, transmitting the need for and processing the material flow in order to acquire the goods. It includes the inventory need detection, requisitioning, preparation and transmittal of the order documentation to the supplier, the acknowledgement, shipping document handling and receiving information input for the inventory.

3. *Supply relational costs* are composed of creating and maintaining a relationship with a supplier. They include many kinds of cost elements from supplier education and travelling to establishing and developing closer co-operation (for instance, in process collaboration, engineering, research or product development).

4. *Landed costs* include the inbound transportation related cost elements. These are the actual transportation costs and delivery terms depending on additional payments.

5. *Quality costs/factors* have an impact on production and sales costs. Furthermore, it influences downstream reverse distribution, customer service and goodwill costs.

6. *Operational/logistics costs* include four key areas: receive/make-ready, lot size, production and logistics chain costs.

    a. Receive and make-ready costs are those flow activities between the inbound transportation delivery and availability for use by production or other processes. This includes unpacking, inspection, counting, sorting, grading, removal/disposal of packaging materials and movement to the use point.

    b. Lot size costs directly affect space requirements, handling flow, unit price and related cash flow. These are a major cost of inventories.

    c. Suppliers of even seemingly similar goods can impact production costs.

    d. Logistics chain costs are also important in both upstream and downstream settings. These are cost factors that are affected by product size, weight, cube and shape plus their resulting costs in transportation, handling, storage and damage.

7. *Indirect financial costs* are linked to the payment terms of the supplier. Rapid payment reduces cash holding and the availability of cash for overnight and other short-term investment or debt reduction.

8. *Tactical input factors* are often less tangible than the previous costs elements, but they are nonetheless important in attaining overall lower costs and higher value in the final product.

9. *Intermediate customer factors* are downstream channel costs pertaining to channel margins, handling costs, ease of sale and contribution margins of subsequent customers between the firm and the final customer. Customer service and the quality of information, transportation and inventory links are included in this factor.

10. *Strategic business factors* are as follows: the cost and value factors that cause the ultimate customer and/or user to select the product from the final seller in the firm's supply chain rather than another. They are the critical success factors that are embedded within the physical product, its price or related services whether they are actual or perceived.

The concept of total cost management has inspired the development of a number of different logistics costing techniques. Perhaps, the most known are the direct product profitability (DPP) and activity based costing (ABC) methods where overhead costs are allocated in proportion to individual activities and their consumption of resources in a company. There are two main ways, according to Fernie (2001), that logistics costing techniques are used: to feed into a firm's corporate strategy as a tool to measure performance (especially its channel strategy) and to measure the impact of changes in activities at one point in the chain or other activities of the chain.

2.1.5. Summary

Based on the literature review, it can be concluded that the ends of successful supply chain are composed of three different dimensions: 1) customer service, 2) capital employment and 3) total costs. Successful supply chains provide customers with more value via improved customer service (relevancy value), effective capital employment (market value) and minimised total costs (economic value). It is essential to understand that there is not one best solution, but it is a trade-off between these dimensions. The aggregate performance of supply chains is always a combination of these three dimensions.

2.2. The means of supply chain differentiation

2.2.1. Preface

It is nowadays a well-known fact that companies can utilise supply chain management as a tool to customise their service offerings to individual customers. It was already since the early 1980s that logistics were considered a powerful means for product differentiation (see Levitt, 1980). Fuller et al. (1993) demonstrated in a number of company-examples how new customer value can be created through tailored logistics systems. According to Holmström et al. (1999) there are two key points in the demand-supply chain that effectively enable tailoring of supply solutions. These are the order penetration point (OPP) in the supplier's supply chain and the value offering point (VOP) in the customer's demand chain. Selecting the most appropriate supply chain for an individual customer requires the right positioning of these two points in the system. Before explaining these concept in detail, this chapter first describes the basic theories and models that are related to the differentiation of supply chains.

Systems thinking and supply chains

It is well known that supply chains are characterised by systems behaviour. Since the late 1950s it has been recognised that the systems used internally within supply chains can lead to oscillations in demand in inventory as orders pass through the system (Wilding, 1998). Forrester (1958) already studied this phenomenon at the end of the 1950s. The phenomenon, named the Forrester effect, is thoroughly described is his book Industrial Dynamics (1961). He explained how industrial dynamics - which was defined as the time-varying, dynamic behaviour of industrial organisations - can be managed by using the principles of systems theory. By using illustrative examples from a production-distribution system, Forrester showed how a minor change in system input led to the oscillating behaviour of the whole system (in this example in the supply chain system). According to this theory, any demand-supply chain is inherently a feedback system, where each node of the chain (production unit or buffer) represents a potential oscillator. Any delay or information distortion may cause the amplification of small demand fluctuations and potential instabilities (Ranta, 1999).

More recently this same phenomenon and its negative effects on supply chains have been analysed more thoroughly by Lee et al. (1997). According to Lee et al. (1997), distorted information from one end of a supply chain to the other can lead to tremendous inefficiencies: excessive inventory investment, poor customer service, lost revenues, misguided capacity plans, ineffective transportation and missed production schedules. It is therefore suggested that the focus should be put on finding a proper way to control these effects. The way to counteract the Forrester effects, or bullwhip effect as Lee and his associates call it, is to focus on the following initiatives: (1) information sharing, (2) channel alignment and (3) operational efficiency. With information sharing, demand information at a downstream site is transmitted upstream in a timely fashion. Channel alignment is the co-ordination of pricing, transportation, inventory planning and ownership between the upstream and downstream sites in a supply chain. Operational efficiency refers to activities that improve performance, such as reduced costs and lead-time.

The relationship between the customer service level and the total costs of a supply chain, as discussed earlier, tends to behave like a steeply rising curve. This mainly results from the high costs of carrying the safety stocks needed to guarantee the service level when unexpected, high peaks occur in demand. It is therefore, according to Wilding (1998), possible that the control systems developed for managing supply chains exhibit chaotic behaviour. Chaos is defined as a periodic, bounded dynamics in a deterministic system with sensitivity dependence on initial conditions, and structure in the phase space (Wilding, 1998). Wilding continues that there are five characteristics of chaotic systems that have implications for supply chain management: chaos exhibits sensitivity to initial conditions, chaos has islands of stability, chaos generates patterns, chaos invalidates the reductionism view and chaos undermines computer accuracy. Each of these are described and demonstrated in supply chains by Wilding (1998):

- ***Chaos exhibits sensitivity to initial conditions:*** The known, basic principle of chaos theory states that a tiny change in the input conditions of a system may result in an enormous change in system output, whereas a substantial change in input may be absorbed without significant effect to the system's output. This sensitivity to initial conditions may, thus, result in dramatic and unexpected changes in system output, which result in cause and effect relationships between current data and previous data becoming increasingly blurred and eventually lost.

- ***Chaos has islands of stability***: A system may be operating in a stable manner, but when a parameter is changed periodic or chaotic behaviour may be witnessed. Systems have been observed that produce a periodic behaviour for a long period of time and then spontaneously lock onto a stable periodic solution. It is, therefore, possible for islands of stability to be present in between areas of chaotic behaviour. This characteristic has been harnessed for some chaotic systems by changing a parameter so that the chaotic system can be controlled to produce more regular behaviour.

- ***Chaos generates patterns:*** Chaos generates endless individual variety, which is recognisably similar. As systems evolve over time, recognisable patterns are generated. This property enables analysts to make some predictions about the system.

- ***Chaos invalidates the reductionist view:*** The reductionist view argues that a complex system or problem can be reduced into simple forms for the purpose of analysis. In chaotic systems this view becomes invalid, since a small change somewhere in a system can unpredictably lead to enormous changes somewhere else in the system.

- ***Chaos undermines computer accuracy:*** An identical program runs on two different makes of computer, or different standard software packages doing the same calculations can produce significantly different result.

The practical implications of this study suggest that deterministic chaos is generated within supply chains and that the only way to remove chaos is by focusing on the customer, communicating demand information as far upstream as possible, and using simple lean approaches. The earlier findings from Lee et al. (1997) also support these results.

The design of supply chains

Although there is a systems theory that can be applied to explaining the behaviour of supply chains generally, and there are studies to suggest how one can minimise the effects of system dynamics, it is still not enough for companies to make far-reaching business decisions on the structure of their supply chains. A big strategic question for many companies is how the supply chain should be built in practice to be competitive in the markets. In other words, what should the architecture of supply chains look like?

Fisher (1997) deals with this problem in his study on selecting the right supply chain from a product point of view. He presents a normative model of how the supply chain should be built for different types of products. First, products are divided into two general categories: functional and innovative products. Functional products are characterised by predictable demand patterns, relatively long product life cycles, low margins and low product variety. Innovative products, on the other hand, are characterised by unpredictable demand, short product life cycle, relative high margins and big product variety. In Fisher's model the second conclusion is to divide supply chains into physically effective and market-responsive ones. The attributes of both supply chains are described in Table 1.

Table 1: Physically efficient versus market-responsive supply chains (Fisher, 1997)

	Efficient supply chain	**Responsive supply chain**
Primary purpose	Supply predictable demand efficiently for the lowest possible cost	Respond quickly to unpredictable demand in order to minimise stock-outs, forced markdowns and obsolete inventory
Manufacturing focus	Maintain high average utilisation rate	Deploy excess buffer capacity
Inventory strategy	Generate high turnovers and minimise inventory throughout the chain	Deploy significant buffer stocks of parts or finished goods
Lead-time focus	Shorten lead-time as long as it does not increase cost	Invest aggressively in ways to reduce lead-time
Approach to choosing suppliers	Select primarily for cost and quality	Select primarily for speed, flexibility and quality
Product-design strategy	Maximise performance and minimise costs	Use modular design in order to postpone product differentiation for as long as possible

Fisher (1997) basically suggests that supply chains should be efficient for functional products, whereas they should be built to be responsive for innovative products. A physically efficient process supplies predictable demand efficiently at the lowest possible cost, whereas a market responsive process responds quickly to unpredictable demand in order to minimise stock-out, forced markdowns and obsolete inventory (Fisher, 1997). This is also illustrated in Figure 5.

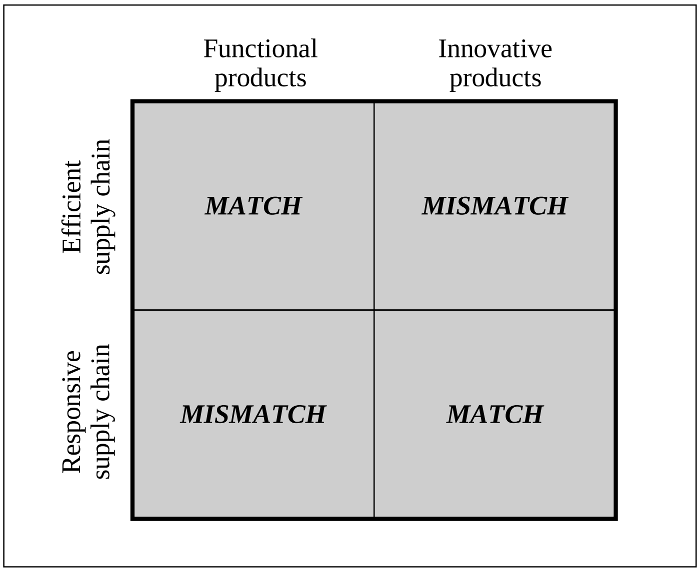


Figure 5: Matching supply chains with products (Fisher, 1998)

Fisher (1997) also states that the root cause of the problems plaguing many supply chains has been a mismatch between the type of product (functional vs. innovative) and the type of supply chain (efficient vs. responsive). This model should provide companies with a good basis for designing supply solutions for different types of products. However, if the product in question belongs to the innovative category in the model, one could still ask a question: how should responsive supply chains actually be understood if customer requirements vary - which often is the case. Should the chain be built to meet the requirements of the most demanding customer, or should there be a modular type of supply chain architecture that can be adjusted based on the needs of individual customers?

For the fast growing cellular network business, an answer to this question can found in the dissertation thesis of Heikkilä (2000), who argues that a modular demand-supply chain architecture is needed in that industry. His conclusions are listed below:

1. Understanding the customer situation and need combined with good relationship characteristics contributes to reliable and timely planning information flows in a demand chain.

2. Understanding the customer situation and need and good relationship characteristics together with the selection of the right demand chain structure contributes to co-operation

between the customer and supplier in implementing good demand chain management practises.

3. Reliable and timely information flows together with good co-operation between the customer and supplier increase the demand chain efficiency.

4. Co-operation between customer and supplier increase customer satisfaction.

According to Heikkilä (2002), the selection of the right demand-supply chain is thus heavily dependent on the customer situation. This statement is very much in line with the proposition of this thesis, based on the contingency theory of organisations by Paul Lawrence and Jay Lorsch (1967). The theory used as the proposition says that there is not one best way to get organised; rather, situational factors should define the best way. The focus is on the fit between an organisation and its environment. The contingency theory of organisation suggests the major relationships that managers should think about as they design and plan organisations to deal with specific environmental conditions. It indicates that managers can no longer be concerned about the one and only best way to organise. Rather, the contingency theory provides a conceptual framework with which to design organisations according to the tasks they are trying to perform in particular business environments. The most effective way to organise is contingent upon the conditions of complexity and change in the existing environment (Hatch, 1997).

The way the contingency theory of organisation is applied in this thesis follows the logic that as customer situational factors and needs may be very different there is not one supply chain mode that best serves all customers. The chain must be designed per customer to meet the specific needs of its business environment. This, logically, leads to the question of how to built a supply chain architecture that can be easily altered to meet the requirements of individual customers?

2.2.2. Order penetration point

Sharman (1984) argues that although the possible combinations of ways to manage the flow of materials are virtually infinite, there is always one key variable in every logistics system where a product becomes earmarked for a particular customer. This point in the supply chain is called the order penetration point (OPP). The control mechanism of the logistics process is decoupled at this point. Downstream of the order penetration point, customer orders drive the systems that control material flow; upstream, forecasts and plans do this driving. In most cases, the OPP is where product specifications get frozen. More importantly, it is also the last point at which inventory is held (Sharman, 1984).

The location of intermediate buffers, and thus order penetration points, may vary from industry to industry. For example, Figure 6 illustrates a range of possible order penetration points in different business situations.

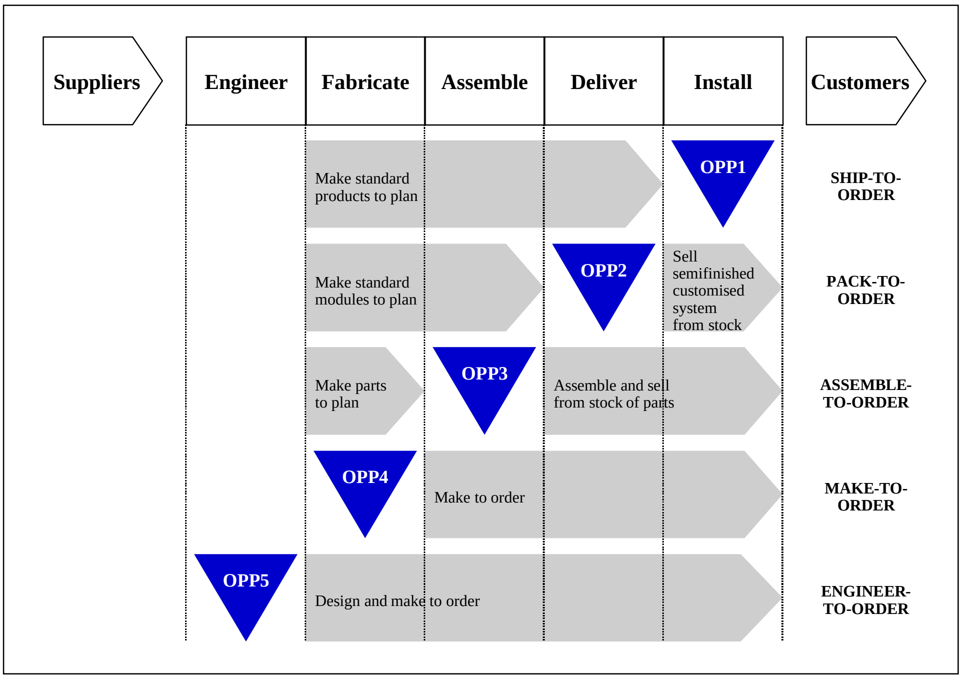


Figure 6: Order penetration points (adapted from Sharman, 1998)

More recently the concept of order penetration point has also been used to customise the supply chain for an individual customer. According to Hoover et al. (2001), the OPP is the point in the supply chain where a customer demand (an order) is allocated to the product. The goods might be allocated from a warehouse, or they might be assembled or manufactured to order. The OPP links the customer’s demand chain to the supplier’s supply chain.

Order penetration point as a term is not well established in the literature. The same concept tends to have several names (see Lehtonen, 1999). For instance, instead of OPP Christopher (1998) uses the term demand penetration point, which is defined as the point where real demand meets the plan. Upstream of this point everything is driven by a forecast and downstream by real customer demand (orders). A key concern of logistics management should be to seek to identify ways in which the demand penetration point can be pushed as far upstream as possible (Christopher, 1998). Another term, customer order decoupling point (CODP), is also used to refer to the same the concept. According to Hoekstra and Jac (1992), the decoupling point is the point in the product axis that customer orders penetrate. It is where order driven and forecast driven activities meet. As a rule, the CODP coincides with an important stock point – in control terms a main stock point – from which the customer has to be supplied. Furthermore, in the manufacturing literature the concept of the order penetration point is often referred to as Master Production Scheduling (MPS) in the production environment (e.g., Lehtonen, 1999). According to Vollmann et al. (1997), three alternative master production-scheduling approaches can be identified in manufacturing strategies. These are make-to-order (MTO), assemble-to-order (ATO) and make-to-stock (MTS). Make-to-stock includes both the pack-to-order (PTO) and ship-to-order (STO) delivery modes.

The OPP is also closely connected to other logistics related concepts, like the postponement and speculation strategies. The concept of postponement has long been discussed in the business literature, but practical examples in logistical arrangements have been published only recently (Bowersox and Closs, 1996). The concept deals with delaying the start of activities until there is a real demand; i.e., a specific customer order, for it. According to Pagh and Cooper (1998), the main logic behind postponement is that risk and uncertainty costs are tied to the differentiation (form, place and time) of goods that occurs during manufacturing and logistics operations. To the extent that parts of the manufacturing and logistics operations can be postponed until final customer commitments have been obtained, the risk and uncertainty of those operations can be reduced or completely eliminated (Pagh and Cooper, 1998). Postponement is a useful approach, especially in the markets that are characterised by turbulent demand fluctuation, short product life-cycles, large numbers of product varieties and a need for customised solutions (e.g., Van Hoek, 2001).

The concept was first time introduced in the literature by Alderson (1950) and later further developed by Buckling (1965). Initially, postponement was only applied in the logistics and distribution environment (logistics postponement), and then later it was also utilised in manufacturing (manufacturing postponement). Apart from the postponed forward shipment of goods (time postponement) and maintaining goods at a central location in the channel (place postponement) certain manufacturing activities could also be postponed (Van Hoek, 2001). Van

Hoek (2001) defines postponement as an organisational concept whereby some of the activities in the supply chain are not performed until customer orders are received.

Postponement offers a strategy to reduce the anticipatory risk of logistics. In traditional arrangements, most inventory movement and storage are performed in anticipation of future transactions. To the degree to which commitment to final manufacturing or distribution of a product can be postponed until receipt of a customer order, the risk associated with improper or wrong manufacturing or inventory deployment is automatically reduced or eliminated (Bowersox and Closs, 1996).

As already mentioned, two types of postponement can be identified as elements in formulating supply chain strategy: logistics and manufacturing (form) postponements:

1. ***Logistics postponement*** is to maintain a full-line of anticipatory inventory at only one or a few strategic locations and to postpone changes in inventory location downstream in the supply chain to the last possible point (Pagh and Cooper, 1998). According to Van Hoek (1998), logistics postponement implies the storing of finished goods at a limited number of locations in anticipation of customer orders (place postponement) and shipping product to order (time postponement). Logistics postponement focuses on time by stocking differentiated products at a central location and responding rapidly when a customer order is received (Bowersox and David, 1996). It can be divided into two dimensions: time and place postponements:

    a. *Time postponement* means that final processing of activities is postponed until the real customer order has been received.

    b. *Place postponement* refers to the positioning of inventories upstream in centralised manufacturing or distribution operations, to postpone the forward or downstream movement of goods.

2. ***Manufacturing postponement,*** also referred to as form postponement in the literature, entails delaying activities that determine the detail configuration and special functions of the product until a customer order has been received. Manufacturing postponement focuses on product form by moving non-differentiated items forward in the logistics system for modification to customer specification prior to delivery date (Bowersox and David, 1996).

According to a study by Zinn and Bowersox (1988), four types of form postponements can be identified. These are labelling, packing, assembly and manufacturing postponements.

a. *Labelling postponement* is based on the assumption that products are shipped into a warehouse unlabeled without detailed descriptions about any customer delivery. When a customer order is received, the labelling is carried out in the warehouse before it is delivered to the customer.

b. *Packaging postponement* is based on the assumption that products are shipped in bulk from the factory to a warehouse where final packing is done based on the received customer order.

c. *Assembly postponement* is based on the assumption that a base product with a number of common parts is manufactured based on anticipatory information. The final assembly takes place only after the customer order is received.

d. *Manufacturing postponement* means that final manufacturing is activated only after the customer order has been received.

The opposite of the postponement concept is the speculation concept, which holds that changes in form, and the movement of goods to forward inventories, should be made at the earliest possible time to reduce the costs of the supply chain. The speculation principle, as the opposite of postponement, holds that goods are transported through the supply chain before a customer order is received. The incentives for the seller to speculate on customer demand by moving inventory into the channel are the probability of having fewer stock-outs and the transferring of the costs associated with ownership, such as inventory carrying costs, to distributors and/or retailers (Zinn and Levy, 1988).

Pagh and Cooper (1998) presented a model for generic supply chain strategies by combining manufacturing and logistics postponement and speculation (P/S). Four different supply chain strategies: full speculation, manufacturing postponement, logistics postponement and full postponement, were identified in the model. These are described as follows:

- ***Full speculation*** represents the supply chain strategy that activates, based on forecasts, both the manufacturing and logistics processes before a real customer order is received. All manufacturing operations are performed prior to the product being differentiated by location; i.e., products are made to stock waiting for customer orders. The buffering is located close to customers, and products are delivered through a decentralised distribution system. This strategy is traditionally the most often used by companies (Pagh and Cooper, 1998).

- ***Manufacturing postponement*** includes some manufacturing operations, for instance assembly, packaging and/or labelling, which are performed at some point downstream in the supply chain only after the real customer order has been obtained. This approach, partly, enables final customisation locally downstream in the chain.

- ***Logistics postponement*** represents the supply chain strategy where manufacturing is based on speculation, and logistics is based on postponement. Manufacturing makes fully finalised products for a centrally located and managed warehouse where they are distributed directly to customers. In this approach the logistics operations, thus, are purely customer order initiated.

- ***Full postponement*** is the supply chain strategy where both manufacturing and logistics operations are postponed until a customer order has been received. From many perspectives this approach is the least risky strategy. However, on the other hand this option often does not provide a short lead-time.

Instead of taking a piecemeal approach, companies must rethink and integrate the designs of their products, the processes used to make and deliver those products and the configuration of the entire supply network. By adopting such a comprehensive approach, companies can operate at maximum efficiency and quickly meet customers' orders with a minimum amount of inventory (Feitzinger and Lee, 1997).

It is quite surprising to note that in the literature there is no explicit explanation of how the order penetration point is linked to the principle of postponement-speculation. Towill and Mason-Jones (1999) slightly touch this relation, but they either do not linked these explicitly together. This is a quite peculiar note, because these two concepts model somewhat similar phenomenon and they both have been extensively used in the literature. Sharman (1984) did define OPP rather loosely as the point at which the product becomes earmarked for a specific customer. However, what does the point mean in practise from the P/S model perspective? Does the point refer to form, time or place? In other words, does it cover manufacturing or logistics postponement, or both?

In the literature, order penetration points are often referred to as different delivery modes, like make-to-order (MTO), assemble-to-order (ATO) and make-to-stock (MTS). Furthermore, the MTS mode can be divided into pack-to-order (PTO) and ship-to-order (STO) delivery modes. If this approach was applied, the OPP would explicitly refer only to manufacturing postponement. However, this cannot be the whole truth, since the location of material buffering, lead times and distribution costs are almost always linked to discussions of OPP (e.g., Van Hoek, 1998; Wouters et al., 1999; Holström et al., 1999; Sharman, 1984). In these circumstances, this work maintains that the applied manufacturing (form) and logistics (time and place) postponement strategies basically determine the location of the OPP, which is a combination of these two axes. The further upstream the location of the OPP in the supply chain, the more the manufacturing and logistics activities are postponed. The aim, naturally, should be to strive for an OPP as far upstream as possible. In other words, from cost management perspective the aim is to postpone manufacturing and logistics as much as possible. This linking of the OPP and postponement concepts is also illustrated in Figure 7.

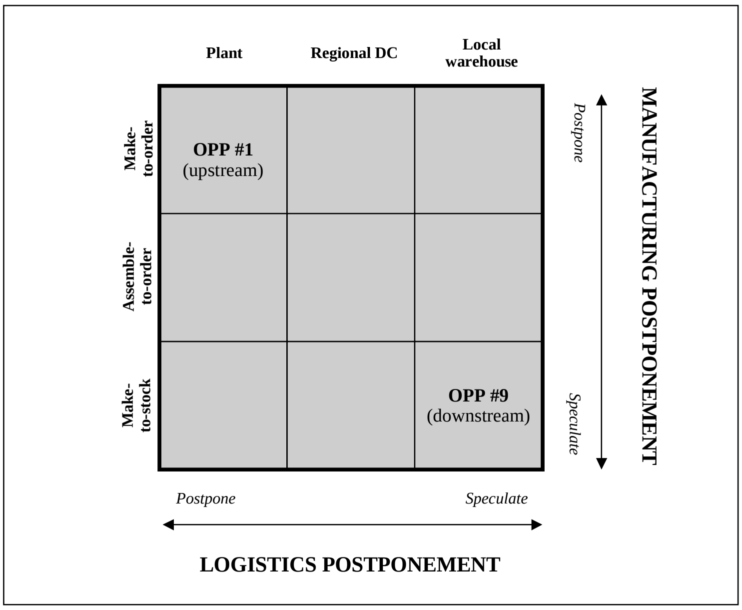


Figure 7: Linking OPP and postponement concepts

For instance, in the STO mode products can be delivered to a customer from the plant warehouse or from the local warehouse. Although this is the same make-to-stock manufacturing strategy, it makes a big difference to supply chain management whether the buffer is located inside the plant or whether it is distributed into dozens of local warehouses. Another example could be to have a local warehouse, where products, instead of finished-goods, are stored as modules and kits, and where the final product is assembled based on a received customer order. The location of the OPP in this situation is much further upstream compared to the situation where buffers, in the same physical location, would consist of finished goods. In other words, both the manufacturing and logistics postponement levels have a big influence on the position of the order penetration point.

2.2.3. Value offering point

Most profitable strategies are built on differentiation: offering customers something they value that competitors do not have (MacMillan and McGrath, 1996). A supplier can basically differentiate itself at every point where it comes in contact with its customers. As a customer value typically does not increase linearly but in discontinuous steps, it is essential to find those points where the increase is significant for the customer. For the demand-supply chain, this point is also called a value threshold. According to Hoover et al. (2001), a value threshold is a supplier value offering that produces a quantum improvement in the operations and performance of the customer.

Each customer demand chain includes a point where a supplier fulfils the demand. According to Holmström et al. (1999), this point is called a value offering point (VOP), which besides the value threshold is a key customer value related concept in the demand-supply chain. A supplier should aim at positioning the VOP in the customer’s demand chain at the value threshold. The VOP, along with the OPP, is actually the second point that links the demand and supply chains together. According to Hoover et al. (2001), the VOP changes a customer’s economics. In practice, moving the VOP downstream largely benefits the customer and requires the supplier to do more work.

Three alternative value offering points for a supplier to the demand chain of a distributor or retail chain are illustrated in Figure 8 as an example.

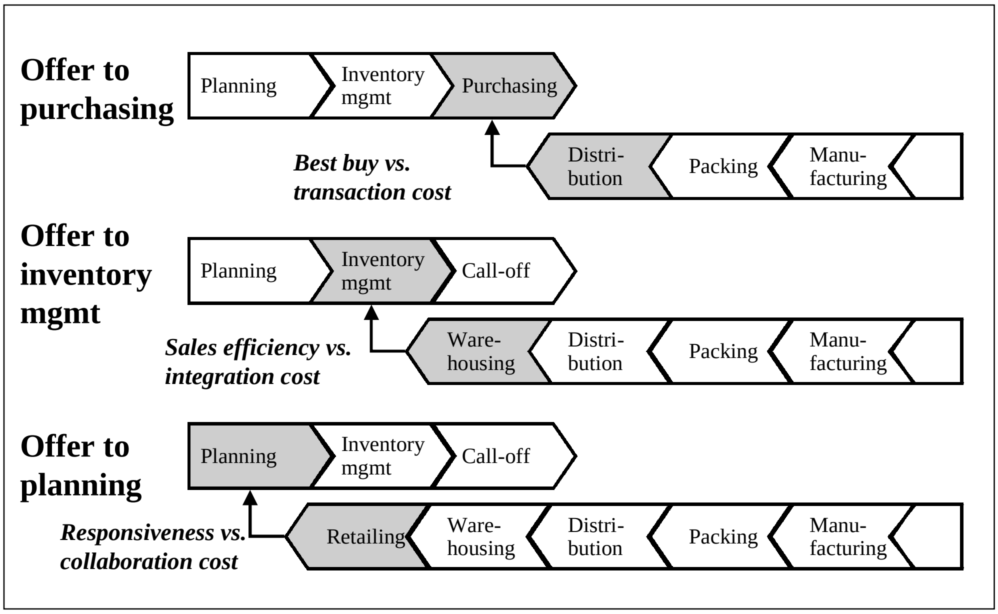


Figure 8: Moving the value offering point changes the customer's economics (Hoover et al., 2001)

In a typical buyer seller relationship, the VOP of the supplier is in the customer's purchasing function. The buyer in the customer organisation decides which supplier to use to fulfil the need. The trade-off for the customer, basically, is between best buy versus transaction cost. When a supplier's value offering is moved further downstream in the chain to offer a vendor managed inventory solution, the customer does not need to bother whether there are enough products in stock or when to place replenishment orders. However, the other aspect is a higher level of process integration costs with the supplier. When customer-supplier relationships are really working and the customer is committed to only one or a few key suppliers, a supplier's value offering point can be moved downstream as planning for the customer. The responsiveness that is achieved increases collaboration costs.

Hoover et al. (2001) present a systematic approach in re-engineering demand-supply chains to achieve improved customer value. It starts with identifying the customer's demand chain, which practically transfers demand from markets to suppliers. For instance, prospecting, specifying the product and making a purchase is a simple demand chain for a customer. The supply chain, in turn, creates products and services that are transferred from suppliers to customers to meet this demand. According to Hoover et al. (2001), reconfiguring the demand-supply chain should follow a 5-step implementation model where the VOP and OPP play a central role. This model consists of following steps:

1. Identify the customer's demand chains
2. Define the potential linkage points for the supplier to the customer demand chains (potential VOPs)
3. Identify your extended supply chains
4. Define the potential linkage points for the customer to the supply chains (potential OPPs)
5. Try out the possible configurations and evaluate the cost and benefit for yourself and the customer

Thus, the ultimate target in the value re-engineering approach is to find such a combination of OPP and VOP that best serve the purpose. The objective is to change the customer-supplier relationship so that value is increased and waste reduced at the same time. The procedure to change the value added and the business rules in a customer-supplier relationship is to move both the order penetration and value offering point in looking for win-win solutions for a customer specific demand-supply chain (Hoover et al., 2001).

2.2.4. Summary

Based on the literature review, this work concludes that two central means of differentiating supply chains for individual customers can be used. The first means is the order penetration point, which can be considered to be a combination of manufacturing and logistics postponement strategies. The second means is the value offering point that connects a customer's demand chain to the supply chain. By using these two concepts, it becomes possible to easily customise supply chains and systematically improve them.

2.3. The conditions for selecting supply chains

2.3.1. Preface

Supply chains, as discussed earlier, are recognised as complex adaptive systems. This axiom is used as a starting point when we begin to search for situational factors and business conditions that have crucial influence on supply chain selection. With roots in many disciplines, such as evolutionary biology, non-linear dynamic systems and artificial intelligence, modern theories and models of complex adaptive systems focus on the interplay between a system and its environment and the co-evolution of the system and the environment (Choi et al., 2001). According to Choi et al. (2001), the same approach can be used in modelling the networks of supply chains. In the context of this thesis, these three dimensions of (1) system, (2) environment and (3) co-evolution can be explained as follows:

- A *system* means the supply chain between the customer and the supplier where both are considered to be decision-making agents in the system. According to systems theory, agents refer to entities (for instance, plants, atoms or birds) that populate a complex system. These agents partake in the process of spontaneous change in such a system (Choi et al. 2001). The system refers to a customer's demand-supply chain.

- An *environment* can be understood as the overall business conditions that affect both the customer and the supplier. As the overall environment in this case would basically be a boundless entity, it is therefore necessary to restrict the examination to only the most significant business conditions of the customer and supplier separately. Thus, the first angle would be the customer and its markets, and the second one the supplier and system deliveries.

- System-environment *co-evolution* refers to the development of supply chain and business conditions over time and their interdependencies with each other. Basically, this is the dynamic change aspect of the relations between all parties involved in the supply chain.

This outline is also illustrated in Figure 9.

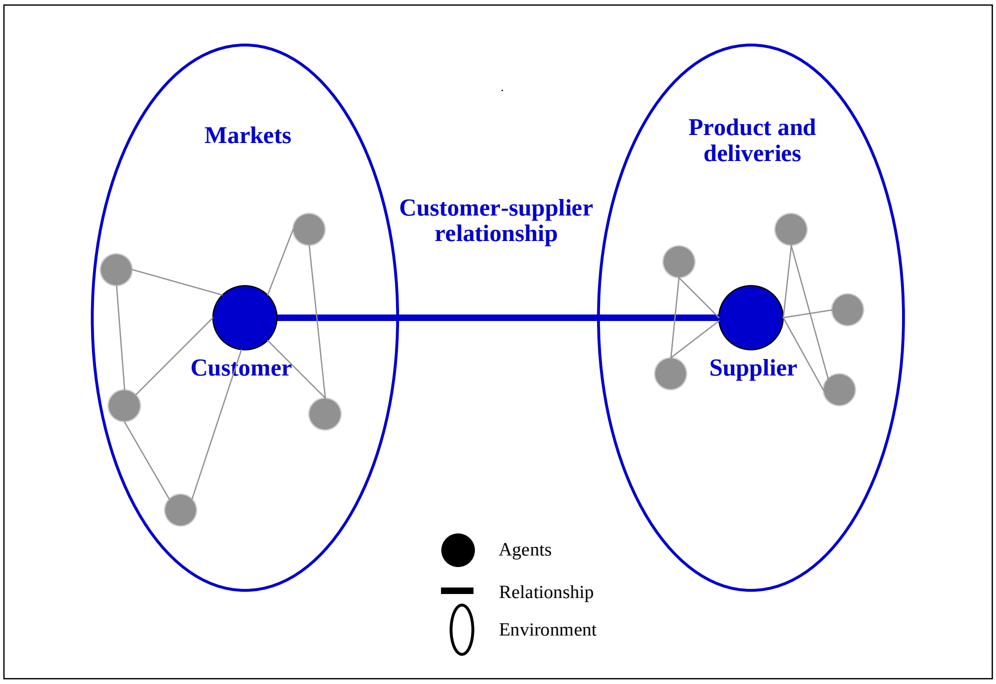


Figure 9: The outlook of conditions for supply chain selection

Based on the figure above, the following three entities are now being used to examine determinant business conditions for supply chain selection:

1. *Customer and markets*
2. *Supplier, product and deliveries*
3. *Customer-supplier relationship*

Each of these is further-developed in the following sections.

2.3.2. Customer and markets

Many technology-based products, such as consumer durables and office automation equipment, have been found to exhibit a pattern of evolution that resembles the life of a living organism. The evolutionary process – commonly referred to as the product life cycle – begins with the introduction of a new product (birth) and ends with the exhaustion of the product's market potential (death) due to technological obsolescence (Chi, 2001).

The similarity of behaviour between product life cycles and living organisms was first discovered by Frank Bass in 1967 when he studied the growth of demand for consumer durables in the US market. According to the new product growth model that he introduced, the timing of initial purchases of new products is based on an assumption that the probability of purchase at any time is linearly related to the number of previous buyers. There is a behavioural rationale for this assumption. The model implies exponential growth from initial purchases to a peak and then exponential decay (Bass, 1967).

Since those days, the product life-cycle theory has been further studied and widely utilised in many industries. In strategic management, according to Ansoff (1984), this theory is widely used as an application to analyse which strategic business areas a company should be in to meet its growth targets. Normally, three coexistent life cycles can be identified in markets: demand, demand-technology and product life cycles. Each of them behaves similarly over time. They can be sub-divided into several distinctive parts:

1) *Emergence*, a turbulent period during which an industry/technology/product is born, and when a number of aspiring competitors seek to capture leadership.

2) *Accelerating growth* during which the surviving competitors enjoy the fruits of their victory. In this stage, demand growth typically outpaces the growth of supply.

3) *Decelerating growth* when early signs of saturation appear, and supply begins to exceed demand.

4) *Maturity* when saturation is reached and there is substantial overcapacity.

5) *Decline* to a lower volume of demand (or to zero), which is determined by demographic and economic factors (such as growth rates in GNP or in population), and by the rates of product obsolescence or product consumption.

The demand life cycle describes a typical evolution of demand from the day a previously unserved societal need (for example, a need for personal transportation, for reception of audio-visual images, for amplification of weak electrical signals etc.) begins to be served by products or services. On the other hand, the demand-technology life cycle determines the demand for products or services based on a particular technology according to Ansoff (1984). This is also illustrated in Figure 10.

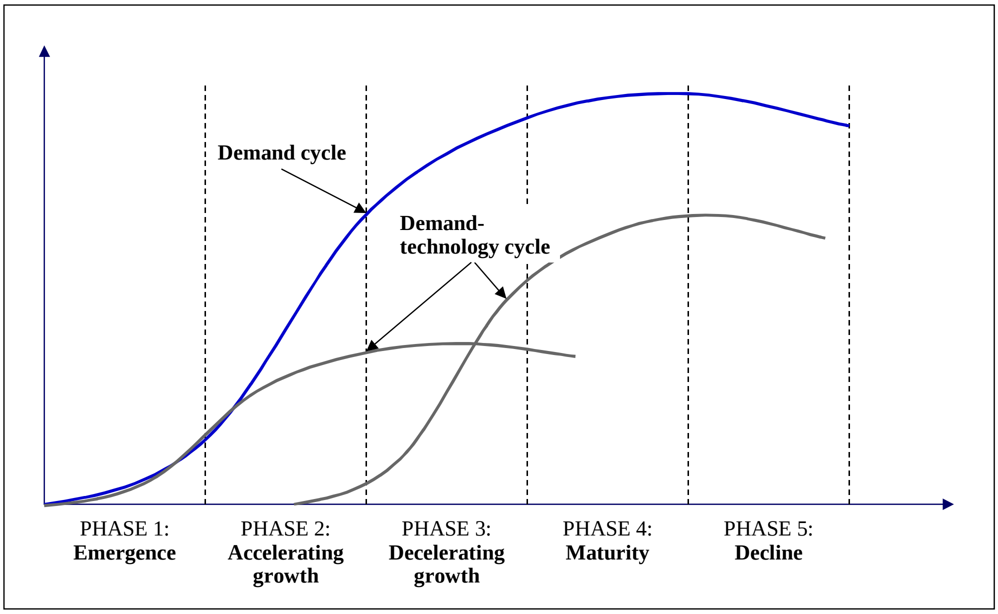


Figure 10: Demand-technology life cycles (Ansoff, 1984)

There may be several product life cycles inside one demand-technology life cycle, similar to how demand-technology cycles are part of one demand cycle. The most important thing is to understand how demand is expected to behave over time when a new technology or product is introduced. For rival companies, first comes the turbulent period where everybody is fighting for market leadership and limited supply. The second step is to ensure a company's strong growth by obtaining more market share. As growth slows down and supply exceeds demand, it is possible to start focusing on cost-efficiency. When a business is getting saturated, a company should already have a new strategic business area to go into.

So, the life cycle theory explains how markets behave over time. However, if there are several players in the same markets, which one should a company build its strategy on? Obviously, the first thing is to understand its existing position in the markets compared to its rivals.

This issue was studied by the Boston Consulting Group (Hedley, 1977), which introduced a practical model in the 1970s. This model positions companies based on their strategic situation in the same markets in a matrix where the axes are measured by the market's volume growth and a company's relative market share. In the model, those companies that are in high growth markets and already have a strong market share are ***"stars"***. Everybody, naturally, wants to be in that position. Therefore, companies in the same markets with lower market share tend to increase investments to grow faster than the markets, to obtain more market share. These companies are called ***"question marks"*** in the diagram. Over time when market growth decreases - that will happen anyway according to the life-cycle theory - the "stars" companies will become ***"cash cows"***, which can still make some profit with the business but do not have growth potential. Those ex-"question marks" that did not succeed in becoming "stars" are in the poorest situation, because they will only make losses with their investments. They become ***"dogs"***. This BCG diagram suggests decisions on future participation by the firm in the respective strategic business areas (Hedley, 1977):

- The ***"stars"*** - high growth, high market share - are growing rapidly; they use large amounts of cash to maintain their position. They are also leaders in the business, however, and should generate large amounts of cash. As a result, star businesses are frequently roughly in balance in terms of net cash flow, and can be self-sustaining in growth terms. These companies should be cherished and reinforced (optimise).

- The ***"question marks"***- high growth, low market share - have the worst cash characteristics of all. Their cash needs are high because of their growth, but their cash generation is small because of their low market share. If nothing is done to change its market share, the question mark will simply absorb large amounts of cash in the short term and later, as growth slows, become a dog. These companies need to be analysed to see whether the investment for converting them into stars is worthwhile (upgrade or maintain).

- The ***"cash cows"*** - low growth, high market share - should have an entrenched superior market position and low costs. Hence profits and cash generation should be high, and because of the low growth reinvestment needs should be modest. Thus, large cash surpluses should be generated by these businesses. These companies should be made to control their investments and send excess cash to headquarters (milk).

- The ***"dogs"* –** low growth, low market share - represent a tremendous contrast. Their poor competitive position condemns them to poor profits. Because growth is low, there is little potential for gaining sufficient share to achieve a viable cost position, though low, the cost position frequently exceeds that generated, especially under conditions of high inflation. These companies should probably be divested, unless there are compelling reasons for keeping them (divest).

According to Ansoff (1984), the BCG matrix is a useful technique in making strategic position decisions about a company's future business areas. Implicitly it also suggests which strategy the company should select in existing markets. This is a model that explains the nature of business in different market positions and suggests where a company should focus based on its position in the markets. If a company wants to become a "star", or if it is already a "star" to only sustain its existing market share, it must gain some competitive advantage over its rivals. How can a company increase its competitive advantage?

This issue has been extensively studied by Michael Porter in the mid 1980s. According to Porter (1985), the value a company creates is measured by the amount that buyers are willing to pay for a product or service. A business is profitable if the value it creates exceeds the cost of performing the value activities. To gain competitive advantage over its rivals, a company must either perform these activities at a lower cost or perform them in a way that leads to differentiation and a premium price (more value). This famous model is presented in Figure 11.

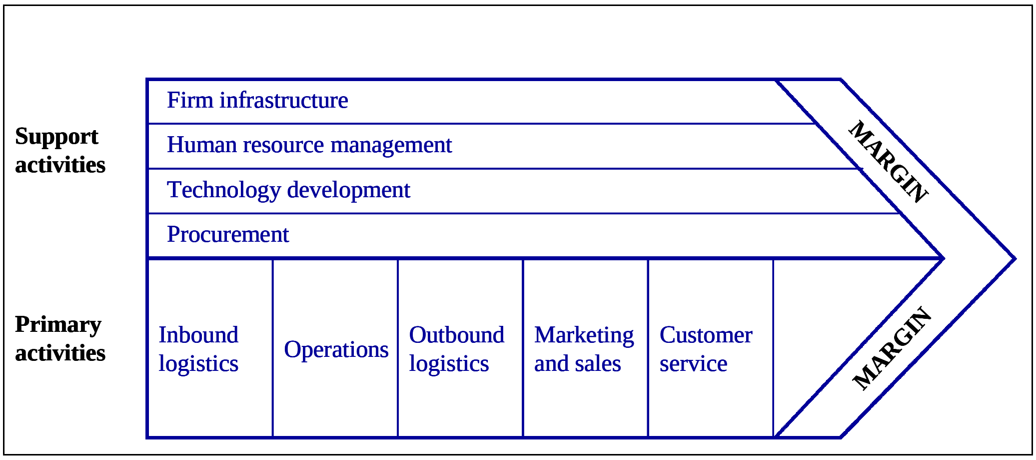


Figure 11: Value chain (Porter, 1985)

Porter (1985) also argues that the value chain for a company in a particular industry is embedded in a large stream of activities, a value system. The value system includes value chains of suppliers, who provide inputs (such as raw materials, components and purchased services) to the company's value chain.

Competitive advantage cannot be understood by looking at a firm as a whole. It stems from many discrete activities a firm performs in designing, producing, marketing, delivering, and supporting its product. Each of these activities can contribute to a firm's relative cost position and create a basis for differentiation. The value chain disaggregates a firm into its strategically relevant activities in order to understand the behaviour of costs and the existing and potential sources of differentiation. A firm gains competitive advantage by performing these strategically important activities more cheaply or better than its competitors.

2.3.3. Supplier, product and deliveries

The research problem of this thesis is explicitly scoped to project oriented business, which holds a few special features from supplier, product and delivery point of view. These viewpoints are first introduced before the actual review on their presence in the project management literature.

First, there are typically only one or a few suppliers for project selected by a customer. As such a project often means long-term commitments, this makes possible for the customer company to request highly tailored supply chain solutions from its supplier. At the same time, for supplier companies it enables truly collaborative processes with the customer. The second important aspect is that end products are always unique for that particular customer. Today, they typically include equipment, software and services. The final product composition of a project certainly influences on supplier's supply chain choices for its customer. The third viewpoint is linked to the importance of just-in-time material deliveries. In project businesses it is especially important that JIT philosophy is applied to guarantee that supply chain in integrated to project's progress. This well-known philosophy, originally developed in Japan as a manufacturing technique in the early 1970s, became first a production management paradigm. In terms of just-in-time logistics, the production and transportation of goods is more frequently in smaller lot sizes. The consequence of smaller lot sizes is smaller inventories along the chain. The way this is applied in the context of this study is in the site-specific base station deliveries in the GSM network building projects.

The importance of project management discipline has noticeably increased in recent years, as many companies have begun to run their business as projects. Instead of building a stable organisation and operations around the utilisation of a new technical innovation, business is nowadays more often conducted as temporary projects. This tendency is also seen in the telecom industry, where communication networks are not only being launched but also further constructed and expanded as efficient, milestone-driven projects.

The Project Management Institute's *Guide to the Project Management Body Knowledge (PMBOK™)* defines a project as a temporary endeavour undertaken to create a unique product or service. Projects and operations differ primarily in that operations are ongoing and repetitive while projects are temporary and unique. Temporary in this case means that every project has a definite beginning and a definite end. Unique means that the product or service is different in some distinguishing way from all similar products or services. Project management is the application of knowledge, skills, tools and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project. The project management knowledge areas describe project management knowledge and practise in terms of its component processes. In PMBOK™ these processes have been organised into nine knowledge areas: project integration management, scope management, time management, cost management, quality management, human resource management, communication management, risk management and procurement management (Project Management Institute Standards Committee, 1996).

According to Leach (2000), the general project management theory is not only based on PMBOK™ standards, but he also asserts total quality management (TQM) and theory of constraints (TOC) to the same level. These three knowledge areas provide different reality filters, or paradigms, for understanding a project system. According to the TQM philosophy, the best way to improve a project system, or any other system, is to continuously try to improve every process in the system. TQM provides specific tools to perform root cause analysis to identify the causes of problems and develop strategies to remove those causes (Leach, 2000).The TOC perspective, however, identifies system constraints and works to improve its throughput. The main idea according to this theory is that any system must have a constraint, a bottleneck, that limits its output, and only by focusing on and removing the bottlenecks can the system be improved. Instead of breaking the process down and improving the efficiency of each step, the theory focuses managers on bottlenecks, or constraints, that keep the process from increasing its output (Elton & Roe, 1998). All these three related disciplines have a central role in project management, but from the perspective of supply chains the theory of constraints is the most relevant. This is because TOC concepts in the area of project management, according to Steyn (2002), are quite focused on project time management aspects; and project scheduling, naturally, is an essential part of any delivery system.

The theory of constraints, introduced in *The Goal* by Dr. Emiliyahu Goldratt in 1984, was first widely applied in the area of operations management where it is better known as the concept of Optimised Production Technology (OPT). After more than a decade, in 1997 another Goldratt book, *Critical Chain*, was published, this time relating the theory to project management. One may fairly ask why TOC or critical chain would be a useful concept for project management because it mainly deals with project time management, only one dimension of a whole system (scope, time and cost). Is time always the constraint of a project system?

Leach (2000) has explained that defining project constraints in terms of the schedule derives from the impact that the schedule has on project cost and project scope. Independent variables that influence a project result include the demanded scope, the project system definition and the resources available to work on the project. The project system outputs are dependent variables (delivered scope, cost and schedule). As the schedule increases with fixed deliverable scope, cost usually increases. As scope increases fixed costs (or resources), the schedule tends to increase. As scope increases with fixed schedule, costs tend to increase. Therefore, it is appropriate to focus first on delivering the project on time.

Steyn (2002) has also argued why project duration should be considered the major constraint of projects in general. He has pointed out three main reasons for this. First, positive cash flow can be obtained faster if projects are completed on time. This is quite evident, especially in industries where product lifecycles are short and speed in launching new products or services on the markets is essential. A second motivation for considering duration to be an important constraint is that the contingency costs of project delays are typically very high. For instance, market share can be dramatically lost if a project is delayed. The third important aspect in keeping the project schedule is to prevent changes in stakeholder needs, and thus to project scope.

Goldratt (1997) defines a critical chain as the longest set of dependent steps to complete a project. The concept of a critical chain in project management is a kind of scheduling technique through which project throughput is maximised by keeping or even coming in under the schedule. A starting point is the assumption that people do make considerable provision for contingencies when estimating activity duration. Goldratt (1997) argues that often there is little incentive to finish an activity ahead of schedule while not meeting a deadline normally reflects negatively on the individual. Rational people responsible for project activities therefore attempt to make commitments that they could meet with a high level of certainty. An estimated duration of an activity depends very much on the level of certainty of the estimation. If you schedule to be on the safe side, say with a 90% certainty of keeping the schedule, the duration estimation is much higher than the median of the probability distribution. That is to say that when making time estimates people, typically, include a safety factor to protect against uncertainty. The duration time difference between the safe and the median (50%) estimates is called the contingency reserve (Goldratt, 1997). This is illustrated in Figure 12.

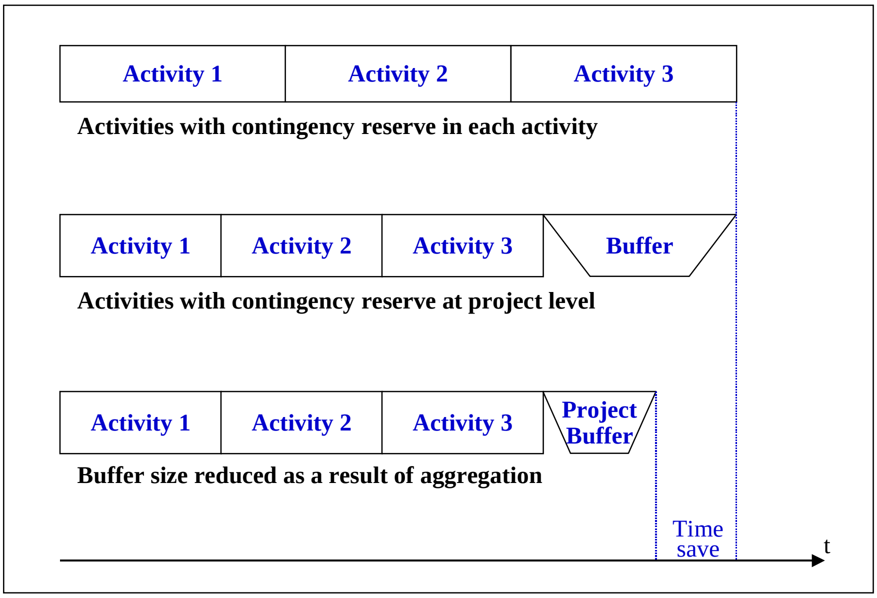


Figure 12: Contingency reserves (Goldratt, 1997)

According to Steyn (2000), aggregation of risk is a common principle that has been applied at least since the dawn of the insurance industry. When n owners of assets worth say $x each do not have insurance on these assets, each one needs a contingency reserve to provide protection against the possible loss of the asset. Therefore a total reserve of $n*x would obviously be required. Should they all, however, accept the offer of an agency that undertakes to insure all the assets against the risk of loss, such an agency would obviously require an aggregated reserve of less than $n*x because the simultaneous loss of all assets would be highly unlikely. From the Central Limit Theorem it follows that if a number of independent probability distributions are summed, the variance of the sum equals the sum of the variances of individual distributions. Therefore if n independent distributions with equal variance V are summed, it follows that:

$V_\Sigma = n*V$ where V_Σ is the variance of the sum. The standard deviation σ can be used as an indication of risk since $\sigma^2 = V$ it follows that

$$\sigma_\Sigma = (n)^{½} * \sigma$$

where σ_Σ is the standard deviation of the sum. Therefore $\sigma_\Sigma < n * \sigma$

This illustrates the reduction in overall risk when risks are aggregated, because $(n)^{½}$ is significantly smaller than n. The effect of aggregation of independent risks is significant. The higher the number of risks that are being aggregated, the more marked the effect (Steyn, 2000).

In a production environment, TOC suggests the protection of throughput with inventory, in projects the protection is done in a similar way with safety time. To keep the critical chain flowing smoothly, TOC advises managers to use safety buffers similar to the inventory buffers used in production lines to make sure that bottleneck machines always have material to work on. Because managers cannot predict exactly when any task will be completed, they need to allow extra time for tasks that impinge directly on the critical path. By inserting a time buffer wherever non-critical paths feed into the critical path, the tasks on the critical path will always have what they need to proceed (Elton and Roe, 1998).

A critical chain is not the same as the well-know concept of the critical path in project management. The concept of the critical chain is based on the obvious fact that the longest time required for project completion could be determined by a resource that, due to limited capacity, has to perform different activities sequentially. In PMBOK™, critical path is defined as the series of activities that determine the earliest completion of the project. During a project life cycle, the critical path will generally change from time to time as activities are completed ahead of or behind schedule. It is traditionally determined by precedence relationships only and resource limitations are taken care of only after the critical path has been defined. The critical chain, on the other hand, takes resource limitations into account and is composed of sections that are dependent on precedence relationships and other sections that are dependent on resource availability. The aggregated “project buffer” inserted at the end of the critical chain provides contingencies for all critical activities.

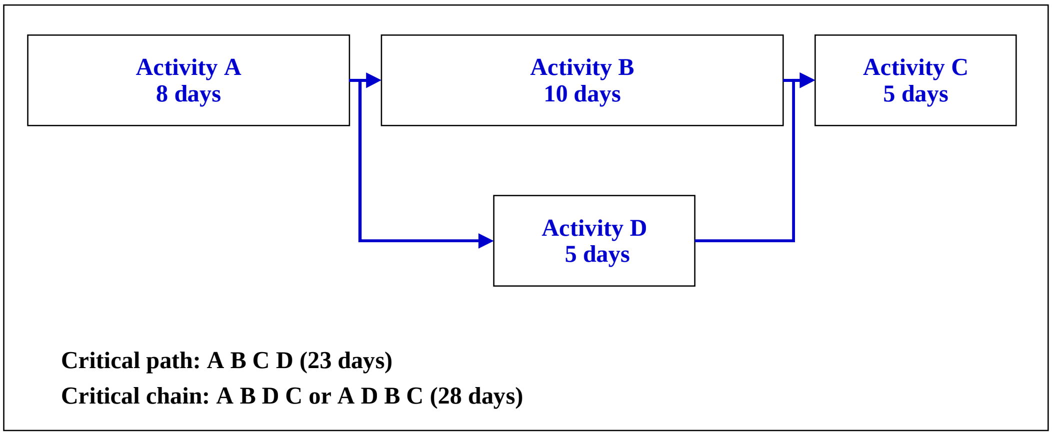


Figure 13: Difference between critical path and critical chain

If a non-critical activity is scheduled as late as possible there is obviously a considerable risk that it might delay the project should the activity take longer than planned. On the other hand, if an activity is scheduled to start as early as possible, changes in the scope of the activity (or changes to subsystems interfacing with the activity) might have an impact on the scope of work of the activity under consideration. This implies a risk of having to repeat the work. The TOC project management approach is to schedule all non-critical activities as late as possible, but with buffers. The objective of these buffers (called feeding buffers because they are placed where non-critical paths feed into the critical chain) is to prevent delay of the execution of work on the critical chain when work on a non-critical path is delayed. The approach provides advantages similar to those that the Just-In-Time approach offers in a production environment. In fact, it could be called "JIT-with-buffers". These advantages include flexibility in the event of unforeseen changes and improving project cash flow (Steyn, 2000).

According to Hatch (1997), uncertainty can be considered to be a property of the environment resulting from two powerful forces: complexity and rate of change. Complexity refers to the number and diversity of the elements in an environment. Rate of change refers to how rapidly these elements change. Environmental uncertainty is defined as an interaction between varying amounts of complexity and change in the environment (Hatch, 1997).

2.3.4. Customer-supplier relationship

Customer relationship management (CRM), one of a most studied theme in these days, is also an especially important aspect in project businesses. According to Freeland (2002), when the concept was initiated in the early 1990s it was mainly focusing on establishing customer service call centers. Nowadays, the focus of modern CRM initiatives is much wider including various sales activities and collaborative process related information systems that enable enhanced productivity for individual customers. CRM is a technique for collecting information from prospects and customers about their needs, and for providing information that helps them evaluate and purchase products that deliver the best possible value to them (Peppers and Rogers, 1997). In other words, it is a kind of partnership mode through which customer value is added. In that sense it is not any new phenomenon but is grounded on the concept of value chain. According to Johnston and Lawrence (1988), a value-adding partnership is a set of independent companies that work closely together to manage the flow of goods and services along the entire value-added chain.

CRM is substantially based on the one-to-one marketing approach that is a philosophy of building relationships that lead to understanding the needs and priorities of each prospect and customer, and providing the products and services that meet those needs. According to Peppers et al. (1999), one-to-one marketing means for a supplier company being willing and able to change behaviour toward an individual customer based on what the customer tells and what else is known about the customer - this naturally requires close and trusty relationships between the companies. One-to-one marketing is also a kind of new mindset that instead of selling one product at a time to as many customers as possible in a particular sales period, the one-to-one marketer uses customer databases and interactive communications to sell one customer at a time as many products and services as possible, over the lifetime of that customer's patronage (Peppers and Rogers, 1997). It is a strategy that requires a business to manage customers individually.

Peppers et al. (1999) defines a generic model of four key steps in implementing CRM, or one-to-one marketing approach in practice. The model starts with identifying customers and recognizing them at every contact point in an individual and clearly addressable way. The second step is to differentiate the customers. Each customer segments represents different levels of value and has different needs. The next step is to interact with the customers in more cost-efficient and effective way than earlier, as improvement is a key component in one-to-one marketing. Finally, the enterprises' behaviour should be customized to lock a customer into a learning relationship.

The implementation of CRM and the management of customer centric supply chains are often combined together in the modern literature. According to Kuglin (2001), the winners of tomorrow will not be those that are transaction-driven, but those that are customer relationship-driven. Transforming a company's supply chain into an optimally efficient customer-satisfying process is one of the most crucial challenges of our day. Kuglin (1998) provides a step-by-step guide for the implementation of one-to-one marketing initiatives in the area of customer centric supply chain solutions. It includes creation of outcome-driven tasks and processes, retooling the structure and business strategy of the organization, setting up effective people/responsibility charts, incorporating technology for maximum benefit, creating performance-based rewards and measuring results.

Putting any kind of CRM approach into practice often requires proper change management schemes with extensive business process re-engineering (BPR) efforts between the customer and supplier's organisations. According to Hammer and Champy (1993), BPR is about fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance like cost, service and speed. In line with big re-engineering projects, typically organisations have simultaneously been developed. This often is necessary, since the changes might affect people across organisational boundaries. Hammer and Stanton (1999) also point out that taking these aspects into account guarantees that the overall commitment from top management is there from the very begin. Because the changes involved in becoming a process enterprise are so great, companies can expect to encounter considerable resistance. According to Hammer and Stanton (1999), it is rarely the frontline workers who impede the transformation. Once they see that their jobs will become broader and more interesting, they are generally eager to get on board. Rather, the biggest source of resistance is usually senior executives, who often either resent what they see as a loss of autonomy and power or are uncomfortable with the new, collaborative managerial style.

It is no wonder that change management is often a critical success factor for re-engineering projects. According to several studies from recent years, the success rate of re-engineering projects has been surprisingly poor compared to the efforts put into the changes. As change typically affects several organisational groups and informal work networks, there are many elements that need to be taken into account when planning the new processes and modes of operations. Personnel have to understand the need for a change in order to be motivated. National culture, organisational culture and occupational culture with their different characteristics affect how people react, become motivated and willing to change their behaviour and their organisational environment (Järvenpää and Eloranta, 2000). All these change management aspects should be taken into account before any re-engineering efforts are started.

The foundation of re-engineering must rest on all people changing and learning, which means that everyone in the organisation must be engaged in the process. Leaders and employees must radically change the way they move the organisation forward, the way they see their work and how they relate to each other. This cannot happen unless the whole community is involved in the design and implementation of change. Re-engineering is not the application of a standardised technology. It requires a discovery by the people in the organisation of new ways and open systems – a sharing of full information from customers, the environment and across boundaries – not the limitation of information by level and need to know. Re-engineering models uphold these principles. Difficulty arises when the pressure of artificial deadlines or for immediate results in terms of cost savings leads to companies straying from these principles (Dennis and Scott, 1998).

Davenport (1999) also states that managers have not put enough focus on managing the change and guiding employees in developing their new role. He points out that employees have taken ownership of their careers, responsibility for their development and accountability for their performance – all at the urging of management. The manager's final role is to help people recognise that the devaluation of their human capital is the biggest risk they face today. It is not an exaggeration to point out that these change management aspects should be issued before establishing any process re-engineering efforts.

According to Dyer (1998), firms should think more strategically about supplier management and perhaps should not have a “one-size-fits-all” strategy for supplier management. Instead, each supplier should be analysed strategically to determine the extent to which the supplier’s product contributes to the core competence and competitive advantage of the purchasing firm. A company’s ability to strategically segment suppliers in such a way as to realise the benefits of both the arms-length as well as the partner models provides the key to future competitive advantage in supply chain management (Dyer et al., 1998).

The importance of both supplier and customer involvement in re-engineering the demand-supply chain cannot be exaggerated. It always requires heavy participation, at least, from both the supplier and customer to make breakthrough improvements in the whole chain. Furthermore, process re-engineering should be understood as a far-reaching decision that also affects the working practises of both parties in the future. Real change takes time and efforts to implement, it also needs to be multidimensional if it is to succeed.

2.3.5. Summary

In conclusion, this section argues that a number of business conditions exist that potentially influence the selection of the right supply chain for a customer. First, the customer and its markets certainly have a major role in designing the supply solution. The second set of conditions is related to the supplier and its environment. Furthermore, relations between the customer and supplier are considered to be significant factors for making decisions on supply chain solutions.

3. RESEARCH METHODS

This chapter introduces the research strategy of the study and provides a comprehensive explanation of basic assumptions made concerning its scientific philosophy. Furthermore, the scientific methods of study applied throughout the research process are fully described.

The chapter consists of four parts. The first part focuses on the introduction of the selected research strategy itself. The second part deals with the scientific reasoning of the study that is also used as a basis for the whole composition of the thesis. The third part provides detailed descriptions of the actual research design and research process. The collection of research material is presented in the fourth sections.

3.1. Action research strategy

This study is an action research conducted in the mobile communications infrastructure business during 1999 and 2000. The research is an inductive, theory-building case study where Nokia Networks represents the main case company. Despite this fact, the research is considered to be a multiple case study, since individual GSM network building projects of Nokia Networks customers are unambiguously handled as units of analysis in this study. The selected research approach is justified below.

According to Yin (1994), a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident and where multiple sources of evidence are used. The case study approach can include a single case or multiple case designs, and it may involve either a holistic unit of analysis or a number of embedded units of analysis. Case studies can basically be used to provide descriptions of phenomena, to test existing theory or to generate new theories. Eisenhardt (1989) has particularly focused on describing the process of building theory using a case study method. In her approach, the main strengths of the method are its novelty, testability and empirical validity. The theory-building approach is particularly well suited to new research areas or research areas for which existing theory seems inadequate (Eisenhardt, 1989). This is also one significant reason why the action research approach - which Gummesson (2000) considers to be the most far-reaching method of case studies - is selected here as the research strategy. Obviously, there is not adequate knowledge in the literature to provide companies a set of criteria to make successful business decisions on the right supply chain selection for their individual customers.

According to Ackoff (1999), the product of scientific inquiry is a body of information and knowledge that enables people to better control the environment in which they live. This philosophy of having both epistemic utility (new knowledge) and practical utility (to better control the environment) as outcomes from science is very typical of applied sciences, like social sciences (e.g., see Niiniluoto, 1992). In social sciences, according to Yin (1994), there are five alternative research strategies: experiment, survey, archival analysis, history and case study. Each research strategy represents a different way of collecting and analysing empirical evidence, and each has its own advantages and disadvantages. Yin (1994) continues that the three relevant conditions: (a) the type of research question, (b) the control an investigator has over actual behavioural events and (c) the focus on contemporary as opposed to historical phenomena, should be considered when making decisions on research strategy. The review of these conditions for this study is as follows:

(a) The type of research question is primarily “how”, since the purpose of the study is to provide companies a normative model in specifying the most successful supply chain for an individual customer in complex business situations. According to Niiniluoto (1992), research aiming at knowledge that is useful for design activity may be called design science - which is a typical research approach in economics and especially management disciplines (e.g., Olkkonen, 1993). The research question would lead the case study to be of an explanatory nature, as the purpose is to provide an explanation of the studied phenomena in complex business systems. However, the study not only provides explanations, but also gains a deep understanding about the various interactions of the studied business systems. Systems thinking is a dominant characteristic of this research. The scientific contribution of research to society, according to Neilimo and Näsi (1980), distinguishes business studies primarily as descriptive or normative. This case study is considered to be a normative research, although it also involves much descriptive analysis.

(b) The role of the researcher in this study is to actively participate in the re-engineering process itself and to be heavily involved in making decisions on the right supply chain solution for individual customers. This enables the researcher to gain the deepest possible understanding of the studied phenomenon. Eisenhardt (1989) also states that the case study method is a research strategy that is intended to focus on understanding the dynamics present within individual settings. The selected action research approach reinforces this intention. An action-oriented approach brings the human being into the focus of analysis, and therefore makes the explanatory model more teleological (Kasanen et al., 1993). The most important application of the case study method, according to Eisenhardt (1989), is the ability to explain the casual links in real-life interventions that are too complex for the survey or experimental strategies.

As the researcher is personally involved in the studied phenomenon, the knowledge that is created through the research process cannot be independent from the subject (the researcher). The research objects are thus being perceived subjectively, although the research material also consists of some quantitative data that is primarily objective. Therefore, this study clearly represents the idealist view of ontology and follows the hermeneutic tradition more than the positivist research tradition.

(c) This study is focused on a contemporary phenomenon and the research problem is extremely relevant for companies in project businesses in innovate product markets. According to Clark (1976), the main strength of action research is that it combines discovery and implementation in one process. Thus, the action research approach can effectively be used to combine a practical action and science at the same time. According to Coghlan and Brannick (2001), action research also involves a collaborative problem-solving relationship between researcher and client aimed at both solving a problem and generating new knowledge. In this study there are altogether 38 different customer projects (units of analysis) where the supply chain was revised. Eleven out of these have been selected for in-depth case study where the researcher was personally involved and where the research was fully conducted in parallel with the action. The experiences and learning processes from those projects are used as the main method of evidence in this thesis. Thus, the research obviously represents the empiricist view of epistemology.

The action research approach has its roots back in the mid-1940s when Kurt Lewin and his associates developed theories on social psychology and group dynamics (e.g., Argyris et al., 1985; Coghlan and Brannick, 2001; Eden and Huxham, 1996). In those days, they conducted several action research projects in different social settings. The basic idea in action research is that it is an approach to research that aims at both taking action and creating knowledge or theory about that action. The importance of this research method has substantially increased over the last decades in social sciences. According to Coghlan and Brannick (2001), inside the generic term, action research, many experimental paradigms can be identified, each of which has its own distinctive emphasis. Over the years various research traditions inside the action research approach have developed among scholars. The list of different paradigms that Coghlan and Brannick (2001) have identified includes traditional action research (e.g., Lewin, 1973), participatory action research (e.g., Whyte, 1991), action learning (e.g., Revabns, 1998), action science (e.g., Argyris, 1982), development action inquiry (e.g., Torbert, 1987), co-operative inquiry (e.g., Reason, 1994), clinical inquiry (e.g., Schein, 1987), appreciative inquiry (e.g., Cooperrider and Srivastva, 2000), learning history (e.g., Kleiner and Roth, 1997), reflective practice (e.g., Schon, 1983) and evaluative inquiry (e.g., Preskill and Torres, 1999). The purpose of the list above is to highlight the strong position of action research in social sciences and its large number of applications in conducting scientific research. In summary, this study complies with traditional action research.

Gummesson (2000) makes a comprehensive synthesis of the main characteristics of the traditional action research method within research in management. The list of characteristics is presented in Table 2 where an additional column has been added to present the appearance of that particular feature in this study.

Table 2: The characteristics of action research and their appearance in the study

Key characteristics of action research (Gummesson, 2000)	**The corresponding appearance in this study**
(1) Action researchers take action.	(1) The researcher was not merely observing how things were developing, but he was personally involved in making decisions on the supply chain within individual customer projects and also actively working at making the agreed change happen.
(2) Action research always involves two goals: solve a problem for the client and a scientific contribution.	(2) The aim of study is two-fold: (a) to provide a normative supply chain selection model for companies to better manage complex decision-making situations in supply chain management and (b) to simultaneously contribute to science by building new theory for the existing body of knowledge about the implementation of customised supply solutions.
(3) Action research is interactive.	(3) The implementation of process changes in customers' supply chain requires extensive interaction between all the parties involved, including the researcher. Moreover, the results of changes were contingent on many environmental factors that could not be foreseen beforehand. Therefore, the actual research process was continuously confronted with these contingencies.

(4) Action research aims at developing a holistic understanding.	(4) GSM market/technology dynamics and the complexity in combining targets for several profit-making organisational units forced the study to take a very holistic approach. The first pre-requisite in developing the supply chain of customers was always to understand their current business situation in the markets.
(5) Action research is fundamentally about change.	(5) The starting point of the study was precisely to make radical changes happen in the supply chain management. The focus was on improving the cost-efficiency (reduce inventory levels) and effectiveness (provide fastest time to profit for customers) for individual customers. For most customers this meant the re-engineering of the whole demand-supply chain in practice.
(6) Action research requires an understanding of the ethical framework, values and norms within the context of the research.	(6) The researcher has more than five years experience in working within the case company in various logistics related roles and has basically seen the development of the GSM markets. Thus, the researcher was very familiar with the business context and the challenges.
(7) Action research can include all types of data gathering methods.	(7) There are many sources of research material in the study, including observations, documents, archives, surveys and operational business measures. Both qualitative and quantitative methods are used in this study. These are described in more detail later.
(8) Action research requires a pre-understanding of the business context.	(8) The researcher has more than five years experience in working within the case company in various logistics related roles and has basically seen the development of the GSM markets. Thus, the researcher was very familiar with the business context and the challenges.
(9) Action research should be conducted in real time (though retrospective AR is also acceptable).	(9) The research was conducted during 1999 and 2000 as a part of the BIRD re-engineering program. All research material was collected and most analysis was performed made during this time period; that is, most of the learning took place at the time. However, there are some detailed insights (as a part of new theory building) that were discovered only during the final data analysing and dissertation writing phase.
(10) Action research represents the hermeneutic paradigm, although elements from the positivistic paradigm may be included.	(10) The study does not aim to test any existing theories nor to follow a deductive reasoning logic – which is typical of positivism. The purpose is to create a new contribution to the existing body of knowledge. This study is an inductive, theory building case study research. Therefore, it represents more the hermeneutic research paradigm than pure positivistic thinking.

According to the selected research approach, all research results and conclusions are valid within the case study settings and their generalisation to a wider context should be further studied.

3.2. Practical inference and technical norm

The reasoning of this thesis directly follows the logic of practical inference (or the practical syllogism of Aristotle), which is an alternative approach to the more traditional, deductive theoretical inference used in the natural sciences. In the social sciences, where human action cannot be explained causally by laws, but must be understood intentionally, the applications of practical inference are very useful (Von Wright, 1963). The basic foundation in practical inference is that a human being assumes the end of an action and considers how and by what means it is to be attained. According to Von Wright (1972), scientific practical inference as a schema of explanation plays a comparable role in the social sciences as that of nomological deductive explanation in the natural sciences. In theoretical inference, both premises and conclusions are declarative sentences, whereas in practical inference the conclusion is always an action (Haaparanta and Niiniluoto, 1986).

Von Wright's concept of a technical norm can be used as a scientific foundation to constitute new knowledge in design sciences where research results should provide some kinds of rules of action, or normative statements (Niiniluoto, 1993). According to Von Wright (1965), a technical norm is a factual statement about the relation between means and ends, the philosophical foundation being based on the practical inference. A technical norm provides normative rules that extract an obligation to behave in a certain way from the pursuit of this interest as an end (Von Wright, 1965). In general terms, the technical norm can be stated as follows:

*"If you want **A**, and you believe that you are in situation **B**, then you ought to do **X**".*

According to Olkkonen (1993), this scientific reasoning is very typical of management research, which aims at providing managers normative rules for complex business situations. There are basically two opposite approaches in applied sciences of using the reasoning of technical norms. The first approach searches for a means [X], which should lead to an end [A] in a certain situation [B]. This approach, obviously, follows the logic of inductive reasoning, and according to Olkkonen (1993) is characteristic of design sciences. According to the other approach, research is meant to find an end [A], when a means [X] is done in a certain situation [B]. Here, the scientific reasoning is based on deductive logic. This approach is often applied in predictive sciences (Olkkonen, 1993). This study belongs to design sciences and clearly follows the inductive reasoning logic. The fundamental concept of how the technical norm is applied in this thesis is presented as follows:

"Which mode of supply chain [X] should be selected in order to reach the most successful supply chain [A] under certain business conditions [B]?"

3.3. Research design

Research design particularly describes the knowledge creation process and methods applied in detail (Yin, 1994). It can also be understood as an action plan for the whole research process. The research design of this study complies with the traditional action research methods according to which the research process is understood as a cycle that consists of a pre-step and three core step activities: planning, action and fact-finding (Lewin, 1973).

The different steps in the research cycle of this study are labelled (1) pre-understanding, (2) planning and action, (3) fact-finding and analysis and finally (4) theory building. These phases are shown in the research process illustrated in Figure 14.

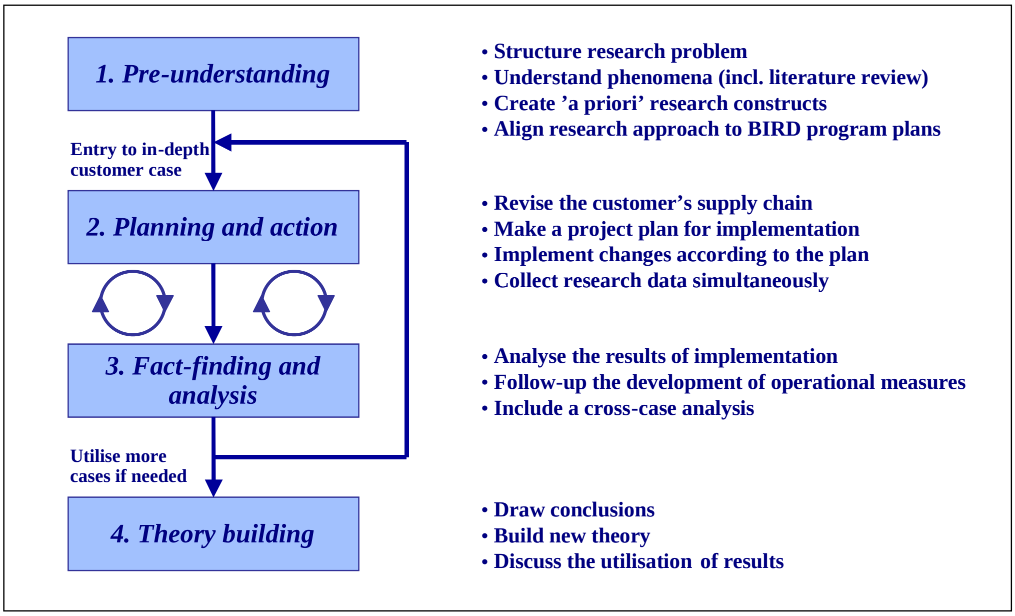


Figure 14: Research process (adapted from Coghlan and Brannick, 2001)

These phases are described as follows:

(1) The ***Pre-understanding phase*** is primarily to increase the researcher's understanding of the researched phenomena in the business context. This research phase starts with structuring the research problem and underlying research questions. This is followed by a review of the literature based on which a tentative 'a priori' specification of research constructs are derived. According to Eisenhardt (1989), this type of specification is valuable because it permits researchers to measure constructs more accurately, although it is not necessary in

theory building research. After setting up these frameworks for the research process, the implementation approach of this study is still aligned with the plans of the BIRD program, which practically sets the prioritisation rules for in-depth customer cases.

(2) The ***planning and action phase*** includes both the preparation and execution of process changes per individual customer. In practice, there are a few process implementation projects going on at the same time for the researcher. This research phase starts with the revision of a customer's existing supply chain solution based on which a detailed project plan about process changes is made. Depending on the customer's business situation, the composition of the project team can vary between different case studies. This is also reflected in the scope of the process implementation. In summary, the implementation of changes is carried out during this phase. The research data is collected simultaneously.

(3) The ***fact-finding and analysis phase*** covers the detailed analysis of findings and research data from the implementation project. The analysis is done in two steps. The first review is carried out at the end of the implementation project just before its completion. If there is something fundamentally wrong with the new process, a new action plan for the customer is immediately implemented to solve the problem. The second, more long-term, evaluation is done months later when the development of operational measures is clearly visible. If there is not enough evidence to draw conclusions from the findings, more in-depth cases are selected for further-analysis.

(4) The ***theory-building phase*** is primarily to draw research conclusions and to create a new theory for the existing body of knowledge. First, the phase still continues the analysis of research data for further validating of the findings. This is done by using data taken from the customer cases that were not part of the in-depth analysis. Second, it presents the research conclusions and links them to the theory. The purpose is to present a new model for selecting the right supply chain for a customer in a project business. Third, the research phase discusses the utilisation of the new theory.

3.4. Research material

Case studies typically combine data collection methods such as archives, interviews, questionnaires and observations (Eisenhardt, 1989). According to Yin (1994), the empirical evidence for case studies may be qualitative, quantitative or both. In this thesis, the research material also consists of a number of sources including both qualitative and quantitative data. The main conclusions, however, are clearly drawn based on qualitative data analysis. Therefore, this study fundamentally represents the hermeneutics research tradition.

The research material includes (1) personal observations and notes, (2) interviews and presentations, (3) standard documents, (4) key operational performance measures and (5) archived records of customer's business situation. The list of research material is presented in Table 3.

Table 3: Data collection methods and research material

Research data collection method	Research material
1) Observations and notes (qualitative data)	• Personal observations • E-mails • Notes on calendar • Meeting minutes
2) Interviews and presentations (qualitative data)	• Customer proposals • Customer satisfaction survey 1999 • Customer satisfaction survey 2000 • Internal process audit interviews • Audit reports
3) Standard documents (qualitative data)	• Project plans • Process descriptions • Final project reports • Account analysis
4) Operational performance measures (quantitative data)	• Inventory composition • Inventory rotation (days of supply) • Delivery accuracy • Delivery lead-time • Demand plan error
5) Archived records from EMC databases (quantitative data)	• GSM penetration per country • Market share • Nbr of GSM subscribers • ARPU (Average Revenue per User)

Observations and notes are made during the implementation projects. Interviews and presentations are specifically designed for individual customers separately, although the customer satisfaction survey includes the same elements for all customers. Templates for standard documents are attached in appendix part as follows: Project plan (appendix 1-1), Process descriptions (appendix 1-2), Final project reports (appendix 1-3), and Account analysis (appendix 1-4). Operational performance measures and archived records are defined in the ‘a priori research construct’ chapter.

Overall summary of research material per individual customer case can be found in appendix 1-5.

4. THE STORY OF THE BIRD PROGRAM

Breakthrough Inventory Rotation Days (BIRD), a large-scale demand-supply chain re-engineering program inside Nokia Networks, is introduced in this chapter. The program was conducted in the GSM network business environment in Europe in 1999 and 2000. Working closely together with the main customers, the implementation program was to develop and implement streamlined supply chain solutions for GSM base station deliveries. The process re-engineering, which was implemented as customer-specific projects, primarily aimed at providing the fastest time to profit for operators and achieving the most cost-efficient supply chain to best serve customer business purposes. This 2-year program included 38 individual customer projects where the demand-supply chain for base stations was re-engineered.

This chapter focuses on describing the case study on the program level. It consists of three parts. The first subchapter describes the business environment and products scoped within the process implementation. This part merely acts a summary of existing knowledge inside the company about the related products and processes. It is mainly built based on Nokia's documents and presentation material. The second part explains the progress of the BIRD program throughout its whole lifecycle. It describes a process how the program was practically implemented, starting from its initiation and ending to its closing. Finally, the third subchapter describes alternative supply chain processes that were created and implemented during the program's lifecycle.

4.1. The business environment

Cellular networks do not have a long history. According to Häikiö (2001a), it was in the early 1980s that the breakthrough in the development of cellular telephone systems really took place as a result of the launching of the Scandinavian NMT-network (Nordisk Mobiltelefon) in the Nordic Countries. This first generation cellular network was developed based on analogue technology, and it did not ever gain significant penetration among telephone subscribers for many reasons. The pan-European GSM (Groupe Spécial Mobile or Global System for Mobile communications) standard, representing the 2nd generation of cellular networks, was introduced in the early 1990s. The first GSM call was made on the 1st of July 1991 in the network of the Finnish operator Radiolinja

(Häikiö, 2001b). GSM is based on a digital technology which, compared to analogue techniques, enables more network capacity, smaller mobile phone terminals, better speech quality and a large variety of new digital services; for instance, short messages. The 1990s were a decade of triumphal march for GSM and digital communications in general. During the decade, more than 400 GSM networks were launched globally.

The building of GSM networks is a quite original business. By its nature it is typically a project business, which requires a very structured approach for planning and control, standard procedures and good day-to-day management skills to run the project implementation. Thus, it clearly has many similarities with the traditional construction industry. However, there are some fundamental differences that make it much more complex. First, the products are all hi-tech equipment, which are characterised by high product value, extremely short lifecycles and a large amount of embedded software. Furthermore, individual products need to be integrated seamlessly together into a complex system that has to work reliably and securely in all kinds of circumstances. Second, a GSM network forms a multi-site delivery environment, as network elements are located around the country. For example, a network can consist of more than ten thousand base station site locations.

In this kind of business environment, there are always a large number of variables that need to be taken into account when planning and executing the project. Examples of these occur in designing the complete radio network and transmission system, in acquiring and leasing site locations, in constructing thousands of base station sites, in managing the work of dozens of implementation teams and in controlling all equipment and material deliveries to the right implementation site. Furthermore, the complete GSM network consists of different high-tech subsystems, each of which must work technically together in a seamless manner. In other words, the need for co-ordination is enormous. This also creates extra requirements for equipment deliveries in order to integrate the supply chain effectively with project management.

As this subchapter is mainly to introduce GSM products and network building processes on a very general level, the content is explicitly taken from Nokia’s internal documentation. Therefore, there is a number of company-specific references used in this subchapter (e.g. documents, slide sets, web-pages, mails). However, as this list of references would be so scattered and informal, it is not included in the final reference list of the thesis.

4.1.1. Introduction to the product

A GSM network consists of different sub-systems, which, in turn, include a number of different network elements. Each network element has its specific function in making mobile communication possible. In addition to the end-user mobile stations (terminal and SIM-card), the entire system of a GSM network is composed of base station, network switching and operation and support sub-systems. In order to get a picture of the overall system, each of these three subsystems is briefly described below:

- A ***Base Station Subsystem (BSS)*** is composed of two main parts: the Base Transceiver Station (BTS) and the Base Station Controller (BSC). The BTS, which is commonly referred to as a base station, has network elements that communicate with mobile stations (for instance, mobile phones) across a standard air interface and with the BSC network element via fixed transmission lines. It houses the radio transceivers that define a cell and handles the radio-link protocols with mobile phones. In a large urban area, there will potentially be a large number of base stations deployed, thus the requirements for a BTS are ruggedness, reliability, portability and minimum cost. The BSC network element, which acts as a link between base stations and the mobile switching centre, co-ordinates the radio resources for several base stations, including handling radio-channel set-up, frequency hopping and cell hand-overs.

- The ***Network and Switching Subsystem (NSS)*** forms the core of the GSM network and consists of a number of network elements: Mobile Switching Centre (MSC), Home Location Register (HLR), Visitor Location Register (VLR), The Authentication Centre (AuC), The Equipment Identity Register (EIR) and GSM Inter-working Unit (GIWU). The MSC acts like a normal switching node for fixed networks, and additionally provides all the functionality needed to handle a mobile subscriber, such as registration, authentication, location updating, hand-overs and call routing to a roaming subscriber. The HLR and VLR, together with the MSC, provide the call-routing and roaming capabilities of GSM. The HLR contains all the administrative information for each subscriber registered in the corresponding GSM network, along with the current location of the mobile. Correspondingly, the VLR contains selected administrative information from the HLR, necessary for call control and provision of the subscribed services, for each mobile currently located in the geographic area controlled by the VLR. The AuC register is used for security purposes to verify user identities, as it provides the parameters needed for authentication and encryption functions. The EIR, also used for security purposes, is a register containing information about the mobile equipment (for instance, it contains a list of all valid terminals). The GIWU corresponds to an interface to various networks for data communications during which the transmission of speech and data can be alternated.

- The ***Operation and Support Subsystem (OSS)*** forms a very useful tool for operators to manage the complete network from a single location. The OSS is connected to the different components of the NSS and to the BSC in order to control and monitor the GSM system. It is also in charge of controlling the traffic load of the BSS.

BTSs are the volume product of GSM networks. There can be several thousands base station sites in an average GSM network. Each site has its specific location, design and function in the network. A complete site consists of three main parts: the base station itself, site solution material and, optionally, a microwave radio link. This is also shown in Figure 15.

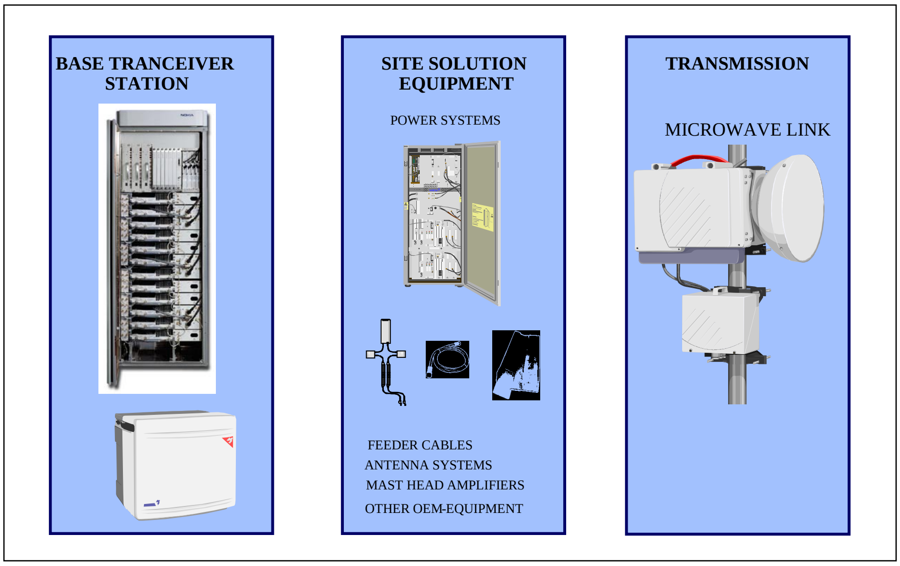


Figure 15: The base station site

A *Base transceiver station (BTS)* consists of transmission units, power supply, cabinets, mechanics, filters and combiners. *Site solution material (SiSo)* consists of special equipment needed for installing a working base station site for particular circumstances. These are products like additional power systems, antennas, antenna lines, feeder cables, amplifiers, combiners and a number of accessories. *Microwave radios (MWR)* enable a cellular transmission when a fixed line is not available. A typical delivery package of a complete base station site includes three crates that total around 5 cubic metres and 800 kg. One site-specific order consists of around thirty order lines.

4.1.2. The BTS site implementation process

One can easily say that understanding the base station site implementation process of customers (demand chain) is a pre-requisite for making equipment deliveries (supply chain) work in practise. The general process for base station site implementation is therefore described in detail below. The main phases of the process are network planning, site acquisition, construction work, equipment delivery, installation and commissioning, and finally the integration of the base station into the GSM network. Only after the site is integrated with the network can it start making money for the operator. Therefore, the main target for the operators is typically to maximise the throughput of the whole site process, instead of optimising individual phases in it (for instance, the delivery part). The phases of the whole process are also illustrated in Figure 16.

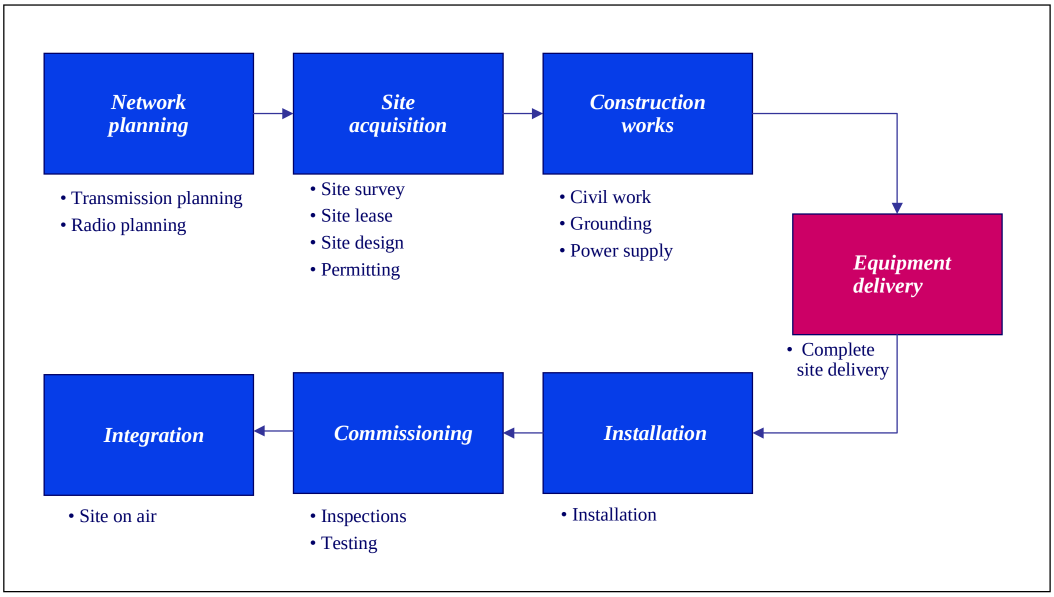


Figure 16: Base station site implementation process

Each of the phases is described more detailed below.

- ***Network planning*** is the phase in the site process when the number and locations of base stations are planned based on the network capacity requirements provided by the operator. It includes both transmission and radio planning.

  The aim of transmission network planning is to turn the operator's business plans into an optimal technical solution. The cellular transmission planning process can be divided into two levels: master planning and detailed planning. Master planning is a higher-level plan and it contains preliminary plans and calculations, such as topology plans and capacity calculations. It defines the framework of the network implementation taking into account future expansion needs. During the detailed network planning process, the master plan is enhanced by adding detailed information that is required by installation, commissioning and integration engineers. The planning is performed based on requirement specifications provided by the customer (for instance, number of subscribers, signalling rate, performance requirements, protection level and site candidates) and information provided by a separate radio network planning team (for instance, total number of base stations and average number of transmission units per one base station).

  The aim of radio network planning is to fulfil the network operator's requirements for coverage, capacity and quality at minimum cost. Therefore, the network planning is an optimisation process, which begins from rough calculations and sketches proceeding to detailed network plans. The aim of the rough calculations and sketches is to estimate the number of required sites and to predict the coverage in the given area. During the detailed planning, the rough calculations and sketches are developed to better correspond to the reality in the coverage area. The detailed radio network planning provides the information on cells and sites that is required by installation, commissioning and integration engineers. The radio network planning is a continuous process as well, since a close follow-up of the network is needed during network development and expansion.

Typical plans and documents generated by this procedure are: master planning, topology plan including media and technology selections, capacity calculations including future expansions, initial synchronisation plan, general network layout drawings, general transmission management network plan, and detailed plans on the microwave, 2 Mbit/s links and time slot allocations.

- ***Site acquisition*** is to ensure successful locations for base station sites based on the information from the transmission and radio plans. The phase consists of a number of parallel activities. It normally starts with site surveys where those sites that fulfil the planning criteria are qualified and other missing or complementary sites and their respective search rings are established. Site acquisition continues with ranking all the potential site candidates and conducting pre-validation for the sites. After the pre-validation phase, the next step is to conduct a transmission-line of sight survey that looks for a transmission solution for the site. Transmission may be through a microwave radio link or by a leased 2 Mbit line from the local PTT operator or other supplier - in some cases this might be the customer itself. If the solution requires a leased line, the request to the line supplier should be made after the final site validation. At this point of the site acquisition process many tasks can start simultaneously. The lease negotiations with landlords can be begun, detailed site design can be made, and the preparations for getting the site permit from local authorities can be finally started. Depending on the local situation, a permit application can be submitted either after the lease contract is signed with the landlord, or in some cases before, if the landlord refuses to sign before the permit is received. The site acquisition phase can be considered to be over only after all related permits are received. The whole process may easily take several months.

- The ***Construction work*** phase is to build the site location so that the equipment can be safely installed. The phase includes a number of activities, starting with the preliminary construction work for the site location (groundings, power supply, etc.). There are many different options for how to build the site depending on its location. The site may be situated in a city centre where aesthetic and traffic requirements typically determine how it should be constructed. Another option could be to have a site located next to a highway that always has a lot of traffic and where the constructions work, therefore, might be very challenging. In rural areas, base station sites are often constructed in high places or on radio masts to get maximum coverage from the base station.

  Thus, there can many kinds of conditions for the construction work. It is therefore difficult to estimate the exact time needed to complete this phase. Many surprises can take place during construction. Only after the site is ready for installation can one say exactly what configuration is needed for the site and when the installation can begin. The completion of the construction work, normally, is still verified with a separate site visit. After the visit there is a meeting, called a pre-installation site meeting (PISM), to confirm the exact start date for the installation. This is also the moment when site call-off order for material is normally made.

- The ***Equipment delivery*** phase naturally includes all the delivery related processes for material deliveries to the site. In practise, there are many ways to delivery products to the site. However, typically they are delivered from a local drop-off point where the site delivery package is already waiting for installation. This is the phase when the actual base station, related site solution material and possibly a microwave radio link are delivered to the site for installation. It is extremely important that the site delivery take place at the right time for the installation team, because there normally is not any place to store the material at the site. The products either need to be received by the installation team at the site, or the team needs to pick up material from the locally managed drop-off point.

  The integration of site deliveries with the time of installation is extremely important in this business environment.

- ***Installation and commissioning*** is to implement the base station site in the GSM network. The phase starts with material delivery inspection by the installation team, as the received equipment is compared to the information in the packing lists. If the site has not been accepted during the site inspection done after the construction work, the installation team verifies the readiness of the site before starting its installation activities. If everything is fine, the installation can start according to the 'site specific' installation work instructions. Typically, there is a checklist to be followed and filled in during the installation. Possible deficiencies, which are quite common, are always recorded in separate site deficiency reports and faulty units are recorded in the failure reports accordingly. Electronic bar code reading is utilised whenever possible.

Installation inspection is an important work phase in the implementation. The purpose of the inspection is to ensure that the installation and the related result documents in the Site Folder have been completed correctly and to finalise the documents related to the work. This phase is important for assuring the good quality of the work because minor defects may cause huge problems in the whole system. For each new installation team the inspection is often done by an installation supervisor according to the steps defined in the checklist used in the work and the installation team members have to participate in the inspection. During the first inspections the main emphasis is on the actual installation work. Later the inspection is based on the work documents (outputs). The Installation Supervisor authorises the Installation Team to carry out the inspection independently as soon as the Team can take responsibility for the quality of its work. This does not invalidate the regularly performed quality follow up. It is also essential for installation teams to update project plans based on the facts of the installation. Often installation is the invoicing trigger for the customer order.

After the actual installation, the next step is to commission the site when the network element is tested to ensure that its units are functioning properly after transportation and installation and to make it ready for integration. There also have to be comprehensive instructions for each commissioning step. Possible new deficiencies are recorded in separate reports. The commissioning work phase is completed with the recording of the hardware configuration electronically with a bar-code reader. Hardware configuration information is needed for the warranty period of the network element.

- ***Integration*** is to complete the base station site implementation process. It takes care of integrating the individual base station with the rest of the GSM network.

4.1.3. Business scope types

There are different ways to deliver system solutions to a customer's cellular network. In this study three general categories to deliver GSM products are used. These three types of business scope for a supplier to deliver products are called (1) "turnkey", (2) "telecom deployment" and (3) "box delivery". The business scope is fundamentally defined by a customer's value chain strategy as described below.

"Turnkey"

The strategy of this value chain is to outsource the whole network building-project to one, or a few, key system supplier(s). This means that the whole site implementation process is covered in one supply contract. The system supplier is responsible for network planning, site acquisitions, construction work, equipment deliveries, installation and commissioning and integration into the network. Agreed business scope is that the system supplier delivers to the operator a complete GSM network solution that is designed and implemented according to the rough specifications of the customer. From the supply chain management viewpoint, everything is in one's hands and this should enable maximum integration of logistics with the site implementation process. Still, the reality is not so black and white, as there are different levels of turnkey contracts in the markets. Operators also want to be involved with decisions about different delivery modes.

This value chain strategy is typical for operators that want to rapidly enter markets to gain market share. Turnkey mode is often selected as a business model in the beginning when main emphasis is getting the network launched. Later when the network is up and running the mode is often switched to telecom deployment or box delivery mode.

"Telecom deployment"

This is a value chain strategy where the system supplier is ordered to deliver and install the complete base station site, but the order does not cover any services prior to base station delivery (for instance, network planning, site acquisition and construction work). This type of business scope basically enables system suppliers to integrate itself with the site implementation process, but the project team now consists of participants from both the customer and supplier organisations. This naturally makes the integration of supply chain to customer's processes even more important than in turnkey contracts.

This strategy is typical for operators who already have a network in operation and want to continue increasing its capacity. This mode is often a continuation of the turnkey contract after the network has been launched and focus shifted to an efficient expansion of the network. Compared to turnkey contracts the telecom deployment mode easily enables the use of several system suppliers to expand the network capacity.

"Box delivery"

This value chain strategy refers to a business model where the customer purchases individual network elements from the system supplier. Thus, there are no services embedded in the deliveries; rather, the operator itself is responsible for the network planning, site acquisition, construction work, installation and commissioning and integration to the network. Typically, in this business model there are several system suppliers providing base stations for the network. For the suppliers, this mode is very straightforward, as they deliver only individual base stations ("boxes") according to the specifications defined in customer orders. From the overall supply chain management perspective, the main challenges are linked to the questions of how equipment deliveries can effectively be linked to the site implementation process, as there are several suppliers involved. Therefore, the operator typically keeps the inventory of base stations itself to ensure smooth flow of the implementation.

This value chain strategy seems to be typical for telecom operators that have been in the markets for a long time and which already have a relatively mature network. The focus is often to improve and optimise the performance of existing network. Moreover, this strategy fits well for those operators that want to keep several system suppliers. These GSM operators are usually old PTT companies, which have strong market share.

It is essential to understand the main business drivers for these different value chain strategies in order to make the correct decisions on the supply chain solutions. It is also important to estimate the development of these business models when supply chain strategies are planned for customers. General trend in the industry seems to be that a customer's value chain strategy develops over time in line with the progress of network building project. In an early phase of the network there are more turnkey type of contracts in the markets, whereas the telecom deployment mode is often the preferred solution when focus is on expanding the capacity of network. Box delivery mode is clearly a dominant mode when markets are getting matured.

4.1.4. Supply chain integration with the BTS site implementation process

The management of the supply chain of base station deliveries to an implementation site is only one aspect of the whole picture as discussed earlier. However, its importance to both operator and supplier current assets – and thus to profit generation - is significant. For instance, if the material needed for one base station site (the value of each site is about equal to a new Mercedes-Benz in) had to be stored one single, additional day before installation and integration could start, it would roughly mean around 100 Euro extra inventory carrying cost. When considering that an average sized cellular network normally includes several thousand base station sites, the sum easily increases dramatically. Further, if the idle time were ten days on average, the sum thus would have to be multiplied by ten. Therefore, it is more than justified – both for the network supplier and the operator - to focus on streamlining the supply chain for base stations and on tightly integrating their deliveries with the network rollout project. This would improve inventory rotation in the whole chain.

The main challenge of supply chain management in delivering base stations for a GSM network is linked to the question of how the integration of physical deliveries to the site implementation process succeeds. The need for integration basically covers all the phases in the supply chain. It starts with demand plans that are derived from realistic network rollout plans for the building project. Then there is a point in the site implementation process where the final ‘site specific’ order can be placed. Although the location of the order triggering point varies between different projects, it must always be linked to the site process. Based on the order, the site delivery can take place. The requirement for the lead-time should basically define the supply chain mode; for instance, whether the products are delivered from a plant or from a local warehouse. After delivery, the invoice is drawn up. Although it is not necessarily site based invoicing, it still should be to linked to the site implementation process. This is also illustrated in Figure 17.

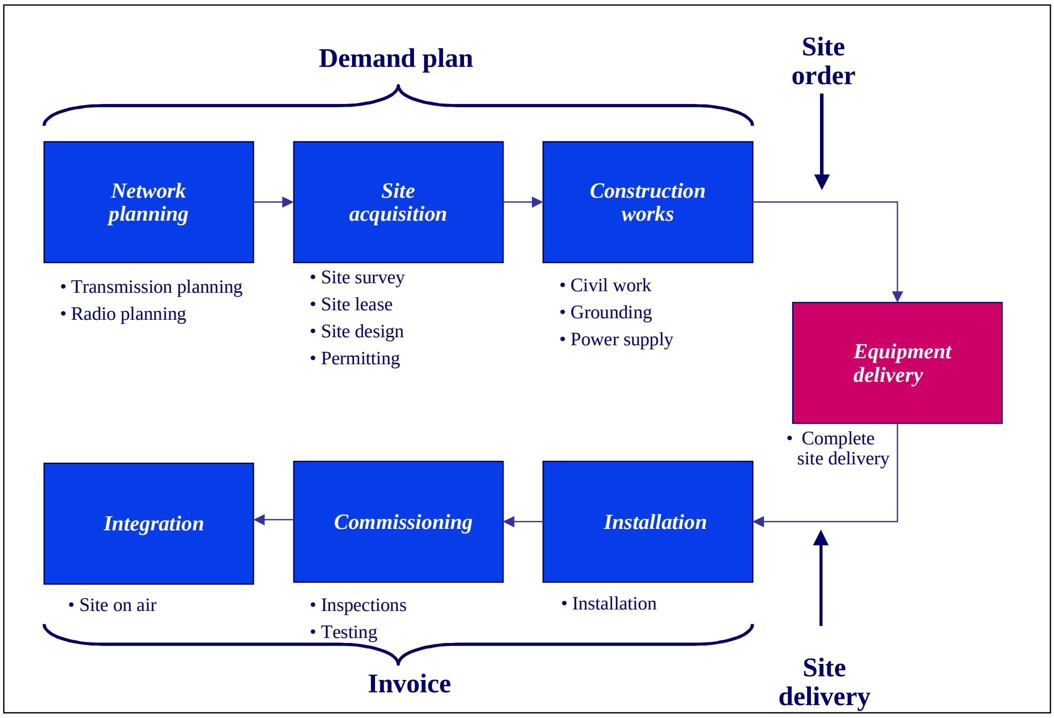


Figure 17: Integration of equipment deliveries with the site implementation process

These different linkage points between the site and logistics processes are described below:

- *Demand plan:* The constantly changing network rollout plans should be used as the basis for demand plans throughout the supply chains. The plans are updated once a month and the information delivered via Nokia plants to the base station component suppliers. There are standard calendars, items and roles for the planning process.

- *Site order*: The site specific order can be made only after the following three variables are known by the project team: product configuration, site location and installation time. This is often difficult to know weeks beforehand. Therefore, buffering is often needed.

- *Site delivery*: The actual delivery takes place to the site either from a local warehouse, or via a drop-off point from a regional distribution centre or plants. It is important to understand the

- *Invoice:* Invoicing is done only after the site is delivered. In box deliveries, the invoicing trigger is normally with the delivery. For telecom deployment, it is when the site is implemented and commissioned. For the turnkey, it can be anything, not necessarily site based invoicing.

The main challenge in delivering base station equipment for a particular site is linked to integration problems The equipment delivery phase means the actual supply of the equipment, including ordering, production or buffering, picking and packing and transportation to installation teams. Site-specific deliveries are shipped to a drop-off point, which is located in the region where the implementation takes place. From there, the installation teams pick up the equipment when going to the site. This supply chain mode defines the time that a project team needs to wait for equipment after the pre-installation phase. In this stage, if equipment is ordered from the plants the idle time for the project naturally is longer than calling for equipment from a local buffer. The main questions are *(1) what the right order triggering point is in order not to build-up unnecessary costs in the demand-supply chain by ordering material too early and (2) what lead-time is needed for the project in order not to delay the complete site implementation process*. The combination of the right order triggering point and the lead-time requirement forms the core challenge in integrating equipment deliveries (supply chain) with a customer's project rollout (demand chain).

4.2. Program’s life cycle

At the very beginning of the program, there was agreement to follow a cross-functional re-engineering scheme that implements a new way of working within the end-to-end supply chain. Target was to provide operators fastest time to profit with their cellular network and radically reduce inventory levels in the whole end-to-end chain. The program basically affected major parts of the Nokia Networks organisation, involving people from account and area management, manufacturing, global and local logistics teams, customer service and information management organisational units. The changes were activated from the beginning of 1999 onward and the closing took place at the end of 2000. The whole life cycle of the program is described below.

4.2.1. Stage 0: Initiation

The supply chain for innovative products should be responsive in order to respond to varying customer needs, as concluded in the literature review part. The starting point for base station equipment was also to have a responsive supply chain in place to meet the different needs of GSM operators. It was noticed already at the beginning of the program that the background and market situation for different operators varied considerably. The network-building projects could also be in totally different stages, which also greatly affects the requirements for the demand-supply chain. Starting to build GSM network coverage from scratch in a new country is completely different from expanding capacity in some rural regions in an already existing network. Furthermore, if an operator is an old, state owned PTT-company or a new, aggressive challenger without any experience in the operator business, these customers certainly have disparate needs.

Therefore, it was consciously decided at the beginning of the BIRD program to build the supply chain flexible to respond to the needs of different customers on a case-by-case basis. Before the program's implementation phase actually started, there was no clear vision or proper understanding of how to build the delivery processes around different customer cases and how they should be developed during network construction.

The starting point in most network-building projects was that there was a project-specific warehouse operated locally either by Nokia or the customer itself. Typically, this was not a desired process, but merely a result of unstable and not-standard working practises between project and logistics teams. Most customers placed base station orders based on information that was retrieved from their existing network rollout plans. The material ordering was done well in advance in order to ensure that the equipment was available when the site was ready for the installation phase. However, it was very typical that customer rollout plans changed during the equipment delivery process. This naturally caused enormous problems within deliveries, as the wrong material arrived at the wrong locations at the wrong time.

It was decided in the early phase of the program that the supply solutions needed to be created through real-life business cases. It was also considered extremely important to get customer involvement at the very beginning. The process implementation for individual customer project should include elements from sales contracting, demand planning, the order-delivery process and project management. In practical terms, the main focus, however, was to integrate base station site – including base station, site solution material and microwave radio equipment - deliveries with customer network project rollouts, and thus to significantly improve inventory rotation in the whole demand-supply chain.

4.2.2. Stage 1: Customer pilots

The solution to the existing problems within deliveries was the identification of two different supply chains piloted with three customer cases during the first half year. These were (1) direct delivery with two customers (the first customer was an experienced big operator and the other was a new challenger with very little previous experience in the business) and (2) a country buffer with a PTT operator that had just started to expand operations into mobile networks. At that time, it was agreed that the direct delivery chain would be the target mode for all customers, whereas a country buffer was supposed to be only an interim step before going to target mode.

However, the lead-time difference in projects in these two separate modes was remarkable – as were the cost implications. Based on experiences from these three pilots, it was understood that these two modes were not sufficient to fulfil the various needs of all customers. It was also difficult to see that the chain could be easily developed from buffer towards direct delivery mode, since the lead-time gap was so big. Thus, a third mode, the regional distribution centre (DC), was created in parallel with rolling out the first two modes.

The process changes were extensive, affecting all parties in the chain, including the customers, Nokia customer service and plants, implementation sub-contractors and logistics service providers. As a result of the changes, customers were to get improved delivery lead-times and better delivery quality. However, it also meant that they needed to provide accurate forecast information to Nokia and to follow more standardised working practises when making call-off orders for base station sites. For Nokia, the changes were more visible and drastic, for instance for some people in sales and marketing, customer service, logistics and production the changes led to new working practises - gradually leading to more process-oriented thinking in each step inside the company, which naturally required strong adaptation from the organisation. For implementation sub-contractors and other suppliers, the changes were seen as more speed and standardised co-operation with Nokia.

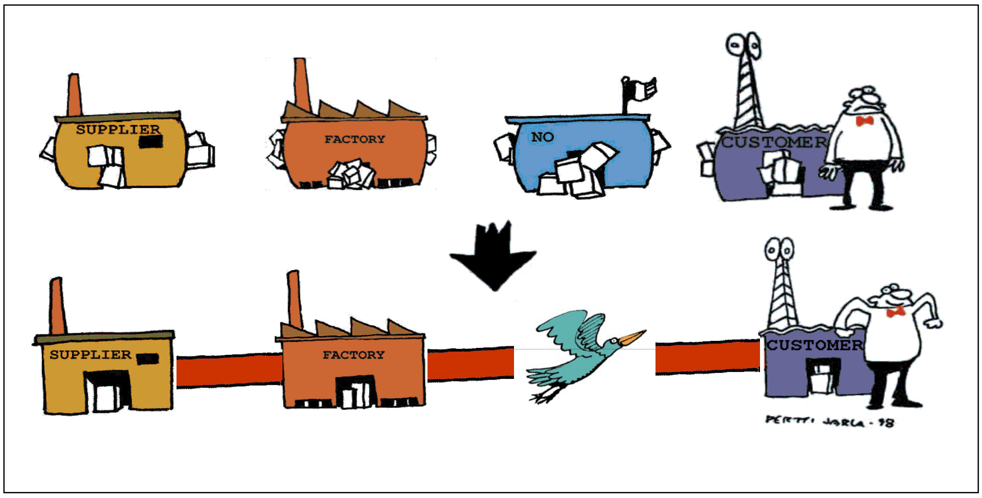


Figure 18: BIRD to streamline the end-to-end delivery process

The basic elements that the process implementation covered are all somehow related to the management of the demand-supply chain. The implementation of a rolling demand planning (forecasting) process together with the customer is one of the key elements. The main focus in the forecasting process is on finding the most reliable source for planning and distributing the info on a monthly basis throughout the whole chain to all parties. Another important element is the integration of logistics processes with customer project management. In practice, it means shared planning and control of daily work, using a clear order trigger point, site specific equipment deliveries with JIT principles to drop-off points that are easily available for implementation teams, and an accurate and simple invoicing process. Naturally, this requires the seamless integration of logistics service providers in the whole delivery. The use of the optimal mode for physical distribution with standard lead-times is the key part of this process implementation. Furthermore, it includes the measurement of standard process metrics, like lead-time, delivery accuracy, inventory rotation and planning accuracy.

4.2.3. Stage 2: Towards a regional distribution centre

During the first customer pilots it was realised that the two alternative supply chain modes; i.e., direct delivery and country buffer, did not suffice to provide all customers with a successful supply solution. There were some customer projects that considered the direct factory delivery lead-time too long but did not want to start buffering material locally. The lead-time requirement was in the middle of the lead-times in the country buffer and direct factory delivery modes. There was a clear need to have a supply solution that could provide customers with some flexibility through shorter lead-times, but at the same time did not build customer-specific buffers in the supply chain.

The answer was the regional distribution centre, which was established as a new supply chain mode during the BIRD program. The new concept was built together with two customers. The creation of this mode was activated in parallel with implementing the existing two delivery modes to other customer projects. Thus, there were created in total three alternative supply chains to the traditional warehouse delivery mode.

4.2.4. Stage 3: Industrialisation

In the beginning when targets were clear, but the means (processes) were often still undefined at an early stage, it was crucial to get the main communication message through and not to confuse people with the new, unproven processes. Therefore it was decided to pilot the detailed delivery process with 2-3 customers first and only after that to fix it and start full-scale implementation inside Nokia Networks. This approach was clearly appreciated by everybody, including the customers. Without have any practical experience, it is really hard to convenience anybody to change.

Process industrialisation also continued on an account basis; that is, process implementation was done customer by customer. Co-ordination and scheduling of different implementations was the responsibility of the program office, which also created and further developed the standard implementation approach. A rollout project was established for each implementation, including Nokia Network personnel from local account teams, customer service, logistics and 1-2 implementation experts from the Nokia Networks global organisation. Key personnel from factories took part in the first customer rollouts, afterwards they continued to provide support remotely when needed. Customer involvement in the process implementation was defined on a case-by-case basis.

A standard implementation project approach for an account is described below. It consists of three phases: preparation, implementation and follow-up. This is also illustrated in Figure 19.

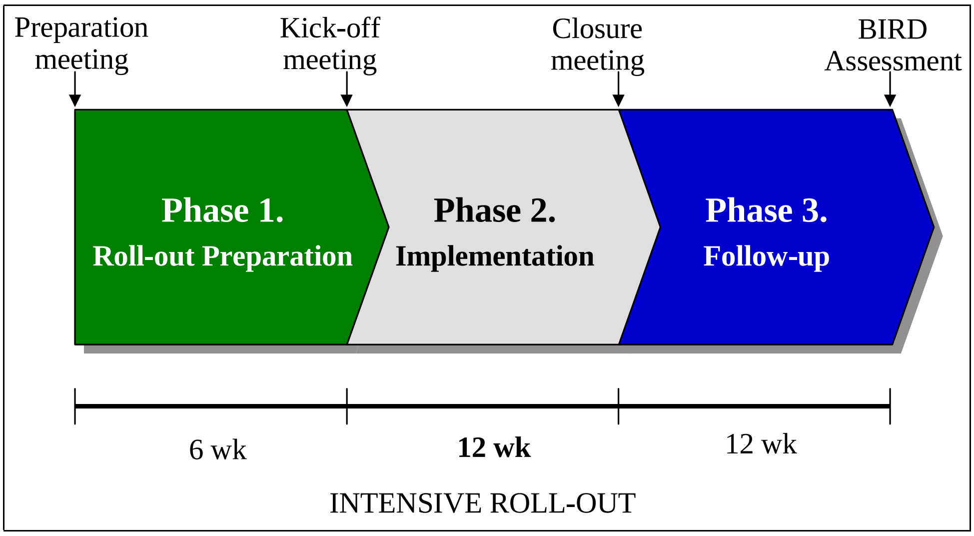


Figure 19: The BIRD implementation approach for a customer

Typically preparation time takes around 6 weeks, during which the correct timing, resource allocation and targets are agreed internally and with the customer. After this the actual process implementation phase starts, where the detailed process is defined, changes implemented and people are trained. Normally it takes around three months per customer. After the process is implemented and new working practises applied, another three month follow-up phase starts. This is meant to control and monitor that the implemented process really works and provides the agreed improvements.

Based on the experiences, it makes sense to have a clear and standard approach for how to run the process changes even though each customer case is different. The common approach makes life easier in many ways; for instance, in communicating schedules and learning.

4.2.5. Stage 4: Closing

The main achievements of the process re-engineering deal with enhanced collaboration between different parties in the end-to-end supply chain. The changes significantly improved the common understanding of the complex business system, improved visibility in the demand-supply chain and made the integration of physical deliveries with the site implementation process possible. The changes also built the relationships between the project and logistics teams. Moreover, there were clear financial benefits, as the end-to-end inventory rotation improved radically. For instance, for DOS (Days of Supply) in outbound part was reduced 56 percent.

4.3. Alternative supply chains

The alternative supply chains are distinguished by the location of the order penetration point. As discussed, it is essential for the success of a supply chain that a supply solution for customers be designed to responsively meet their specific requirements. It is not the costs of the supply chain that matter for the operators, but the effectiveness of the whole site implementation process. The throughput of a network project can be risked by optimising only the efficiency of the supply chain. The market situation and operator background can vary a lot. Therefore, alternative supply chains are needed. The starting point, when designing the right solution for the operator, should always be an understanding of the customer situation.

The alternative supply chains that were used within the BIRD implementations are (1) traditional warehouse delivery, (2) country buffer, (3) regional distribution centre and (4) direct delivery modes. The way the location of the order penetration point varies in the supply chain is illustrated in Figure 20. Most upstream supply chain solution is represented in the illustration by the top left corner, and most downstream solution accordingly by the down right corner.

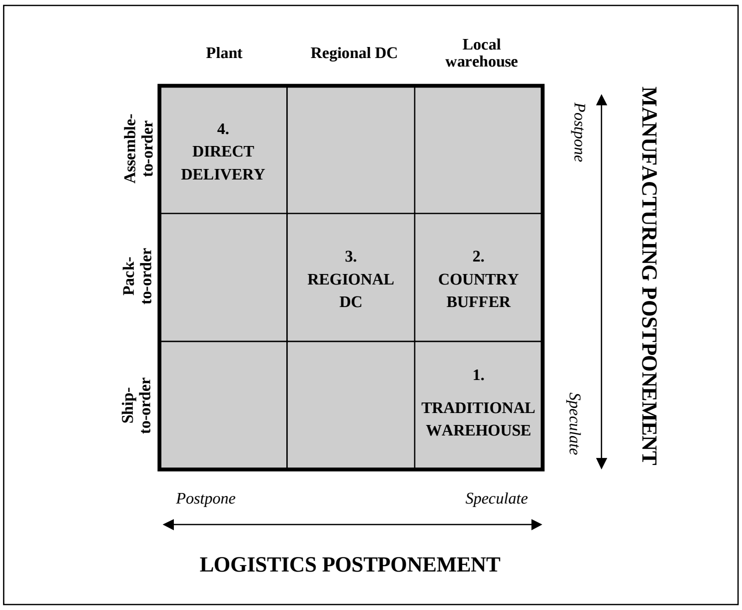


Figure 20: The alternative supply chains

Each of the supply chain modes is described in more in the next sub-chapters.

4.3.1. Traditional warehouse (ship-to-order mode)

The most common way of working within supply chains for base station equipment is called the traditional warehouse delivery mode. This was the starting point in most customer specific BIRD projects, before the processes were re-engineered. Either the operator or Nokia’s local subsidiary warehouses stored ready-made base station configurations for the network building project team. In this mode, the site specific ordering is made based on the rollout plans. The ordered material, which is already configured and assigned to a particular site, arrives at the local warehouse to wait for the final site call-off order from the project team. As/if the call-off is received, the material is shipped out from the local warehouse to the site.

In this case, the order penetration point is located downstream in the chain, because the finished products, the configured base station sites, are ordered and delivered from the plants based on forecast information, and because the final customer order, as it arrives, is delivered in the ship-to-order mode. Thus, both the manufacturing and the logistics postponement levels are very low. Orders are made based on speculative forecast (demand plan) information.

In the traditional warehouse delivery mode, the manufacturing postponement level is downstream in the supply chain, because ready-made base station configurations are stored for the customer based on forecast information. Due to easily changing site implementation plans, this supply chain mode involves high product obsolescence risks. For instance, if the site design is changed during the site acquisition process, the base station configuration might not be usable anymore and the material might need to be cannibalised or returned back to the plants.

The logistics postponement level in the traditional warehouse delivery mode is also located downstream, as the material is stored in the local warehouse, close to the customer. This option naturally embeds additional inventory carrying costs in the process. These costs might even be unnecessary; for instance, if the site construction work is delayed.

The successful use of the traditional warehouse delivery mode seems to have one strict requirement, that project plans are always reliable. Otherwise, the risk of having problems with deliveries is likely. This requirement of always having a reliable project plan available, however, also enables the successful use of direct factory deliveries, since the delivery lead-time should not be an issue for project teams. As there are not that many benefits from this mode, it was decided by Nokia to not support this supply chain anymore.

4.3.2. Country buffer (pack-to-order mode)

A country buffer is the supply chain mode that enables very short product delivery lead-times, but still allows some flexibility in terms of product configurations. The detailed processes applied in this delivery mode were developed during one of the BIRD customer pilot cases. The basic idea is that base stations are buffered in a warehouse for particular customers as in the traditional warehouse mode, but the buffering is now done as standard units and modules, instead of ready-made configurations. The warehouse, managed by an experienced logistics service provider company, is located close enough to the customer to enable fast deliveries around the whole country.

Base station call-off orders are filled at the warehouse by combining the ordered units and modules during the packing for the specific site delivery package, which means that this is a pack-to-order delivery mode. The way it differs from the tradition warehouse mode is the level of manufacturing postponement. Now, the site delivery is made during the picking and packing process. Therefore, this is also further upstream in the supply chain than the traditional country warehouse mode. The material is not ordered from the plants as configurations but as units and modules that can be combined effectively into a number of configurations. The buffer is replenished from the plants in pull-mode (Kanban cards were used). The buffer levels are defined by the rolling demand plans, which are based on the network project plans.

Compared to the warehouse mode, the logistics postponement level in the country buffer remains the same. The material is delivered downstream close to the customer in order to guarantee short lead-time for site deliveries. The benefits are achieved through the possibility of last-minute product configuration. This requirement, obviously, is needed by some network building projects, and the country buffer is a solution for it. The mode is naturally quite costly compared to direct deliveries. The site delivery lead-time in the country buffer mode is between hours and a few days.

4.3.3. Regional distribution centre (pack-to-order mode)

The regional distribution centre mode means that base stations, site solution material and radios are all buffered in a European distribution centre as standard units and modules. In other words, it operates in pack-to-order mode, which is similar to the country buffer supply chain. However, the major difference is that the buffer is not dedicated to any particular customer; rather, it serves several operators. By doing this, it can achieve major economies of scale. The regional distribution centre is located in a central position in Europe (in the Netherlands) to enable short lead-times for most customers. As the material is buffered on a unit and module level, it is in practice possible to support all possible base station configurations.

When a ‘site specific’ call-off order arrives from a customer project team, a shipment is picked and packed in the distribution centre according to the specification in the order, and then transported to a destination drop-off point for the project teams. The drop-off point is a building (with a locked door) where the product can be delivered and where it can be safely stored for a while. It is not a warehouse as such, but only a place where material can be left for pick up by the installation team. Typically drop-off points are located according to the project regions. Each region has its own drop-off point location where material is checked and unpacked before going to the site.

Similar to the country buffer mode, replenishment orders are made to the plants in pull-mode and the buffer levels are defined based on the monthly demand plans. Although there are no clear benefits from the manufacturing postponement, the logistics postponement level is clearly further upstream as the material is not delivered downstream before the final site call-off order. Moreover, the buffers are not dedicated for a particular customer anymore.

An average delivery lead-time from the distribution centre is around one week. As the equipment lead-time for a project is squeezed to one week, order triggering is to be when a site is ready for implementation to avoid ordering material to the drop-off points too early. Naturally, buffering causes additional costs for the customer's supply chain, and the overall flexibility is not as good as in direct delivery mode. However, the shorter lead-time is a clear benefit for the project

4.3.4. Direct factory delivery (assemble-to-order mode)

The direct delivery mode supply chain, obviously, is the most cost-efficient and flexible (in terms of product configurations) solution. Therefore, both Nokia and customers consider it to be the most preferred option. Generally, it is the target delivery mode. The location of the order penetration point is upstream in the chain.

The manufacturing in the plants is postponed until the customer order is received. The manufacturing of base stations operates in assemble-to-order mode; that is, customer orders are filled by assembling units into their final configurations. There are around thirty suppliers that manufacture components for base station assemblies. They ship material to the plant where the assembly is carried out. The logistics postponement level is also upstream, as the deliveries take place from the plant where they are also assembled.

Site deliveries are also delivered to drop-off points as in the regional distribution centre mode. For customers that want to have their own warehouse, the direct delivery mode means deliveries from the plant to the customer warehouse. In these situations, the direct delivery mode is actually the only reasonable supply chain selection. There might be customer cases where site delivery consolidation is needed somewhere in the chain during the delivery process. An example would be when a complete site is ordered with products from the base station factory, the microwave radio factory and the supplier of site solution material. The delivery consolidation is then done at the distribution centre, in the Netherlands, before the complete site is delivered to the project team.

The average delivery lead-time in the direct delivery mode is around a few weeks. For customer project teams this, in practice, means that site specific call-off must be frozen a few weeks before the planned installation date, which means that the project plan has to be reliable in order to avoid material arriving too early, to the wrong location, or in an incorrect format. Otherwise, the direct delivery mode is not a workable solution.

5. 'A PRIORI' RESEARCH CONSTRUCTS

This chapter introduces the 'a priori' research constructs and operational study propositions that are used and replicated through each customer case study in this research. The purpose of these study propositions is to direct attention to items that are examined within the case analysis units. The propositions are mainly derived from the applicable theories, models and concepts introduced in the literature review chapter. The purpose of this chapter is to implement these study propositions to fit the business environment of the customer case studies.

The basic axiom in this research, the contingency theory of organisations explicitly states that there is not one best way to organise; rather, it depends on the environment (Lawrence and Lorsch, 1967). This assumption is applied in the thesis as follows: "There is not a single supply chain mode that is suitable for all customers, rather the selection of the right chain depends on the customer's business situation." Based on the reasoning of the technical norm, which was discussed in the research methods chapter, it is necessary to divide the research constructs into three elements: (1) situational factors, (2) means and (3) ends. This is also shown in Figure 21.

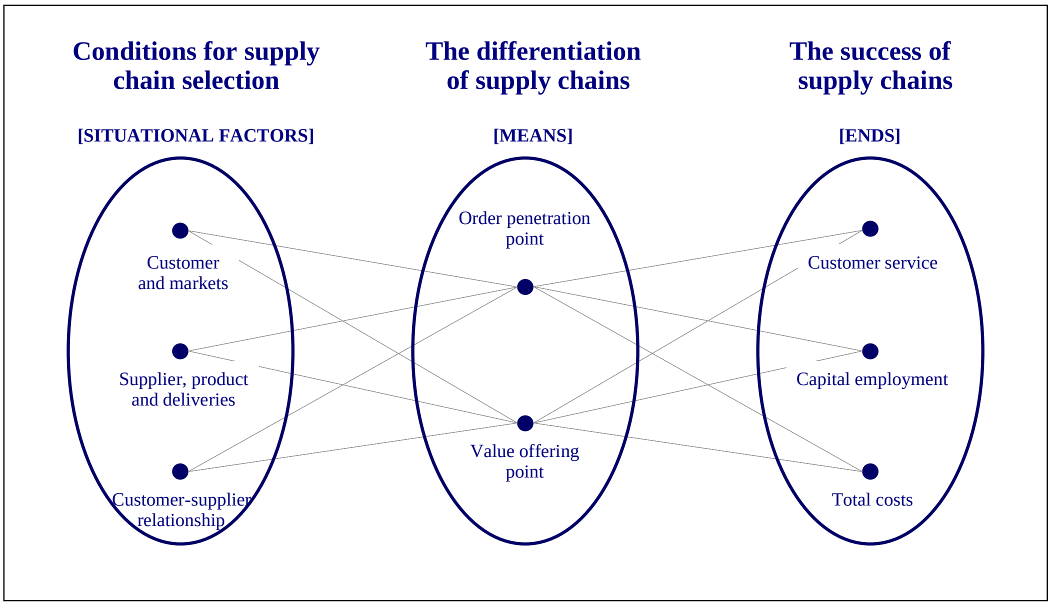


Figure 21: The research constructs

The research construct elements, based on the literature review, can be broken down further. First, 'systems thinking' implies that the actors of a system, their respective co-evolution and the system environment form determinant conditions for the supply chain selection. Thus, we conclude that the following three conditions (a) customer and markets, (b) supplier, product and deliveries and (c) customer-supplier relationship are used to study the situational factors. Second, it was noted that the locations of (a) value offerings and (b) order penetration points are considered to be effective means to differentiate supply chains. Third, we can conclude from the literature review that the ends of a successful supply chain are the following three simultaneous dimensions (a) customer service, b) capital employment and c) total logistics costs.

Each of these constructs is now developed further into operational level measures, which include both quantitative and qualitative data.

5.1. Conditions for supply chain selection (situational factors)

Customer and markets

The strategic situation of operators in GSM markets, intuitively, must also have a significant impact on the requirements of supply chain management in the network infrastructure business. A comprehensible example is a situation where a GSM operator wants to improve its strategic position in the markets and to rapidly increase its market share. Perhaps, the very first thing for the operator is to ensure that there is blanket coverage and enough capacity in the network, before it can even start planning any aggressive marketing campaigns. Obviously, the main focus in the customer's network building project is to maximise the throughput to provide sufficient conditions for network functionality. This also means that the effectiveness and flexibility of supply chain management are highly appreciated by the customer. Whereas in a situation where the operator wants to optimise the usage and capacity of its network, the main focus is probably more on cost-efficiency aspects.

The literature review suggests that the stage of the technology life cycle, the competitive position of customers in the markets, and their value chain (and the whole value system) play a central role in setting up determinant conditions for the supply chain selection. The detailed operational measures are defined based on this theoretical framework.

- ***Technology life cycle***

  The theory of life cycles describes the typical evolution of how market demand behaves over time for new technology and product innovations. It is also assumed that the demand in GSM markets behaves according to this theory. Therefore, the stage of the GSM technology life cycle is expected to have a significant influence on the requirements of supply chains.

An operational measure used to analyse these impacts is the development of GSM penetration in the country where the customer operates. The measure of GSM penetration is defined as follows:

(1) $$GSM\ penetration\ [\%] = \frac{Nbr\ of\ GSM\ subsrcribers\ in\ the\ country}{Nbr\ of\ inhabitants}$$

- ***Competitive positioning***

The Boston Consulting Group model describes how rival companies can be positioned in the same markets, and explains how a company’s strategy should be aligned based on that position. It is assumed that the competitive position of a GSM operator also influences the supply chain management of a base station.

Key operational measures are the development of market growth and the operator’s market share.

The development of market growth is specifically measured as follows:

(2) $$Market\ grotwh = Increase\ in\ GSM\ penetration$$

The relative market share of a GSM operator is measured as follows:

(3) $$Market\ Share\ [\%] = \frac{Nbr\ of\ GSM\ subsrcribers\ in\ the\ country}{Nbr\ of\ GSM\ subscribers\ in\ the\ operator's\ network}$$

- ***Value chain and value system***

Based on the literature review, the concepts of value chain and value system indicate that sustainable competitive advantages can only be achieved through value adding activities, which are performed either at a lower cost or in way that leads to differentiation and a premium price compared to its rivals. Those activities done inside a company make up a value chain, and activities inside a particular industry a value system.

An important aspect is to understand which part of the operator's value chain is outsourced to system suppliers; that is, which primary activities in building the GSM network are carried out by the operator itself and which by system suppliers. Therefore, it is essential to understand what the value chain looks like for individual operators. It basically specifies the scope of the business to its suppliers.

(4) *The business scope* of suppliers determined by a customer's value chain.

Supplier, product and deliveries

The supplier and its business environment certainly have major impacts on the supply chain selection. This must be crystal clear for everyone. This study, however, is focused on the case study approach within the setting of a single supplier. In other words, the same supplier (Nokia) delivers to all the customer cases in the research. This fact – which was taken into account while setting up the problem and scope for the research – leads the study to not be so interested in the supplier specific factors (plant locations, manufacturing process, organisation, etc.), which in any case are standard for all customers. Here, the focus is explicitly on customer specific issues within the supply chain; for instance, things like what kind of role the supplier has, what the product scope is, what the delivery scope is and what the performance of deliveries to the customer has been.

The following two theories, which were discussed in the literature review, are used for creating detailed study propositions (1) Just-In-Time delivery and (2) project management. The detailed operational measures are defined based on these theoretical frameworks.

- ***Just-In-Time delivery***

The content and timing of deliveries are also the main elements of a successful delivery system in the GSM network business. The content of base station delivery packages is agreed with individual customers beforehand. A supplier may deliver the whole package that is needed to install the product, or it may only deliver the core technical element for which the customer has to purchase add-ons (antenna cables, installation material, etc.) separately. The content of a detailed product portfolio, which is always agreed with the customer in the contract, might significantly influence the supply chain selection. In this business context, product portfolios with a wide range of products, typically, represent the flexibility of supply chains.

(5) *The product portfolio*, which is agreed between supplier and customer in the contract, defines which items are deliverable as a part of a complete base station site package.

Another essential factor discussed in the literature review is related to the timing and commitments to delivery schedules. In project businesses in general, it is important that everyone knows the delivery schedule so that it is possible to synchronise different activities. Moreover, it is essential that delivery schedules can be trusted. This is measured by a delivery accuracy measurement that is defined as follows:

$$(6) \qquad Delivery\ Accuracy\ [\%] = \frac{Nbr\ of\ Items\ Delivered\ on\ Time}{Nbr\ of\ Items\ Ordered}$$

- ***Project management***

The literature review discussed the overlapping theories of project management and supply chain management. Based on this, it can be concluded that the supply chain of base stations and the project management of GSM network building should be strongly interdependent. Earlier observations from real-life have shown how important an aspect this is to make supply chain management successful. Independent from the scope of contracts, all building projects ultimately are the customers of supply chain management. Actually, the success of a project greatly depends on just-in-time material deliveries to installation teams. However, no supply chain can work properly without good planning information about future demand. Therefore, it is also in customer projects’ own interest to provide accurate planning information to suppliers.

This is measured with a measurement of demand plan error, which indicates how well, or poorly, project plans are realised. The demand plan error measurement is defined as follows:

$$(7) \qquad Demand\ Plan\ Error\ [\%] = \frac{Ordered\ amount - Forecasted\ amount}{Ordered\ amount}$$

Otherwise, the relationships between project management and supply chains are difficult to measure in quantitative terms. Therefore, these relationships are evaluated with the following qualitative factors listed below:

(8) *Character of network* in terms of geographic and cultural circumstances

(9) *The stage of project* in terms of network coverage and capacity

The theory of constraint (TOC), as discussed in the literature review, says that any system has a constraint that limits its output. The system output can only be improved by replacing the constraint. Therefore, non-bottleneck processes should operate at lower efficiency to reserve capacity for fluctuations. In the context of this study, equipment deliveries and the supply chain can be considered to be non-bottleneck activities for project managers. It is probably the whole implementation process for a base station site that includes a bottleneck and forms the critical path for the project schedule. Therefore, it is essential to analyse the site implementation process in each customer case. For this purpose, the following qualitative measurement is defined:

(10) *Site implementation process* that is described per each customer case

Customer-supplier relationship

The relationships between the GSM-operator and system supplier also play an important role in collaborating and developing demand-supply chain related processes. For instance, implementing a rolling demand planning process requires not only open and frank communication between the parties, but also standard working practises. The partnership mode also defines the basic characteristics of the customer-supplier relationship within the supply chain management. The related theories introduce a traditional path of evolution of building long-term relationships between customer and supplier.

The efficiency of the customer-supplier relationship is always hard to measure. In the case studies this is evaluated with the following qualitative factors:

(11) *The mode of partnership* specifies whether the relationship is partnership or arms-length

(12) *The length of co-operation* in the cellular network business

(13) *Process collaboration* between customer and supplier

5.2. The differentiation of supply chain (means)

Value offering point

The value offering point (VOP) as discussed in the literature review is the point in a customer's demand chain where the customer allocates demand to a specific supplier. In other words, it can be said to represent the point in customer internal processes that triggers ordering and at which the final content of an order is fixed. VOP is a fairly new concept and there are not that many applications of using it in the literature. In the studied business context, it can be understood to be an order trigger that initiates the execution process of the supply chain. By intuition, the location of the VOP might impact the supply chain selection; that is, the location of the order penetration point. At this stage of the study there is not enough understanding about the possible options for VOP. However, the qualitative measurement that is analysed in each customer case is as follows:

(1) *Order trigger* that is studied in each customer case

Order penetration point

The order penetration point (OPP), as discussed in the literature review, is the point in the supply chain where product becomes earmarked for a particular customer. Its location can be used to differentiate supply chains. We concluded earlier that OPP is actually determined by two dimensions: (1) the manufacturing postponement level and (2) the logistics postponement level.

Manufacturing postponement refers to the stage of the product form at the time when a customer order is received. For instance, if a base station is already fully configured (ready-made) for a particular customer site when the real order for it is received, the delivery system is said to be in the ship-to-order mode. Correspondingly, if a base station is packed and shipped after the order is received, it is in pack-to-order mode etc. In the researched business context there are four alternative 'manufacturing postponements' in use. They are make-to-order (MTO), assemble-to-order, pack-to-order (PTO) and ship-to-order (STO). The strategy of manufacturing postponement is by intuition considered to be a very essential dimension, as there can be a large number of different base station configurations for one customer. Thus, the following qualitative measurement is analysed in each customer case:

(2) *Manufacturing postponement level*

Logistics postponement refers to the delivery time and location of the product at the time when the real customer order is received. For instance, if the base station is stored in a distribution centre when the customer order is received, the logistics postponement is in the distribution centre. Correspondingly, if material is stored at the plant, the logistics postponement is at the plant. In the researched business context there are also four alternative logistics postponements in use. They are delivery from plant, delivery from distribution centre, delivery from local warehouse or delivery from drop-off point. The strategy of logistics postponement is by intuition considered to be an essential dimension, as the logistics strategy allows variations in the buffering locations. Thus, the following qualitative measurement is analysed in each customer case:

(3) *Logistics postponement level*

5.3. The success of supply chains (ends)

Customer service

The customer service aspects are essential factors that make supply chains be successful or be complete failures. In this study the level of customer service is evaluated through a number of measures, because its qualitative nature. There are three ways to evaluate this in the research: by using direct feedback from the customer, by evaluating the results from the customer satisfaction survey and by measuring the improvements in product lead-times. These operational measures are analysed for each customer case. The definitions of these measures are explained as follows:

(1) *Direct feedback from the customer:* direct comments from representatives of the customer organisation and project teams provide immediate feedback on the perceived performance of a supply chain within the process implementation.

(2) *Customer satisfaction survey:* An annual customer satisfaction survey that is used to evaluate delivery performance.

(3) *Lead-time reduction:* The lead-time reduction for the customer achieved through the streamlined processes.

Capital employment and total costs

The literature review revealed that a major cost element of supply chains is often associated with inventory levels. This is especially the case for innovative high-tech products, which are characterised by short product life cycles and relatively high financial value. Also in the context of this research, the base station equipment inventory creates the main cost savings potential for the customers and the supplier. Based on quick calculations, within a couple of days the amount of inventory carrying costs for one base station site, on average, exceeds a saving potential from optimised transportation routes. Therefore, in this study inventory days of supply is exclusively used to represent total costs, too.

The operational measures used to evaluate these costs are defined as follows:

(4) $Inventory\,Composition\,[\%] = Goods\,in\,Transit\,[\%] + Physical\,Stock\,[\%] + Work\,in\,Process\,[\%]$

The meanings of different inventory categories are:

- *Goods in Transit (GIT): The value of goods that has left the production line and is not received in the destination country.*
- *Physical Stock (PS): The value of goods that has been received in the local warehouse and has not been shipped to a site.*

- *Work in Process (WIP): The value of goods that has been delivered to an installation site and has not been invoiced.*

(5) $$Inventory\ Days\ of\ Supply\,[d] = 91.25 * \frac{Average\ Inventory\ Value(3mths)}{Rolling\ Cost\ of\ Sales(3mths)}$$

5.4. Summary

This chapter introduced the 'a priori' research constructs and derived operational measures for evaluating the study propositions. A summary of the main content of this chapter is presented in Table 4.

Table 4: Summary of research construct and operational measures

	RESEARCH CONSTRUCTS	OPERATIONAL MEASURES FOR CUSTOMER CASES
CONDITIONS FOR SUPPLY CHAIN SELECTION [SITUATIONAL FACTORS]	***Customer and markets***	*(1) GSM penetration* *(2) Market growth* *(3) Market share* *(4) Business scope*
	Supplier, product and deliveries	*(5) Product portfolio* *(6) Delivery accuracy* *(7) Demand plan error* *(8) Character of network* *(9) Stage of project* *(10) Site implementation process*
	Customer-supplier relationship	*(11) The mode of partnership* *(12) The length of co-operation* *(13) Process collaboration*
THE DIFFERENTIATION OF SUPPLY CHAINS [MEANS]	***Value offering point***	*(1) Order trigger*
	Order penetration point	*(2) Manufacturing postponement level* *(3) Logistics postponement level*
THE SUCCESS OF SUPPLY CHAINS [ENDS]	***Customer service***	*(1) Feedback on changes from customer* *(2) Customer satisfaction survey* *(3) Lead-time development*
	Capital employment and total costs	*(4) Inventory composition* *(5) Inventory days of supply*

6. CUSTOMER CASE ANALYSIS

This chapter presents an analysis of the customer case studies. The chapter consists of five sub-chapters. The first part is reserved for the overview of the eleven in-depth case studies. In addition to the introduction, it explains the rules for analytical case sampling; that is, it answers the question of why these eleven customers in particular were considered for the in-depth case studies. Then, the analysis continues in separate sections for each scope of business. First, the “box delivery” customer cases are analysed; second, the “telecom deployment” cases; and third the “turnkey” cases. Finally, a cross-case analysis is conducted to validate the results observed from the in-depth cases.

6.1. Introduction to the case studies

The BIRD re-engineering program included a total of 38 different customer cases where the demand-supply chain was, more or less, revised. Out of those customer projects, 11 in-depth cases were selected for more detailed in-depth analysis in this study. The logic of this analytical sampling includes the three following main standpoints:

1. **Business scope.** First, the sampling logic starts with an attempt to find different types of customer cases inside one business scope category. So, the first rule was to have representative samples from all the three business scopes (“box delivery”, “telecom deployment” and “turnkey”) that are determined by the value chain of the customer. This was done because the scope of delivery was considered to be significant in distinguishing the requirements for the supply chain. Of the 11 customer cases, three represented “box delivery” customers, five were “telecom deployment” customers, and the remaining three belonged to “turnkey” customers.

2. **Supply chain.** The second rule deals with the selected supply chain mode. As the objective is to find criteria for the right selection of a supply chain, it makes sense to examine the customer cases of the possible supply chains. It was especially interesting to study the cases where the supply chain was switched from one chain to another. Of the 11 cases, there are five customers who ended up in the direct delivery mode, four of them moved to the

regional distribution centre mode, and the country buffer was the solution for two customers.

3. **Performance.** The third criterion for analytical sampling was the success of the selected supply chain, which is roughly broken into three categories (1) good, (2) satisfactory and (3) poor. Each performance level is represented within one business scope.

These customer cases are placed in a BIRD account map, where the axes refer to business scope and supply chain. This is illustrated in Figure 22.

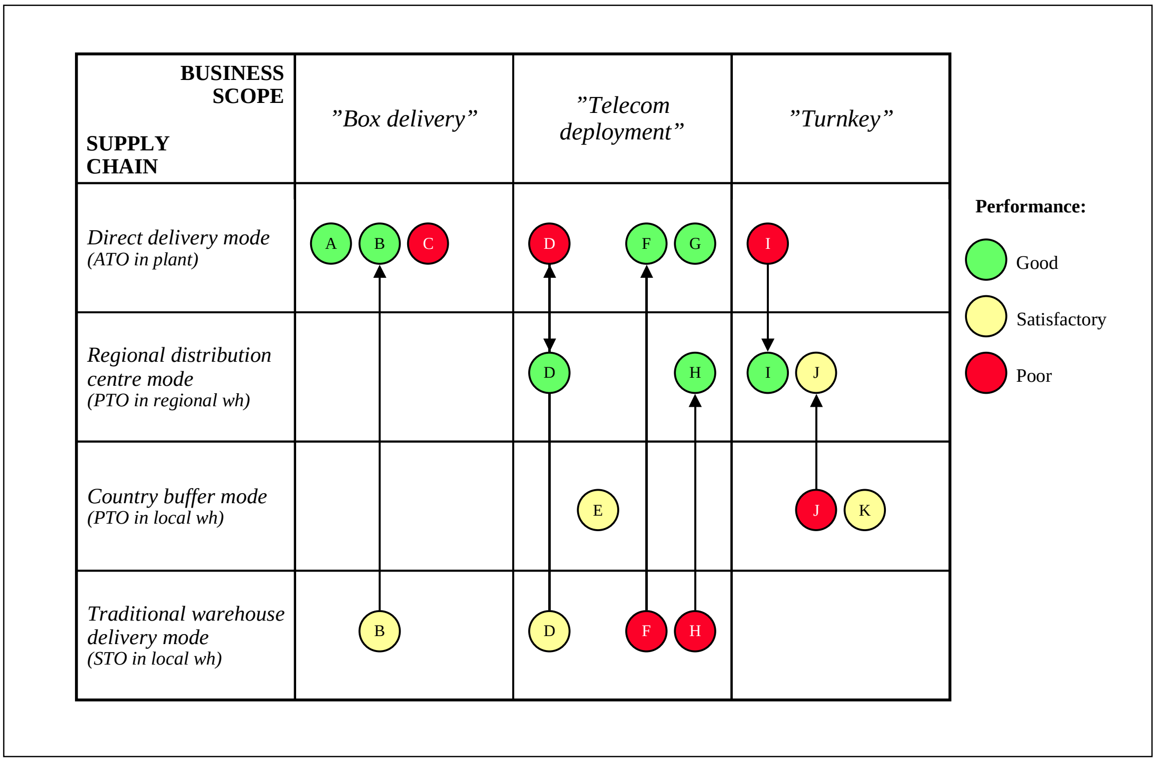


Figure 22: In-depth case studies positioned in the BIRD account map

The details of the sampling logic are discussed below based on the above matrix.

"Box delivery" customers

The first case was operator A, which was already operating successfully in the direct factory delivery mode when the BIRD project was activated. The reason why it has been selected as one of the in-depth case studies is to investigate the reasons why the direct factory deliveries had been a working supply chain solution for a long time. The case indicated a good performance by the supply chain already before the BIRD principles were introduced to the customer.

The second case, operator B, was selected for analysis because it was a good showcase of how the switchover from the traditional local warehouse to direct factory deliveries was successfully implemented together with the customer. The starting point was that both Nokia and the operator had a warehouse for base stations and that there was no clear process agreed for how the deliveries from Nokia were ultimately going to the installation site. Material was first delivered from the factory to the local Nokia facilities, and from there they were delivered to the operator’s own warehouse. The performance of the supply chain in the beginning of the BIRD project was not considered to be that good by either the customer or the supplier.

The third case was operator C. It was selected for an in-depth case study analysis because the customer satisfaction was not good at the beginning and because it was not possible to change the actual delivery process during the BIRD project. Nokia did not have a base stations warehouse, everything was delivered from the factory directly to the customer’s own warehouse. From the supplier point of view the delivery process was working. It was cost-efficient and delivery schedules were met. However, the customer suffered from big inventories and therefore the case showed negative customer satisfaction, although basically the customer was satisfied with Nokia delivery performance. The interesting point in this case was to understand why the process re-engineering with the customer was not activated in practice, although there was a clear need for it from the customer and Nokia was naturally ready to streamline the common processes, including the factors preventing improvements.

“Telecom deployment” customers

For the “telecom deployment” customers, five in-depth cases were needed to find a proper explanation for the successful supply chain selection factors. The first case, operator D, was selected because the supply chain was revised a few times before it was considered to work. It started with the traditional warehouse delivery mode and switched to the direct delivery mode, which clearly tended to not be a workable solution. Then, a new implementation was started towards the regional distribution centre mode, which finally ended up being the solution. This was also the first pilot customer for the new supply chain. The interesting point is to understand why the switchover to factory deliveries was not successful, the operator required a shorter lead-time to be able to run the network building project smoothly.

The second case, operator E, was a good example of where both the customer and Nokia considered a local warehouse to be needed. The country buffer mode was considered the only delivery process that could work in that business environment. It was a beginning GSM network project. The delivery process was planned and implemented together with the customer. The process implementation was successful and the warehouse operations could be done in a relatively cost-efficient way.

Operator F, the third customer case for in-depth analysis, is an excellent example of how supply chain performance could be radically improved, if the change is considered to be a win-win situation for the operator and supplier. In this case both the customer and Nokia were urgently looking for a more streamlined solution to arrange base station deliveries to the final installation site. The history of this case was that there were huge inventories to be handled by both parties. The obsolescence risk of old base station configurations that were lying in the warehouses was significant. The whole site implementation process was rearranged and local warehouse deliveries were banned.

The fourth case, operator G, was an old and experienced GSM operator, but it was a new business case for Nokia. The implemented delivery process was designed to be a direct factory delivery mode. The process was planned and implemented together with the customer. The case was a success in terms of customer satisfaction and cost-efficiency. It is a proven case for Nokia that it is possible to successfully start a new “telecom deployment” business with a direct factory delivery mode.

The fifth case, operator H, had initially selected Nokia as the sole system supplier and the deal was a “turnkey” at the beginning. The customer wanted to do the network planning and site acquisitions itself, and thus the business case for Nokia became a “telecom deployment”. In connection with this switchover, the delivery process was re-engineered between the companies. Due to lead-time considerations, the customer was not willing to choose direct factory deliveries, the common win-win solution was the use of the regional distribution centre mode. This enabled a seamless integration of physical deliveries to the project rollout. The starting point was that Nokia had a fairly big inventory of base stations dedicated to the customer. The ramp-down of the warehouse was realised as a part of the BIRD implementation. Despite big changes for both parties, the case turned out to be a successful process implementation.

"Turnkey" customers

The first "turnkey" business case was operator I, which was a starting GSM operator. The delivery process was carefully planned with the project teams to be direct factory delivery. After a few months, however, it became obvious to everybody that the process was not working and did not serve the needs of the project rollout. Both the customer satisfaction and cost-efficiency of the supply chain were not on a satisfactory level because the product lead-time for a seamless process was too long. Therefore, arrangements for the regional distribution centre were activated. A year after the BIRD implementation, the delivery mode was then switched to the regional distribution centre mode. The case was an example of what could happen if the efficiency of the supply chain is prioritised over the project rollout targets in a start-up network business environment.

The second customer case, operator J, was also a start-up case. The lessons from the previous case were learned. The local country buffer mode was implemented. However, the implementation was not that successful and the case was not a success story. There were huge problems with inventory levels and keeping the project schedule, although a buffer was in place. After the most hectic phase in the network start-up, the whole site implementation process was revised. At the same time, the site call-off trigger was changed to enable a switchover to the regional distribution centre mode. The preparations for the changes were activated. After the improvements in the site implementation process both the cost-efficiency and customer satisfaction slightly improved.

Operator K represents the third in-depth case study that was a starting GSM network project. The local country buffer mode was successfully implemented at the beginning of the project. According to the feedback from the project teams, the supply chain supported the ramp-up phase of the network very well. The development of inventory rotation was also pretty good after the first launch of the network.

6.2. "Box delivery" customer cases

6.2.1. Operator A: Minimise logistics costs

The first case analysis is based on a "box delivery" customer that has successfully operated with the direct factory delivery mode for some time already. Therefore, this customer case does not include any major changes in the design of the supply chain during the BIRD implementation project. The main purpose of process changes was merely to fine-tune the existing supply chain with the customer. The customer motives were primarily to minimise logistics related costs that were allocated to the building-project.

This case analysis identifies those situational factors that enable the successful use of the direct delivery mode with a "box delivery" customer. The BIRD implementation and data analysis period was between P8/99 and P1/00.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

  Customer A was the first GSM-operator in this European country, launching the network in the northern part of the country in mid-1993. Only a few months afterwards another mobile telecom operator introduced its GSM network services in the same country. The markets have been steadily growing since those days so that the technology penetration has already clearly risen above 60%, reaching the maturity phase. The development of GSM-penetration in the country and the operator's market share are illustrated in Figure 23.

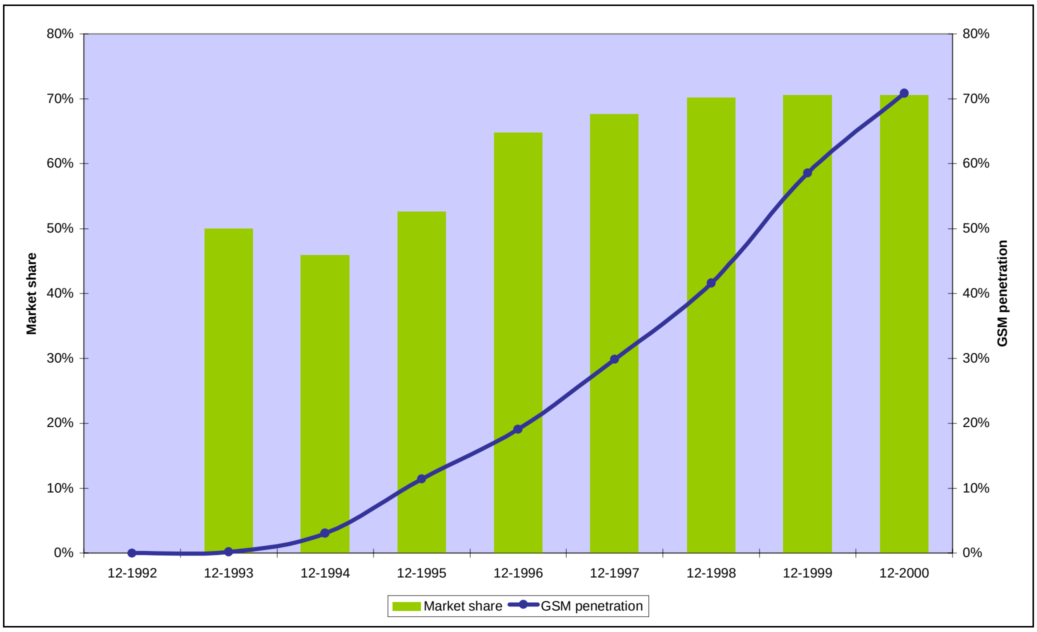


Figure 23: Market growth and operator A's market share

After the accelerating growth phase in the markets, the competition between these two rival operators has stabilised, which is also shown in the figure. The market share of customer A has settled at the 65-70% level, which is clear evidence of its position of market dominance.

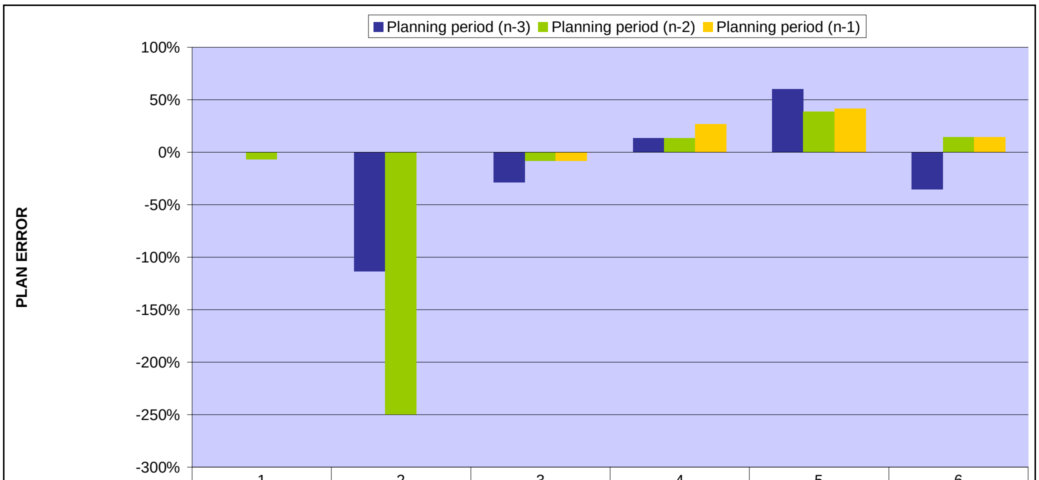
The customer's value chain consists of activities to plan, build and maintain the network by the operator company itself. The strategy has been to keep the network planning, site acquisition process and the overall management of the building project inside the company. Although there are some base station related installation services that have been outsourced to a local implementation subcontractor, the scope of business can obviously be considered to be a "box delivery" from the system supplier point of view.

- **Supplier, product and deliveries**

The detailed product portfolio that is supplied by Nokia basically only includes base station equipment. The related site solution material is mostly purchased from other vendors and subcontractors. The same purchasing logic is applied for the microwave radio links in those rare situations where it is not possible to use a leased line to connect two base stations. From the supply chain point of view this means that the customer has to carry out the site delivery consolidation somewhere in its facilities before the base station can be delivered to the site for installation.

The network covers almost 100% of the country, already including thousands of base station sites. Thus, there is no real need for coverage building anymore, new deliveries are mainly for capacity extensions to the network. As the network is located in a country whose geography varies a lot, it makes the network planning and site visits process very challenging. Still, this aspect is not considered to be that problematic any more by the customer. This is mainly because the operator already has many years of experience in the GSM business. The site acquisition and permitting processes are also relatively straightforward in practise due to the favourable business conditions in the country.

At this stage of the network building-project, the customer's main focus is clearly on the optimisation of the network and cost-efficient delivery processes. In normal daily delivery situations it is not the most important thing to get a single base station site on the air as fast as possible, because an ordered site is only meant to expand the existing capacity. Therefore, short delivery lead-times are not considered that critical by the customer, the more important aspect is to have standard lead-times and reliable processes implemented with site installation teams. It is therefore no wonder that the planning process of network building has been fairly reliable. This can be seen in Figure 24.



	1	2	3	4	5	6
Planning period (n-3)	0%	-113%	-29%	13%	60%	-36%
Planning period (n-2)	-7%	-250%	-8%	13%	39%	14%
Planning period (n-1)	0%	0%	-8%	27%	41%	14%

PERIOD

Figure 24: Operator A's demand plan error

The average 1-month planning error – a comparison between the volume of real demand and planned demand one month before the actual ordering – has fluctuated pretty nicely around the target 0% level during the whole data analysis period. The mean absolute percentage error was 15% during the data analysis period. There was only one month (P5=December), which indicates some problems in the planning of the site implementation process, since the plan error bounded up to 41%.

Nokia as a supplier has been able to keep the promised lead-times fairly well. The delivery accuracy from the base station plant is illustrated in Figure 25.

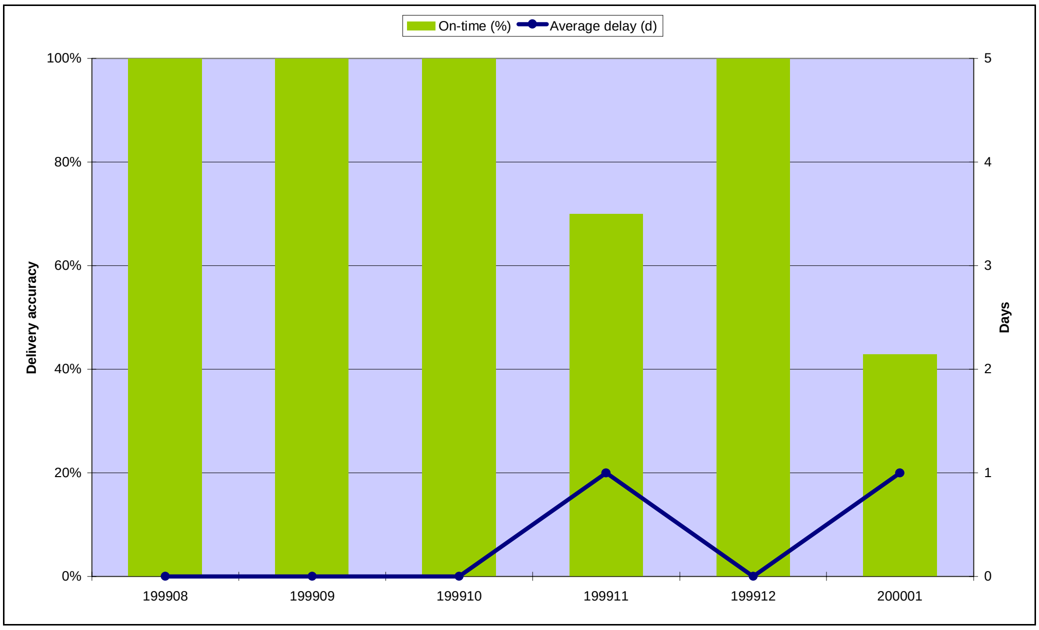


Figure 25: Delivery accuracy for operator A

The first three months in the analysis period achieved 100% on-time deliveries. Then some delivery problems occurred in November and at year's end. The delays in January were also linked to the unforeseen peak in the demand in December that can be noticed in the analysis of demand plan error. During the data analysis period on average 80% of deliveries were on time, and the delays on what was promised were only one day.

- **Customer-supplier relationship**

Operator A has two main system suppliers, the first one supplying a mobile switching system and base stations, and the second one delivering only base station equipment. Nokia has been selected as the second supplier for base stations. The co-operation with the GSM network started already in 1994. The nature of the relationship has developed positively over the course of time through the building of the network. Although Nokia is considered to be the second system supplier, the overall customer-supplier relationship is very good and can be called a partnership. The contract covers only equipment deliveries, and no services are included.

Due to many years of experience in rolling the network out, processes inside the project have already stabilised and are fairly efficient. For instance, the working practises are so standardised that there is only one type of base station configuration in use. The contacts and communication channels are also working fine. It is relatively easy for both parties to collaborate in developing common business processes. For instance, the monthly demand planning is done according to a standard process, which includes data collection from the operator's regional project teams consolidated in a logistics organisation directly with local Nokia logistics people.

THE DIFFERENTIATION OF SUPPLY CHAIN

- **Value offering point**

'Site specific ordering' was already in place before the BIRD processes were introduced to the customer. Site ordering is done based on the existing network roll out plan. The supply chain was considered to be a working solution by the both parties. Therefore, during the BIRD project there were naturally no reasons to change this part of the process. The order trigger was in project planning. Thus, the value offering was already implemented as downstream as possible.

However, there were certain elements that were looked into during the process implementation. The ordering principles were slightly revised, since there had been some order changes in the past and the lead-time had not been standard all of the time. Earlier the ordering was done twice a month based on the information in the network rollout plans. One order could cover several site configurations that were ordered at the same time, although the due dates were probably different. Now it was agreed that the sites would be ordered one by one a standard time before the planned start time of the installation. The change slightly improved working practises and made the process more standardised. However, it did not change the fact that site call-off orders are still made based on the site implementation plan, not any milestone in the process.

- **Order penetration point**

Already before the BIRD implementation, the site-specific orders were placed directly with the base station plant, where base stations were assembled according to the specifications in the customer order. This means that the manufacturing postponement is in the assemble-to-order mode, and logistics postponement is at the plant. This process seemed to work very well because the operator was able to define the detailed configuration a few weeks before the actual installation time. A reliable site implementation process made this possible.

The direct delivery mode, as mentioned above, was successfully working and the lead-time from the factory was acceptable to the customer. There was no reason to start to speculate with the time and location of the delivery based on the information given in the demand plans. The plans were mainly utilised to estimate the volumes and capacity needed in the production process.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

Direct comments from the customer indicated that it had already been relatively satisfied with the overall delivery performance for months. However, the operator was still very willing to make changes to further streamline the delivery process. The operator also appreciated those improvements made during the BIRD project, although they were considered minor ones. The main issue for the operator, as they put it, is to be able to trust the lead-time.

According to the annual customer satisfaction survey, the operator is satisfied with the quick response and the close contacts with local Nokia personnel. Nokia is easy to access and very willing to help find solutions to queries and problems, as well as being creative in finding new solutions. The main issue is the need for timely delivery, and the operator sees that Nokia is keeping promised time schedules, and is quite satisfied with the performance.

The lead-time reduction for base station deliveries that was achieved through the BIRD process implementation was about 50% for the customer.

- **Capital employment and total costs**

The inventory development on the supply chain indicates the efficiency of the common processes with the customer. Basically, there is no excess material tied up in the chain, and everything is driven by the real demand in the site implementation process. The development of inventory levels is shown in Figure 26.

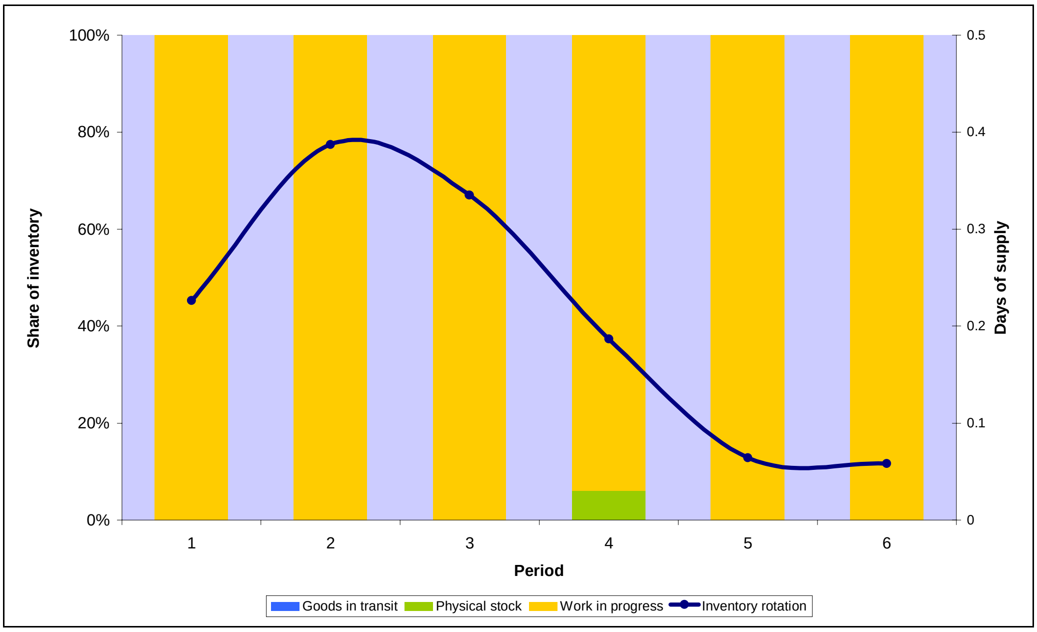


Figure 26: Inventory days of supply for operator A

The figure clearly indicates that most of the material is in work in progress during the ending period. The practical reason for these very low inventory figures is due to the fact that customer deliveries are not scheduled for the time periods when the financial books are closed in both companies.

6.2.2. Operator B: Improve supply chain efficiency

The second case analysis includes another “box delivery” customer. This case represents a business situation where an existing delivery process could not be considered that efficient, as both the customer and supplier suffered from unnecessary inventories. During the BIRD project the supply chain was radically redesigned.

The purpose of this case analysis is to describe how the local warehousing process was replaced with the effective use of the direct delivery mode. Furthermore, this case analysis studies which factors enabled this transformation. The BIRD implementation and data analysis period was between P1/00 and P6/00.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

  Operator B was the first GSM service provider in this European country. The network was launched at the end of 1994. It was a company fully owned by the state at that time. During the first two years, the company was basically able to start-up its new operations quite steadily without any competition. The development of GSM penetration in the country was rather slow in the early emergence phase of the industry. However, as the growth began after a few years, it was really sharp. This development of GSM penetration is also shown in Figure 27. By the end of 2000, the penetration had already risen close to the 80% level.

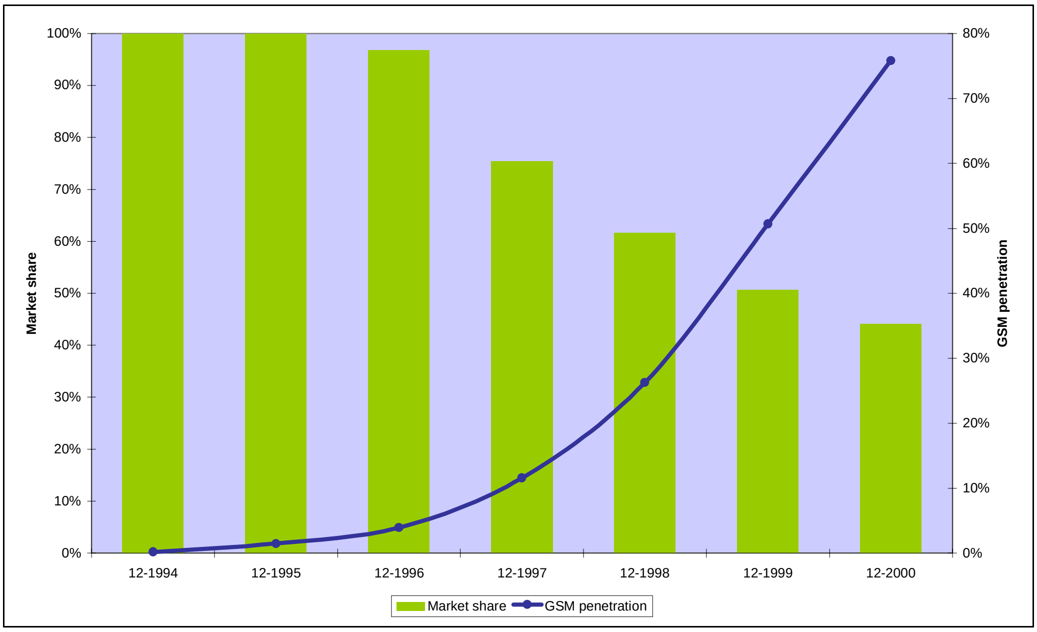


Figure 27: Market growth and operator B's market share

After the first two non-competitive years, another private operator launched its network at the end of 1996. Two years after that, a third competitor entered the markets. The markets are very competitive nowadays. There were three competing GSM operators in the markets at the end of 1999 when the BIRD project was activated. Furthermore, a fourth one was about to enter the same markets. As the competition really started, operator B's market share dramatically dropped to a level of 40% where it has now stabilised.

The customer's strategy clearly has been to keep the network planning, site acquisitions and overall project management in its own hands. System suppliers only deliver equipment to the network. Thus, the business scope is considered to be a "box delivery". However, some installation services are purchased from a number of locally operated subcontractors.

- **Supplier, product and deliveries**

According to the contract, Nokia is merely the supplier of base station equipment. In addition, the product portfolio includes some site solution material that is needed in installing the Nokia equipment in the GSM network. The consolidation of site deliveries was earlier done without a mutually agreed process either by the customer or by the supplier. This situation led to a somewhat non-standard process in managing the supply chain.

The network launched in December 1992 already covers thousands of base station sites around the country. Today, its coverage has reached 100% in most regions and the scope of the network rollout project is mainly to expand the capacity of the network. This is done either by implementing completely new sites or by making capacity extensions to existing ones. Due to the difficult landscape, it is difficult and costly to acquire new base station sites in some regions of the country. Therefore, the preferred option is to utilise existing sites as much as possible, which in turn makes the radio planning challenging. Furthermore, there are a large number of varying product configurations in use.

Despite the challenging environment, the basic site implementation process for new base stations works pretty well and the network rollout plans have been fairly reliable. For site extensions situations, it is more on an “ad hoc” basis. The development of demand plan error is illustrated in Figure 28.

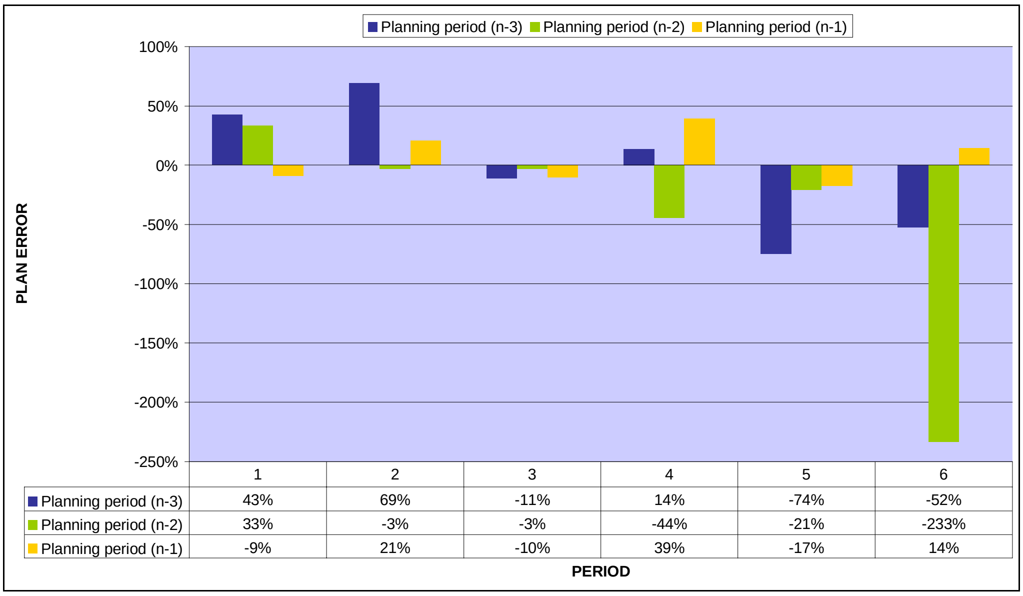


Figure 28: Operator B’s demand plan error

One positive trend that the figure shows is that the demand plans generally get more accurate the closer they are made. The 1-month demand planning error is constantly in the +/-40% range. The mean absolute percentage error was 18% during the data analysis period. Moreover, they fluctuated around both sides of the target 0% level, meaning that they are not essentially skewed.

The delivery accuracy during the data collection period is shown in Figure 29.

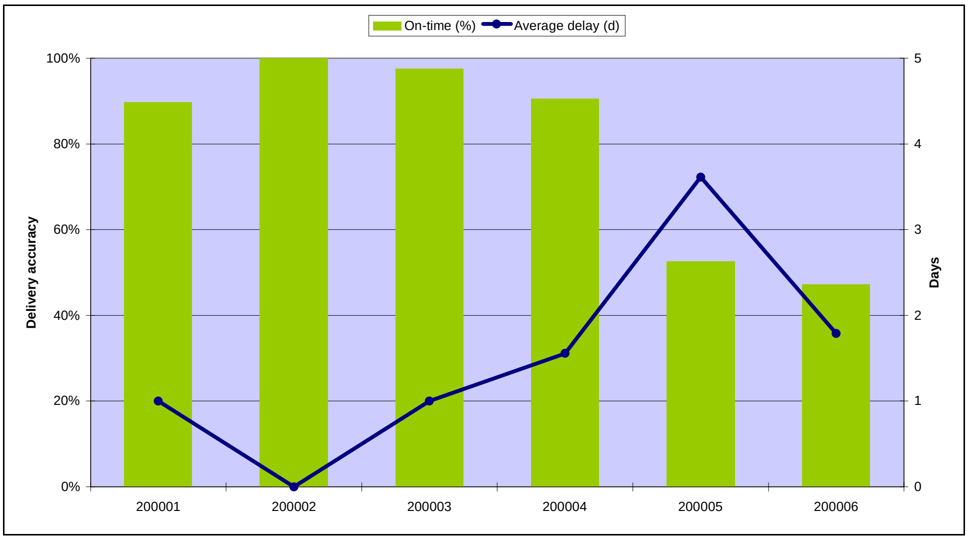


Figure 29: Delivery accuracy for operator B

The development of the delivery accuracy does not look that good because of the global electronic component shortage situation that hit the industry in late spring 2000. These negative impacts are clearly seen in the delivery performance figures during May and June. During the data analysis period on average 86% of deliveries were on time, and the delays on what was promised were 2.2 days.

- **Customer-supplier relationship**

Operator B uses three main system suppliers for network building; one supplier for its mobile switching system and the two others only for base station systems. Nokia is considered to be the first base station supplier for the network. There are no installation services included in base station deliveries. The co-operation that was started in 1997 has been constructive and communication is open all the way. Overall, the relationships are very good and can be classified as a partnership.

There are many ongoing promising and fresh attempts at business process collaborations. A recent collaborative effort was the development of an e-business solution for automated ordering via an extranet. It was a new concept for both companies, and therefore it was agreed to start it as a pilot. In parallel with this, the customer was implementing a new ERP system. In order to streamline the whole supply chain, it was agreed to take the BIRD principles into the scope of the e-business project.

THE DIFFERENTIATION OF THE SUPPLY CHAIN

- **Value offering point**

Before the BIRD implementation, the location of the value offering point was at the customer warehouse management, as the operator ordered basic base station configurations and additional TRX units separately for its own locally managed warehouse. The final site configurations were made in the warehouse only when the site call-off was received from the project teams. The customer, practically, ordered equipment to replenish the local warehouse. There were also some deliveries that were ordered by the customer, but waited for the final site delivery in Nokia's local warehouse.

The process change that was implemented during the BIRD project focused on finding the right trigger point for ordering. During process brainstorming sessions with the customer it was agreed to have two separate processes: one for new base station sites and one for extensions. Site specific ordering with the direct delivery mode was implemented for new base station sites. There, the installation subcontractors placed material call-off orders only after the site construction work was finished. It was agreed to postpone the ordering to pre-installation site meetings (PISM), where the detailed schedule for installation is also agreed. According to the agreed processes, Nokia only delivers complete sites, base stations and related site solution material at the same time. This means that each delivery is already consolidated as it arrives at the customer's drop-off point. The product portfolio for the site solution material was fixed and a process for updating it agreed. This is to guarantee standard and short lead-times from the buffer in the Netherlands.

- **Order penetration point**

As mentioned earlier, the starting point was that the operator had its own warehouse of partly configured base stations. In addition to this, Nokia also stored some material locally for the customer. Earlier the customer made batch orders based on their network rollout plan. Although the orders were basically site specific and were placed directly with the factory - and the manufacturing mode was thus considered to be assemble-to-order - the reality was that the customer had to often cancel or reorder material many times because of changes in the network plan during the delivery process. This was also the reason why both

Nokia and the operator had material in their warehouses. In practise, the mode was ship-to-order when the final call off order was received.

During the process brainstorming with the customer, it was agreed that there would be two separate processes: one for new base station sites and one for extensions. Site specific ordering with the direct delivery mode was implemented for new base station sites. Call-offs are placed only after the site construction work is finished. It was agreed that decisions about the ordering would be taken in pre-installation site meetings (PISM), where the detailed schedule for installation was also agreed. According to the agreed processes, Nokia only delivers complete sites, base stations and related site solution material at the same time. This means that each delivery is already consolidated as it arrives at the customer's drop-off point. The product portfolio for site solution material was fixed and a process for updating it was agreed. This is to guarantee standard and short lead-times from the buffer in the Netherlands.

For the extensions, the operator wanted to continue having a small stock of TRX units in its own warehouse. According to the customer, this stock enables flexible changes in the sequence of installation schedules. This was advocated mainly due to unexpected challenges that are typically caused by the climate and geography around the Alps. However, from the supplier point of view this process is also considered to be a factory delivery.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

Direct feedback during the process indicates that the customer greatly appreciated the process improvements. The streamlined supply chain especially helped them to re-engineer their internal processes better in parallel with their own ERP implementation project.

According to the customer satisfaction survey, the relationship in developing processes with the local Nokia team is good, and the equipment deliveries are performing very well. The improvements to the delivery systems over the last months were especially pointed out. Nokia introduced a new delivery concept that enables a just in time logistics solution to be in place. The ordering procedure was also improved.

The lead-time reduction for base station deliveries as a result of the BIRD implementation was about 50%.

- **Capital employment and total costs**

Improvements in cost-efficiency were clearly visible. The development of inventory levels is illustrated in Figure 30 in which the positive trend is visible.

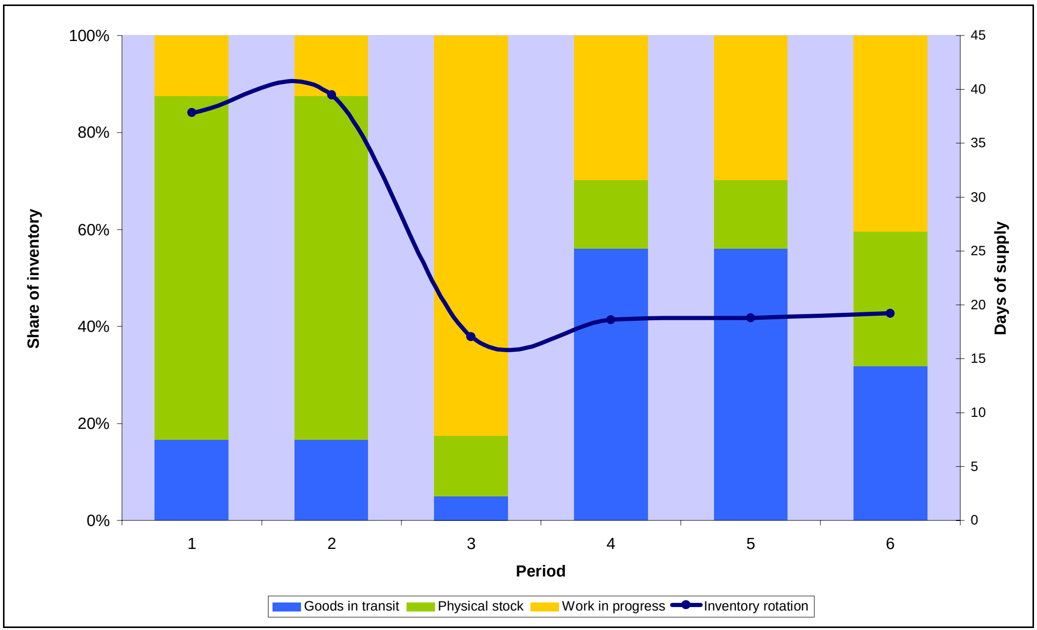


Figure 30: Inventory days of supply for operator B

For new base station sites, the direct factory delivery mode is yielding the most cost savings. The rolling three months inventory rotation improved over 60%, as the inventory rotation measure came down from over 30 days to a level of 10-15 days.

6.2.3. Operator C: Guarantee roll out targets

The third case analysis of “box delivery” customers represents a situation where the customer holds inventory and is not willing to replace the warehouse at the existing stage of the building project. The supply chain is a direct factory delivery mode. The main purpose of this analysis is to explain why the customer primarily wants to guarantee short product lead-times and prefers to continue costly warehousing instead of adopting a streamlined supply chain.

The BIRD implementation and data analysis period was between P5/00 and P10/00.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

Operator C was the first GSM operator in a European country, launching its network in mid-1996. A few months after the launch, a second operator introduced its GSM services. The customer is a privately owned company. The development of GSM penetration in the country has grown quite steadily, until the turn of the millennium when the growth markedly increased. At that time, a third operator also entered the markets. The market growth is also shown in Figure 31. By the end of 2000, there are still no signs of the maturity phase.

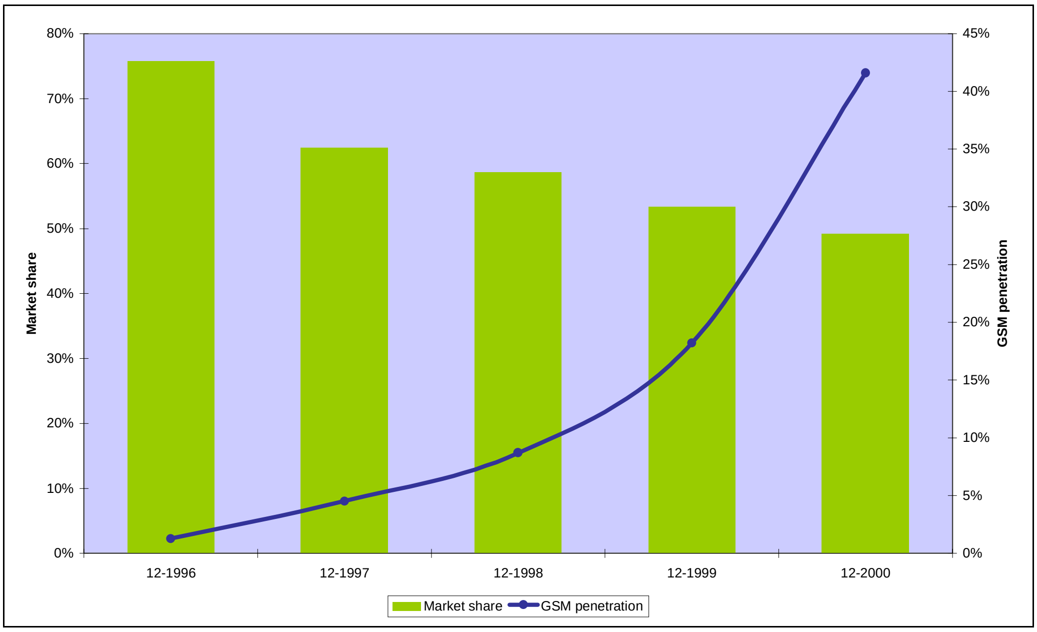


Figure 31: Market growth and operator C's market share

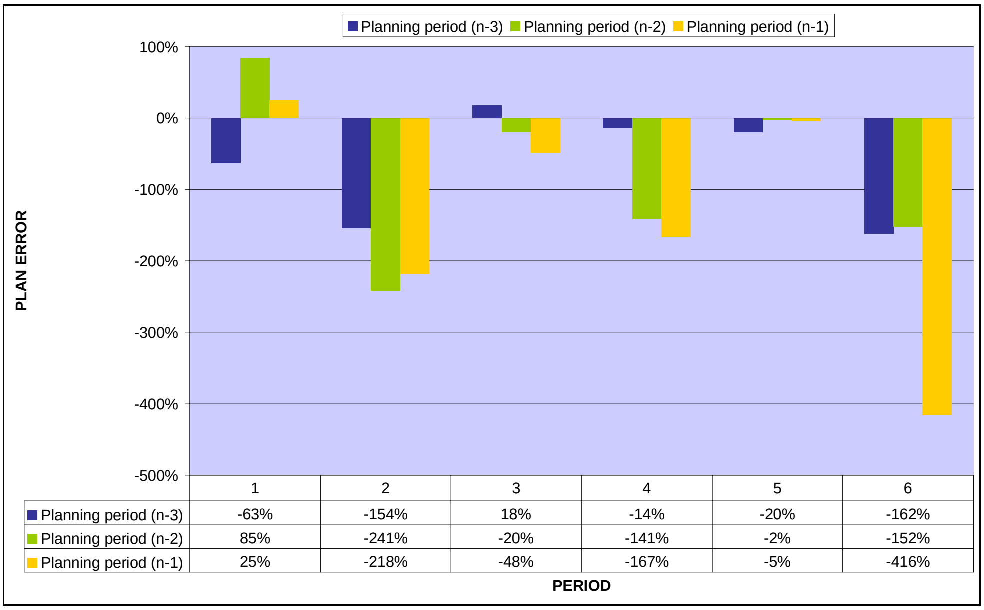
Since the launch of its network, the customer's market share has constantly dropped from the 75% level to below 50% at the end of 2000. The operator is the market leader of the country, although competition is getting tough.

The customer has selected a strategy in which it has chosen only one system supplier that is to take some responsibility for its network planning and project management. However, overall project management remains in the hands of the operator. For mobile switching systems the scope is a “turnkey” business, but for the base station system part the operator has wanted to keep it in a “box deliveries” mode.

- **Supplier, product and deliveries**

Nokia supplies base stations and some site solution material to the customer. Microwave radio links are purchased from another supplier. This makes it quite difficult to manage the whole site implementation process because deliveries have to be consolidated by the customer itself. Therefore, delivery process collaboration also cannot be that straightforward with Nokia.

The network project is still clearly in its activate rollout phase, since the network does not cover the whole country yet. The main cities and highways are fully covered, but there are rural areas without network coverage. Furthermore, the network capacity in the cities needs to be improved. Due to a hectic phase in the rollout, the project plans have been badly unrealistic, which is shown in the demand plan error in Figure 32.



	1	2	3	4	5	6
Planning period (n-3)	-63%	-154%	18%	-14%	-20%	-162%
Planning period (n-2)	85%	-241%	-20%	-141%	-2%	-152%
Planning period (n-1)	25%	-218%	-48%	-167%	-5%	-416%

Figure 32: Operator C’s demand plan error

Obviously, the planning accuracy has not been that good. The mean absolute percentage demand plan error was 147% during the data analysis period, and the rollout plans are constantly oversized. Significantly more base stations are planned for installation than are implemented.

The delivery accuracy for the customer during the data analysis period indicates exceptional negative results, as shown in Figure 33. This is mainly due to the global shortage situation for some key electronic components.

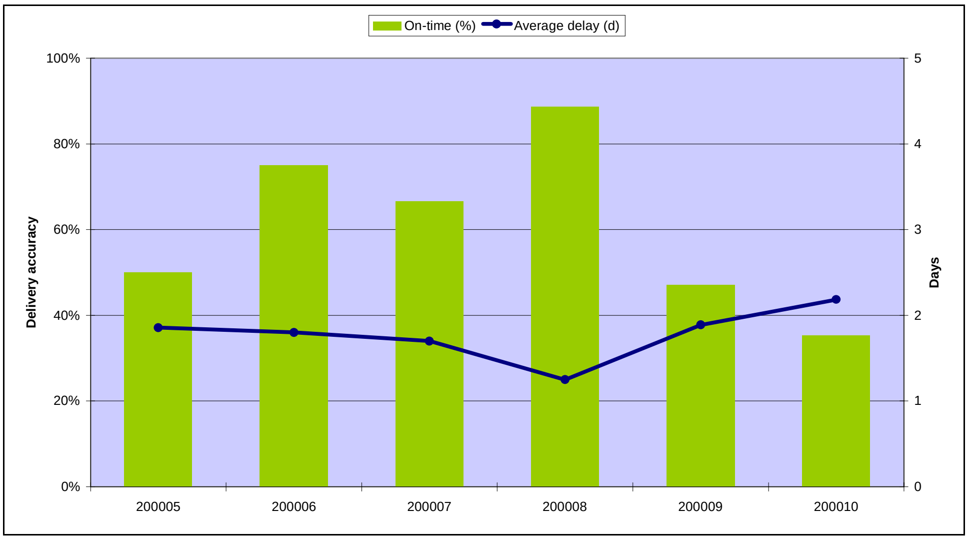


Figure 33: Delivery accuracy for operator C

Only 65% of deliveries were on time with an average delay of less than two days. However, this poor delivery performance during the analysis period did not cause huge damages to the building project because the customer's inventory acted as a safety buffer.

- **Customer-supplier relationship**

Nokia is the sole supplier of mobile switching system and basic base station equipment. For the switching system, the planning and installation is also covered in the contract. The co-operation started in the early 1990s with NMT cellular networks, which is the analogue mobile system that is the predecessor of GSM. The basic relationships are fine, especially open and frank at the operational and middle management level. Therefore, the relationships can be classified as a partnership.

THE DIFFERENTIATION OF THE SUPPLY CHAIN

- **Value offering point**

  From the supplier viewpoint, the supply chain mode is direct factory delivery. The customer places orders based on the material consumption in the warehouse. Thus, site specific ordering is not implemented.

  The BIRD principles were discussed with the customer, but they were not interested in changing their internal processes due to the tight schedule in the rollout project. Therefore, the basic delivery process was not touched at all, although the operator suffered from high inventory levels. The process implementation covered areas to improve the existing working practises, like the collection of demand planning information from the project teams.

- **Order penetration point**

  Although Nokia supplies in direct factory delivery mode, the process from the customer viewpoint was not considered that cost-efficient as it had own warehouse of Nokia base stations. In other words, the logistics postponement level was, in fact, downstream in the supply chain. The success of the network project required that the product lead-time be minimised, so therefore the operator had to store material next to the installation teams.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

  Based on observations when the BIRD principles were discussed with the customer, it became obvious that the management of the customer organisation is not all happy with the logistics processes. However, it is not because of the supplier; rather it is due to their internal processes in site implementation. At the moment BIRD was on table, the main thing was only to ensure the progress of the rollout project – with the cost of high inventories.

  According to the customer satisfaction survey, they are happy with deliveries from Nokia and see that the performance has even improved since the BIRD improvements started. However, they are not satisfied with their own inventory that is needed for the consolidation of deliveries from two suppliers and to protect the project's progress from high demand fluctuations.

The potential lead-time reduction for the customer was 50%. Basically this benefit was not systematically utilised because of their internal fixed processes.

- **Capital employment and total costs**

From the supplier's perspective, the delivery process is pretty cost-efficient because equipment is delivered from the factory directly to the customer's warehouse. The inventory rotation has fluctuated around 10 days. However, the main inventory is in work in progress, which basically indicates that material has been delivered but not yet invoiced.

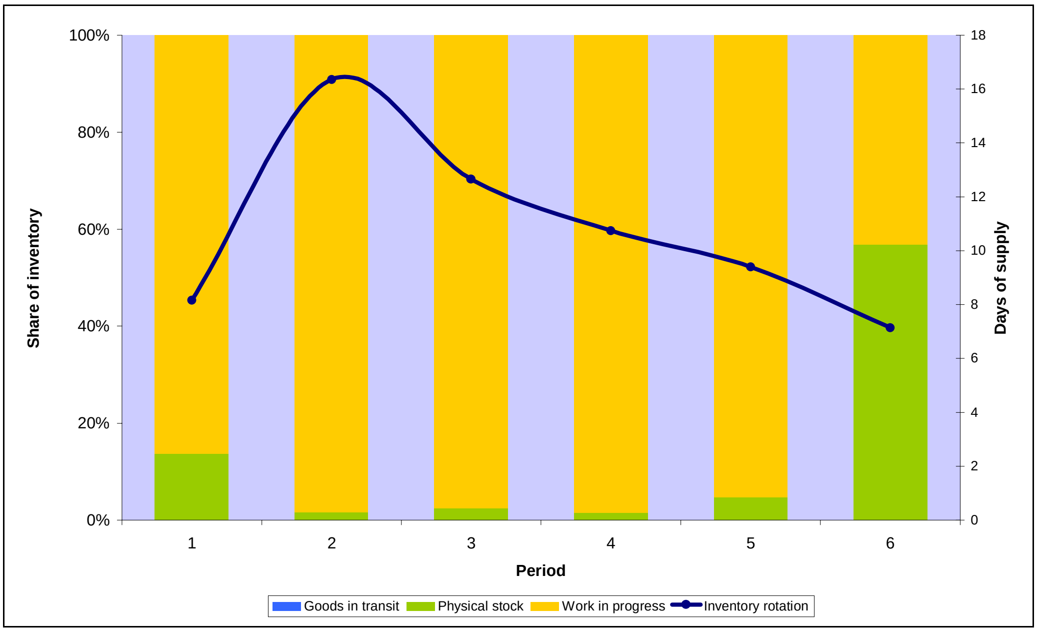


Figure 34: Inventory days of supply for operator C

From the supplier's perspective, the direct factory delivery mode is working fine. The customer is also relatively satisfied with the actual delivery performance, although there were temporary delays during the data analysis period - the customer's warehouse practically acted as a safety buffer.

6.2.4. Summary

The most interesting point in these “box delivery” customer cases is to see that the direct factory delivery mode is considered to be the preferred delivery option. All these customer cases indicate that the most direct and streamlined supply chain solution best suits customers in the business situation, where the system supplier is only responsible for supplying equipment to the network. The main requirement by the customers was that the equipment lead-times must be reliable to be able synchronise physical deliveries with their network rollout plans.

However, these customer cases do not indicate that no buffer is needed in the chain. For instance, customer C has its own base station stock, which they did not want to remove due to risks of interfering in the progress of the network project rollout. Customer B also wanted to continue having a small buffer of TRX units in their facilities to ensure some flexibility in the installation of capacity extensions. The customers were not expecting nor asking that the system supplier should hold the inventory for them. This kind of behaviour is quite understandable, if it is remembered that the customer has overall responsibility for the co-ordination of the network project. This co-ordination role can be quite enormous when there are several system suppliers providing material for the project and several installation subcontractors installing the equipment in the network.

6.3. "Telecom deployment" customer cases

6.3.1. Operator D: Improve process efficiency

The first case analysis of "telecom deployment" customers is an example of a business situation where an inefficient supply chain had to be revised twice before it was considered to be successful. In the first step, the local warehousing process was replaced with the direct factory delivery mode, which soon turned out to be an even more inefficient and less effective supply solution. Therefore, the delivery mode was switched one step back to the regional distribution centre mode. The main purpose of the analysis is to explain why the regional distribution centre mode was preferred to the direct delivery and local warehousing modes. The customer was looking for improvements in the efficiency of its end-to-end site implementation process.

The BIRD implementation and data analysis period was between P9/99 and P5/00.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

  The first GSM-network in this European country was launched by the operator D in early 1994. The network is owned by a joint venture company, which is owned by partly state and party privately owned companies. The company was alone for more than two years in the markets without real competition. The development of GSM-penetration in the country was rather slow in the early emergence phase of the industry. However, the growth began to increase very rapid after 1997, as shown in Figure 35. The penetration is still growing fast, and there are no clear signs of the mature phase yet.

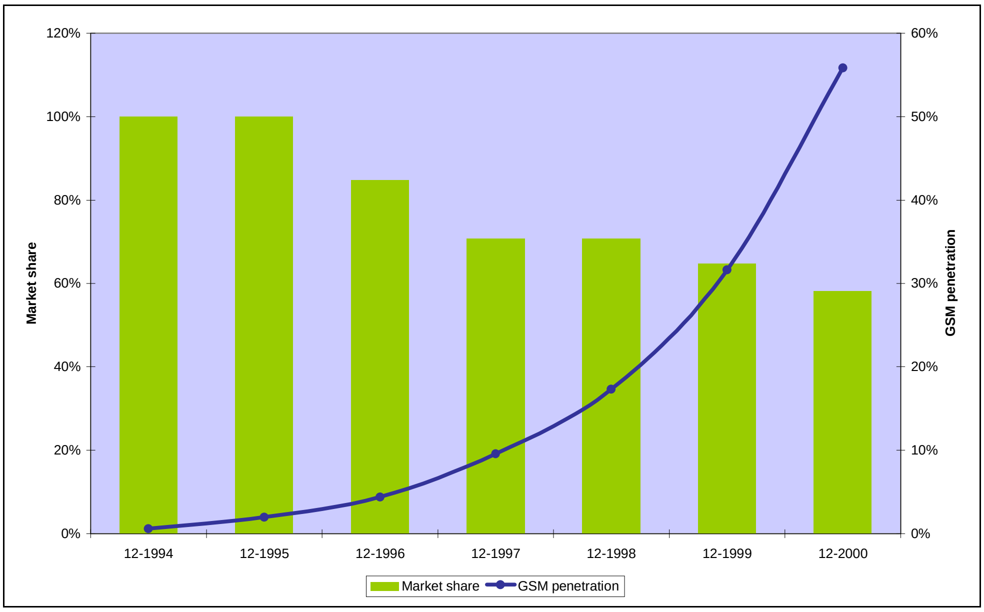


Figure 35: Market growth and operator D's market share

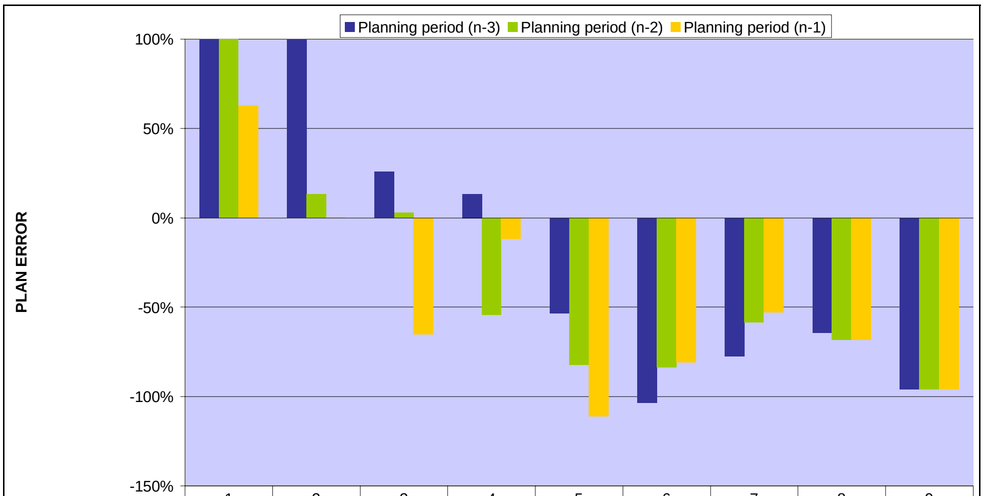
At the end of 1996 another operator entered the markets and started to rapidly take market share from operator D. Presently there are three rival GSM operators in the markets. The customer's market share has dropped constantly to the 50-60% level. It seems that the competition is only getting harder around the millennium.

The customer's strategic decision about the value chain is to outsource parts of the project management to system suppliers. According to this strategy, the site installation and additional technical support services are purchased from system suppliers. Furthermore, the network planning has to some extent been outsourced. Therefore, the scope of business is "telecom deployment".

- **Supplier, product and deliveries**

Nokia supplies base stations and related site solution material to the customer. The supplier also does the consolidation of site deliveries. The network was launched in January 1994 and it nearly covers the whole country. The network-building project is primarily focused on expanding the capacity of the network. Although the business conditions are generally favourable for the project, there still are constant delays in site acquisition and construction work.

Concerning supply chain management, the main challenges are linked to the question of how site implementation and logistics processes are integrated. As the site implementation process does not work optimally, project schedules tend to change. This fact is clearly visible in the accuracy of the customer's demand plans. The demand plan error during the analysis period is illustrated in Figure 36.



	1	2	3	4	5	6	7	8	9
Planning period (n-3)	100%	100%	26%	13%	-53%	-104%	-77%	-64%	-96%
Planning period (n-2)	100%	13%	3%	-54%	-82%	-83%	-58%	-68%	-96%
Planning period (n-1)	63%	0%	-65%	-12%	-111%	-81%	-53%	-68%	-96%

Figure 36: Operator D's demand plan error

As shown in the figure, the implementation plans are mainly overly optimistic. During the data analysis period the mean absolute demand plan error has been 65% for the rolling 1-month demand plans. Furthermore, it seems that the planning is not essentially getting more accurate compared to the 3-month figures.

In terms of on-time deliveries the performance has been fairly good. The delivery accuracy for operator D during the data collection period is illustrated in Figure 37.

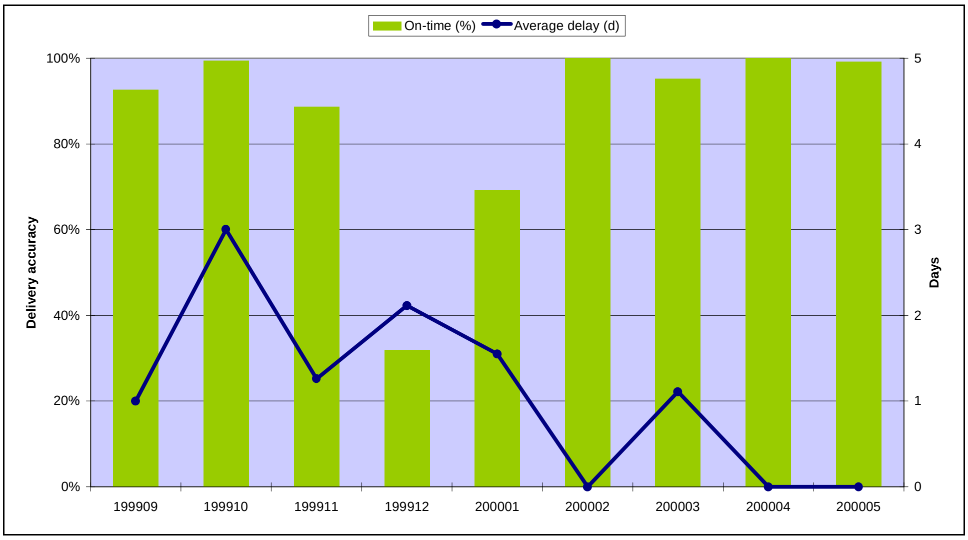


Figure 37: Delivery accuracy for operator D

Delivery accuracy has basically been at a satisfactory level during the data analysis period. At least 86% of deliveries have been on time and the average delay has been less than two days. However, there is one month at the turn of the year that showed significantly negative performance. Taking a more detailed look at the data, it indicates that these delays are mainly connected to the Christmas holidays.

- **Customer-supplier relationship**

The customer has two key system suppliers. Nokia is the supplier for the mobile switching system and the main supplier of base stations. The co-operation started in early 1996.

The operator basically has a good relationship with Nokia, but there have also been areas of significant weaknesses. These are very much linked to communication on a daily level; for instance, equipment delivery and installation schedules. Those issues were thoroughly looked into during the BIRD project.

THE DIFFERENTIATION OF THE SUPPLY CHAIN

- **Value offering point**

In the beginning, site ordering was done based on existing project plans. In the first trial this approach was not touched at all, only the location of the order penetration point was moved from the local warehouse to the plant. Only after the first trial failed was it agreed that site-specific orders would be done only after a pre-installation site meeting (PISM) was held between the customer and supplier. Thereafter the value offering point was finally switched from project planning to project execution.

- **Order penetration point**

The starting point was that there was a local warehouse of base stations for the operator. The process was clearly in the traditional warehouse mode; that is, site configurations were ordered based on the demand plan information and material waited in the local warehouse for the actual call-off order to the site. The manufacturing mode was in practise the ship-to-order-mode. However, this process was not working because of the constant changes of the site configurations and locations. Both Nokia and the customer wanted to change the process.

The first trial was to go for the direct delivery mode, which showed that in fact it did not improve the process at all. The reason was that the lead-time was too long to respond to the requirements of the site implementation process. Due to the long lead-time, site call-off orders were place too early in the site process; for instance, before the construction work started. As the plans changed, this caused problems similar to those before. In fact, the process acted in a similar way to the traditional warehouse mode. The main challenge was the question of how to integrate the site implementation and logistics processes.

As the customer was not willing to delay ordering without a shorter lead-time, it was agreed to revise the process once again. The solution was that Nokia would provide a shorter lead-time by implementing the regional distribution process and that the customer would delay site call-off ordering until the PISM meeting was held. This solution enabled both parties to work more efficiently than earlier.

The manufacturing postponement was moved from the assemble-to-order in the direct delivery mode to the pack-to-order in the regional distribution centre mode.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

According to direct comments during the BIRD implementation project, the customer sees clear benefits from the new processes for both parties. They are especially satisfied with the common and more standard working practises in the site implementation process. According to the customer, Nokia has earlier had a poor record in delivering what was needed on a timely schedule. Now there appears to be improvement in this area as Nokia is seen as more flexible and proactive.

In the annual customer satisfaction survey, the feedback from the customer is that the performance when delivering and expanding the network has improved since BIRD implementation. However, there is a feeling that Nokia has optimised its own delivery systems, but does not take account of the customer's reality, and shifts the burden to the client. The customer also comments that sometimes delivery schedules are so tight that there is no room for the flexibility needed in dealing with the realities of site construction.

Standard delivery lead-time has dropped around 50% for the customer.

- **Capital employment and total costs**

The development of inventory levels shows clearly that the first choice of implementing the direct factory delivery mode was not working in practise. Inventory levels increased, with the work-in-progress increasing in particular, since material arrived too early. When the regional distribution centre mode was taken into use the inventories development showed positive results immediately. In practise, what happened was that site call-off ordering could be postponed to the moment when it was 100% sure that the site was ready for the installation phase.

The development of inventories is shown in Figure 38.

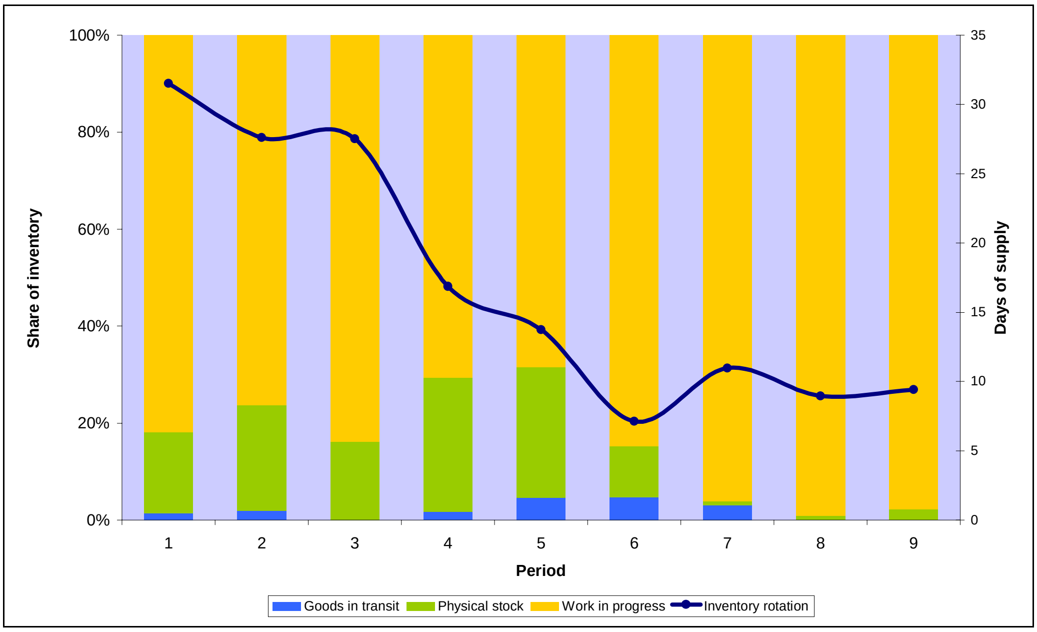


Figure 38: Inventory days of supply for operator D

Concerning cost-efficiency and total costs, the regional distribution centre mode is considered to be a working supply chain solution for the customer. Inventory days of supply for the customer dropped over 60% I the supply chain, and at the same the customer satisfaction improved.

6.3.2. Operator E: Ensure fast deliveries

The second "telecom deployment" customer case represents a situation where the customer project wants to ensure fast deliveries from the local project-specific buffer. The customer is ready to pay extra for the supply chain in order to guarantee the progress of the network rollout during the early phase of its network building. This case was selected to represent the good supply chain performance with a local warehouse mode.

The BIRD implementation and data analysis period was between P5/99 and P1/00.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

Operator E was the third GSM-operator in a European country, launching its network in early 1998. Market entry took place in the middle of an accelerating growth period of GSM penetration. The penetration has continued to growth rapidly since then, and reached the 60% level during 2000. Nowadays, there are already signs of maturity in the GSM-markets, as shown in Figure 39. However, during the BIRD project implementation in early 1999, the growth was still very fast.

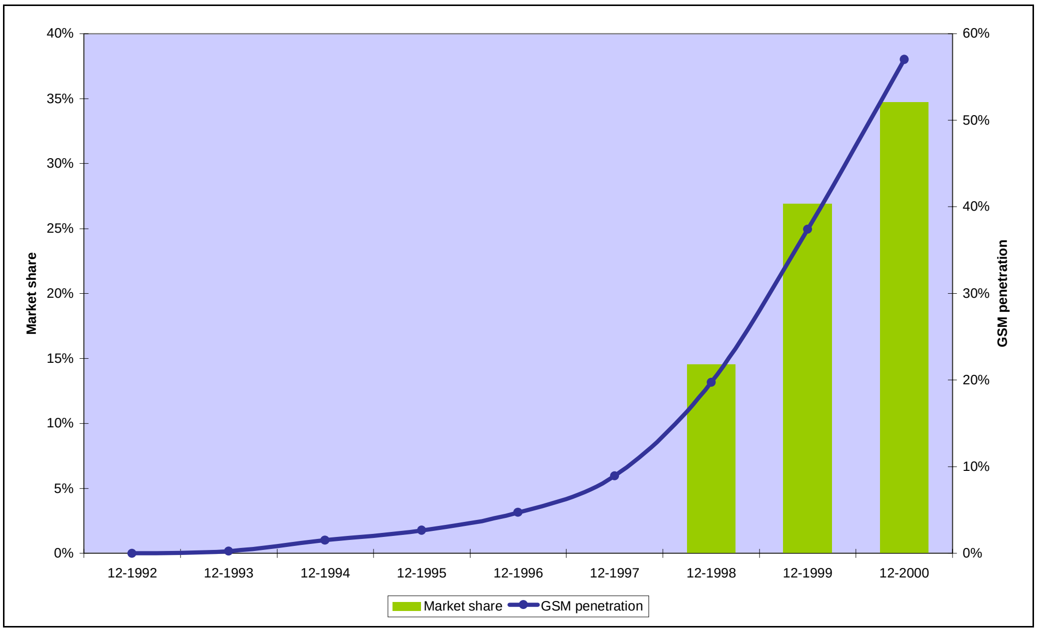


Figure 39: Market growth and operator E's market share

Despite the tight competitive situation in the country, the customer has successfully managed to enter the markets and increase its market share constantly since operations started. During 2001 it actually achieved the position of market leader with a market share above 40%.

The operator has chosen a strategy of building a network with a sole system supplier and has outsourced the installation and commissioning services to the system supplier. Therefore, the scope of business is "telecom deployment".

- **Supplier, product and deliveries**

Nokia provides a wide range of equipment to the operator. There are a large number of different base station and radio link configurations in use. Furthermore, the product portfolio of site solution material consists of hundreds of different items.

At the time when the BIRD project was activated, there were about five hundred base station sites on air and 250 sites under construction. The average rollout speed was about fifty-sixty sites per month. Nokia provided a wide range of equipment to the operator. The network-building project was in a phase where it was gradually changing from building coverage to building capacity. Coverage building is now concentrating on the islands, which is challenging from the radio transmission point of view. There are roughly 25 base station configurations in use. About 70% of transmissions are done with leased lines and the rest with the supplier's microwave radio links. There are a large variety of configurations and transmissions in use, which is also the reason for the high inventory levels.

One of the problems with the site implementation process is that the customer's transmission planning is already so late that it is not possible to provide any 'site specific' data at the moment radio equipment is ordered from the factory. This leaves the rollout demand and time schedule open. The site is specified at the last moment, which makes it very hard to use this trigger as an ordering point. These problems are also visible in the demand plan error rate as illustrated in Figure 40.

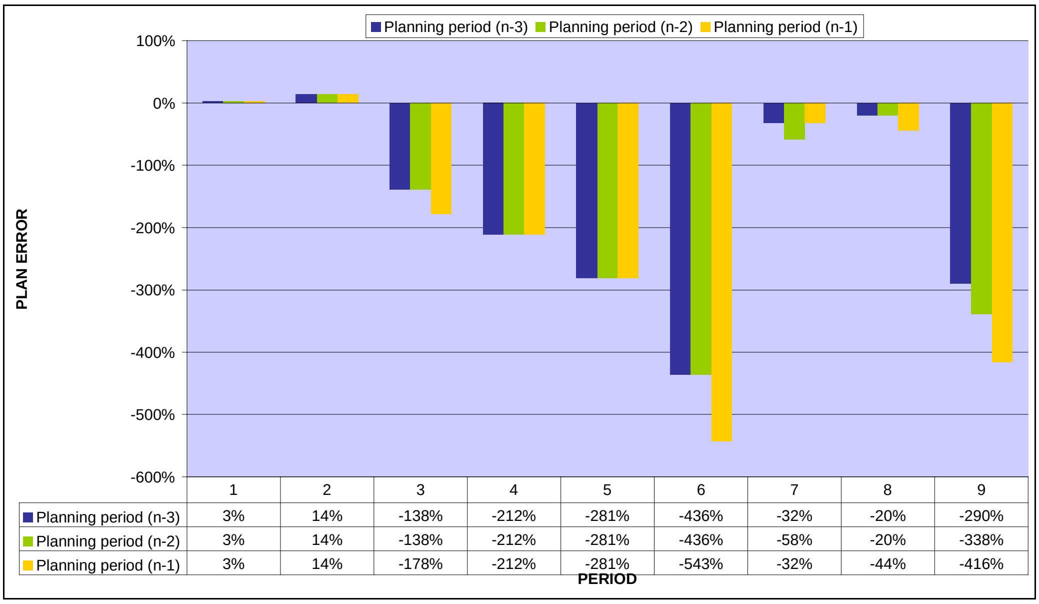


Figure 40: Operator E's demand plan error

As shown in the figure, the implementation plans are consistently highly optimistic. The mean absolute error has been up to 191% for the rolling 1-month demand plans. Furthermore, it seems that the planning is not essentially getting more accurate compared to the 3-month figures. This clearly proves that the site implementation processes are not standard.

In terms of on-time deliveries, the situation looks rather black and white. The performance has been very good when material is available in the buffer, but when some items are missing from the buffer the performance drastically drops down. This is clearly visible in Figure 41.

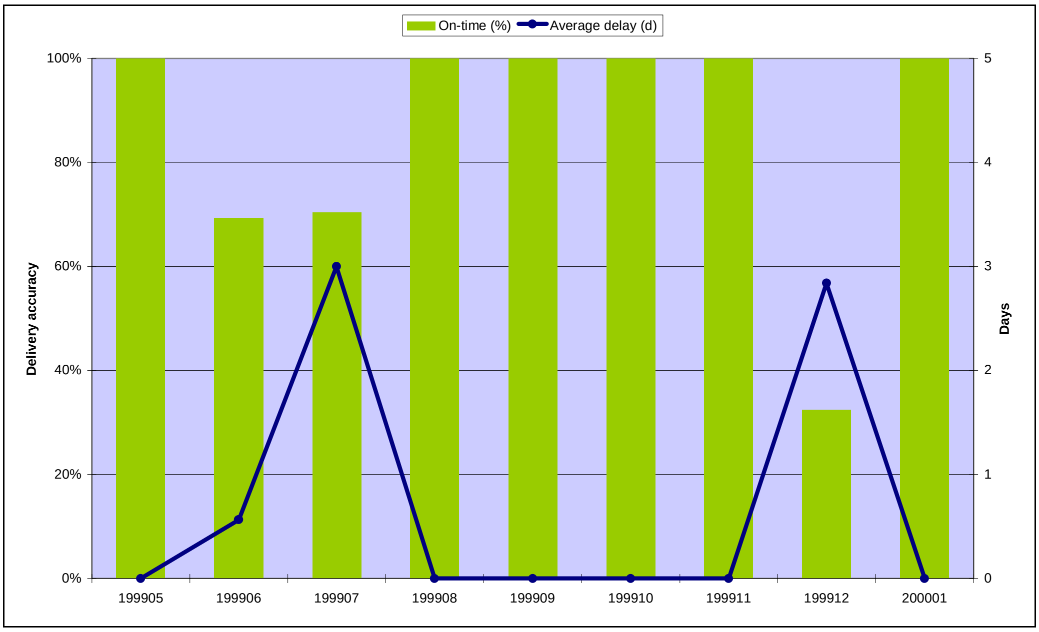


Figure 41: Delivery accuracy for operator E

Generally, delivery accuracy has basically been on a satisfactory level during the data analysis period. Over six months all deliveries were on-time, and on average more than 81% of deliveries have been on time with a delay of less than two days. The last month of the year again shows exceptional negative performance. These delays are connected to the Christmas holiday season.

- **Customer-supplier relationship**

Nokia is the sole supplier of the mobile network, including the mobile switching system, base stations and their installation and commissioning services. The co-operation that started in 1997 has been fairly good. As the customer is a fast-growing GSM operator with ambitious expansion plans, the requirements for the suppliers are demanding. Therefore, it is not surprising that the customer feels that its needs were not totally met in terms of delivering the network. In particular there is a perception that Nokia is not flexible and responsive enough to meet the customer's local needs.

There also seems to be these kind of negative issues with process collaboration because of the cultural differences between the companies and the people. According to the customer, they call for a flexible system supplier partner, not a 'box' seller who insists on everything being ‘standard’, which is rather how Nokia was perceived by this customer as the BIRD processes were implemented.

The demand planning process was implemented in co-operation with the customer. Now it is one of our regular meetings with our customer and they have committed to this process.

THE DIFFERENTIATION OF THE SUPPLY CHAIN

- **Value offering point**

As the site implementation process is not working optimally, the rollout plans are constantly changing. As the lead-times from the factory were on the level of a few weeks, this easily led to big inventory levels to secure the progress of the project rollout. Therefore, a unit based local country warehouse was needed for the operator to enable ‘site specific’ call-offs to be made with only a few days lead-time.

During the BIRD process implementation, the network-building project was run in direct export mode, which means that the customer was buying the equipment from Nokia Corporation in Finland and equipment was invoiced as it was shipped from the factories. The ownership of the products changes to the customer when the equipment arrives at the local warehouse in the country. However, the warehouse is fully operated by Nokia.

- **Order penetration point**

It was decided to put the logistics postponement location as close to the customer as possible. This is because of the demanding lead-time requirements of the project. Therefore, the country buffer mode was selected as the solution. Manufacturing postponement was switched from ship-to-order to pack-to-order mode, as the site deliveries were picked and packed in the warehouse based on the final call-off order.

The aim agreed with the customer was to move the order penetration point further upstream later on, as the network building progresses.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

  Direct feedback during the BIRD implementation showed that the customer really valued the efforts of Nokia to improve the performance of the supply chain, although the relationships were not the best possible at that time - due to the hectic rollout phase.

  According to the customer satisfaction survey, the logistics have improved during this year and are better than the competitors. Due to the standard working practises in logistics, the communication between different installation teams has also improved.

  Lead-time dropped dramatically as the real local warehouse mode was implemented. It basically dropped from the level of a few weeks to the level of a few days. At the same time the inventory level came down.

- **Capital employment and total costs**

  The development of inventory levels is illustrated in Figure 42. During the first three months there was not statistics available about how inventory was divided into “goods in transit”, “physical stock” and “work in progress”.

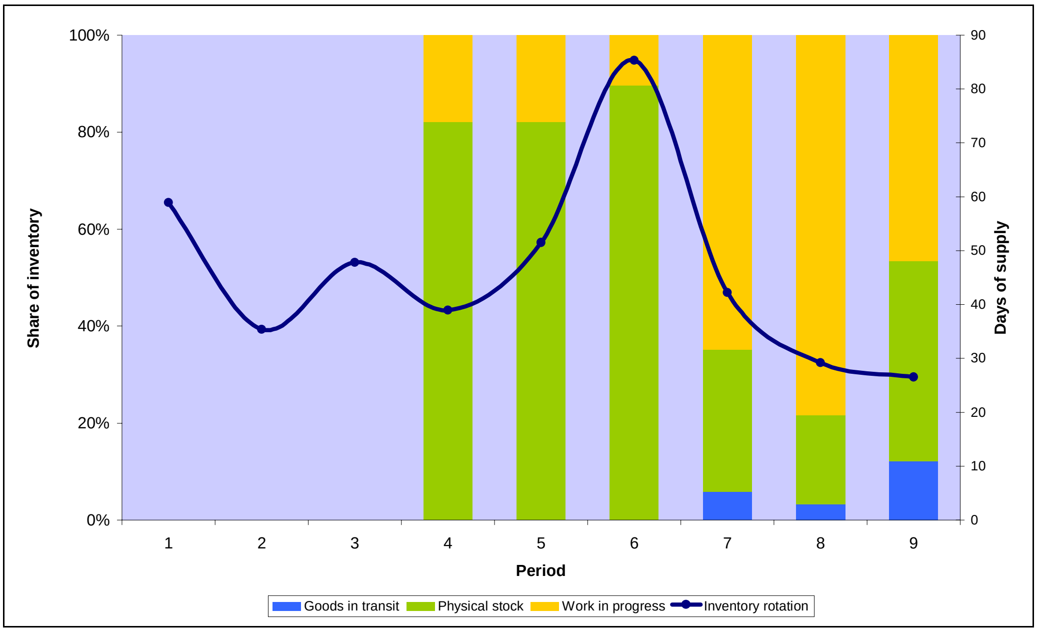


Figure 42: Inventory days of supply for operator E

In terms of cost-efficiency, figures are relative fluctuates. However, it is seen in the figure that the local warehouse delivery mode was a better solution compared to the situation beforehand, when operation with 'site specific' deliveries directly from the factory was attempted. The high peak in the inventory levels is connected to a poor month of demand plan error.

6.3.3. Operator F: Reduce inventory costs

This case analysis represents a situation where the customer project wants to radically reduce its inventory costs and minimise the risk of obsolescence. The customer is looking for the most streamlined supply chain possible to support its stable site implementation process.

The BIRD implementation and data analysis period was between P5/99 and P1/00.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

Operator F was the second GSM-operator in this European country, launching its network in late 1992. The company was privately owned already at that time. The market entry took place only a few months after the first operator launched its services. The GSM-penetration developed quite moderately in the beginning. However, after the first three years the markets started to increase very rapidly. The rapid growth has continued and has reached the 60% level. Nowadays, although the growth has become even, there still are not clear signs of maturity. The development of the markets is shown in Figure 43.

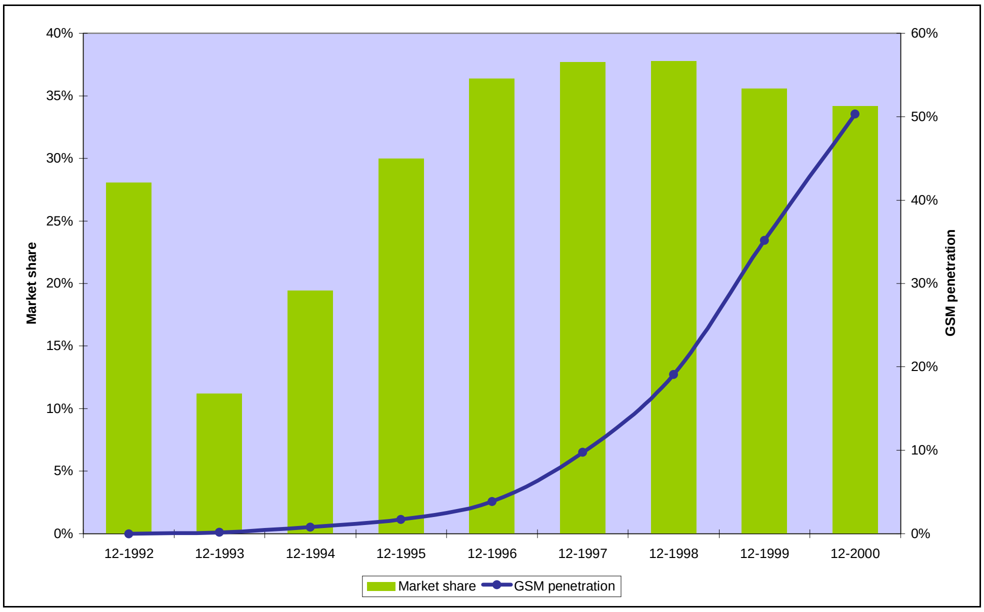


Figure 43: Market growth and operator F's market share

Today, there are three competing GSM operators in the country. The customer has managed to gain about a third of the markets. Since 1996, the market share has stabilised at that level, as shown in the figure.

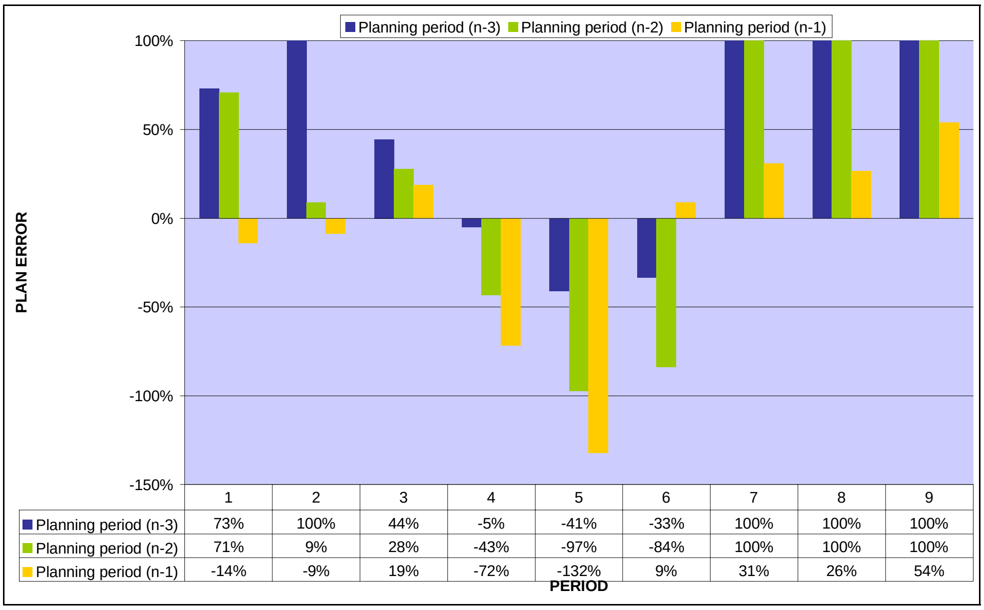
The customer's strategy has been to build the network with a few system suppliers. The operator wants to manage the overall project by itself, but it has outsourced the main installation and commissioning services to the system suppliers and local installation subcontractors. Therefore, the business scope is "telecom deployment".

- **Supplier, product and deliveries**

The product portfolio agreed with Nokia includes only base station equipment. The related site solution material is purchased from other vendors. This means that the operator needs to do the delivery consolidation somewhere before the installation process.

Network operations started in 1992 in some restricted areas. By the end of 1993 the network covered the main cities in the country as well as the interconnecting routes. By end of 1997 the network coverage reached over 85% of the population. In early 1999, when the BIRD project was activated, the network already covered most of the country and the focus was switched to the capacity extension phase.

After years of experience in building the network, the site implementation process works pretty well and rollout plans are quite accurate. There is no need to postpone the call-off ordering since the plans are reliable, and material ordering can be made based on the plan. The development of demand plan error is illustrated in Figure 44.



	1	2	3	4	5	6	7	8	9
Planning period (n-3)	73%	100%	44%	-5%	-41%	-33%	100%	100%	100%
Planning period (n-2)	71%	9%	28%	-43%	-97%	-84%	100%	100%	100%
Planning period (n-1)	-14%	-9%	19%	-72%	-132%	9%	31%	26%	54%

Figure 44: Operator F's demand plan error

As shown in the figure, the demand plan error fluctuates around 0% during the data analysis period. It indicates that the project planning is not systematically skewed; that is, the plans have not been either too optimistic or too pessimistic. The mean absolute error has been an even 41% for the rolling 1-month demand plans.

In terms of delivery accuracy, the situation has been very good. The development delivery accuracy during the data analysis period is shown in Figure 45.

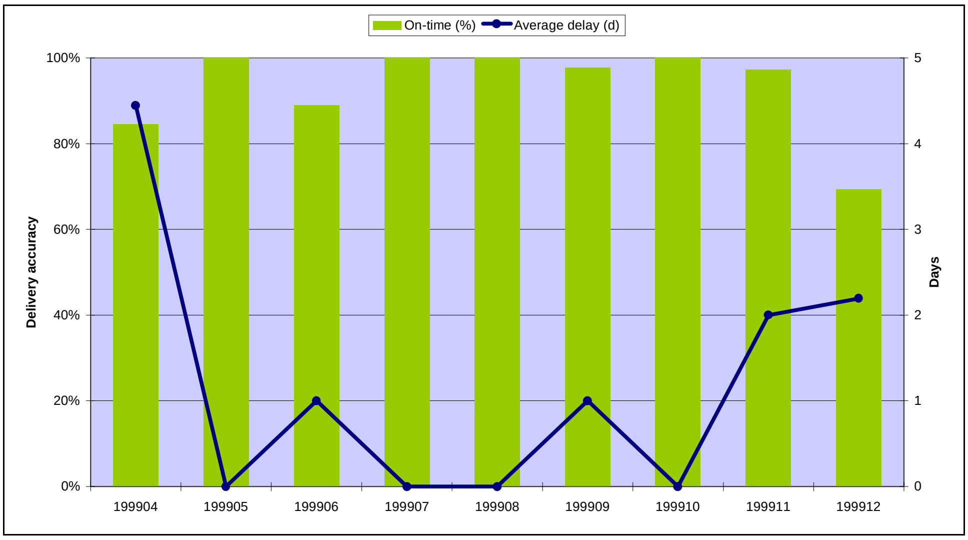


Figure 45: Delivery accuracy for operator F

The delivery accuracy was at a good level during the data analysis period. About 91% of deliveries have been on time and the average delay has been 2.3 days.

- **Customer-supplier relationship**

The customer has selected several system suppliers to provide equipment for the network. Two system suppliers supply mobile switching systems and three the base station systems. Nokia is one of the key suppliers of base stations, including their installation and commissioning services. Product scope is limited to only base stations. The contract does not include site solution material or radio links.

The co-operation started at the end of 1996, and it can clearly be considered to be a partnership. However, due to the several suppliers for the network, the level of process collaboration has been quite limited. A basic demand planning process is implemented with the customer.

THE DIFFERENTIATION OF THE SUPPLY CHAIN

- **Value offering point**

  The starting point before the BIRD process implementation was that there was a local warehouse for the customer. It was operated in the traditional warehouse mode. Fully configured base stations were ordered based on rollout plans. The material was stored in the warehouse waiting for the customer call-off order.

  Earlier the site implementation process had not been reliable, and the planning accuracy was thus very poor. Due to the heavy rollout of the network, a huge inventory of base stations assigned to the customer was accumulated over the last few years. The risks of obsolescence were significant to both parties.

  As the delivery processes were re-engineered with the customer, it was agreed to have as much a direct delivery mode as possible. The plans were made to switch from this traditional warehouse mode to the direct factory delivery mode. At the same time, a new customer contract was re-negotiated and these BIRD principles were applied in the contract.

  The process changes that were implemented included site-specific ordering, standard lead-time to installation site without the use of a warehouse, and invoicing on delivery at site. The call-off ordering was to take place only after a certain milestone in the site implementation process had been achieved. These improvements benefited both companies.

- **Order penetration point**

  Earlier the manufacturing process was in practise in the ship-to-order mode, as the customer ordered site specifically from the local warehouse. During the BIRD process implementation, the manufacturing postponement was shifted from STO to ATO mode. The logistics postponement location was also moved from the local warehouse to the plant. This change was successfully implemented, as the whole site implementation process was revised. The reliable site implementation process made it possible.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

According to direct comments during the BIRD implementation project, the customer sees clear benefits from the new processes for both parties. They are especially satisfied with the standard and simple way of working inside the supply chain.

The lead-time reduction is about 50% for the customer.

- **Capital employment and total costs**

The cost-efficiency improvements were clearly visible. The development of inventory levels is illustrated in Figure 46. For the first six months there is not statistic available about the inventory categories.

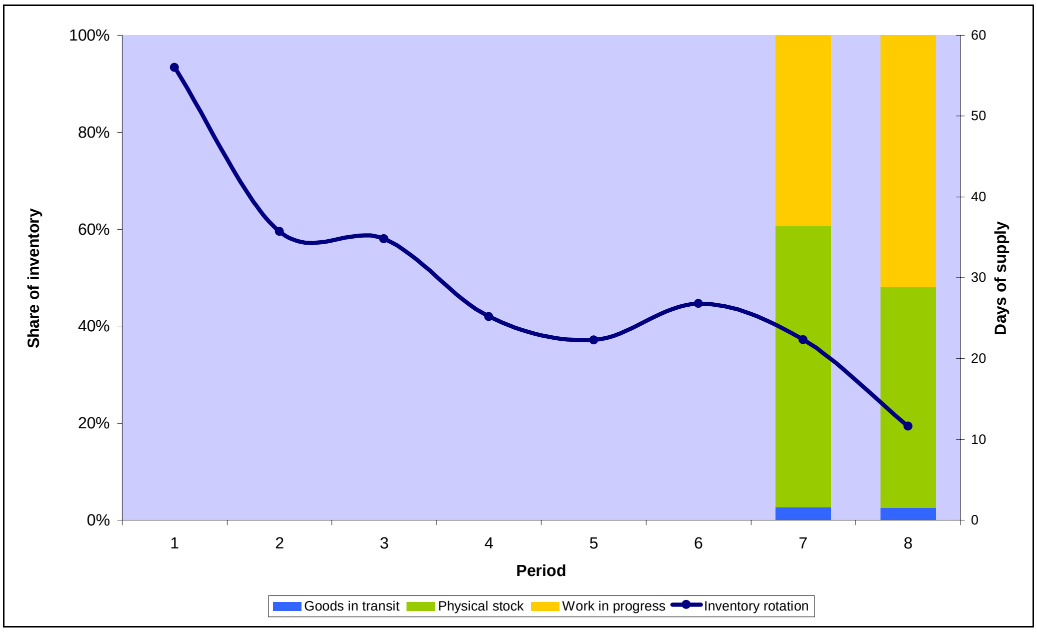


Figure 46: Inventory days of supply for operator F

Based on the figures it becomes evident that the direct factory delivery mode is obviously the best supply chain solution for the customer. DOS dropped almost 80 percent and at the same time customer satisfaction improved.

6.3.4. Operator G: Implement an efficient supply chain

This case analysis represents a situation where a new delivery process is implemented with the customer from scratch. The customer wants to have an efficient and reliable supply chain implemented for its site implementation process. Direct factory deliveries were successfully implemented.

The BIRD implementation and data analysis period was between P1/00 and P9/00.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

  Operator G was one of the two operators that introduced a GSM network in a European country in late 1992. In the beginning it was a state owned company, but now privatisation is ongoing. The GSM-penetration developed quite moderately until 1997, when rapid growth started in the markets. The penetration has already reached the 70% level, and the markets are clearly getting mature. The development of the markets is shown in Figure 47.

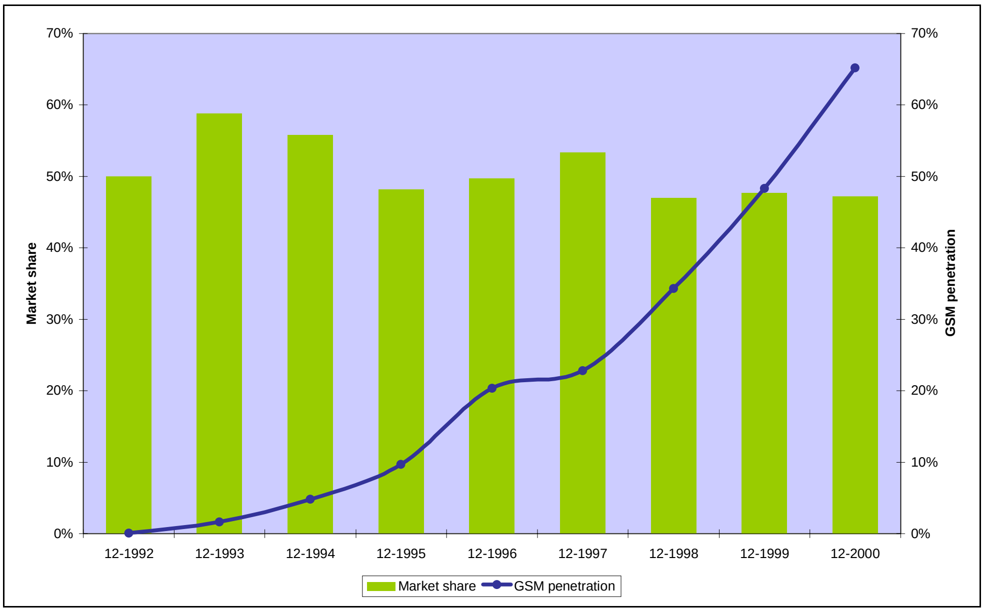


Figure 47: Market growth and operator G's market share

At the time the BIRD project was started, there were already four GSM operators in the markets. The other networks were launched in the beginning of 1998 during the rapid growth phase. The customer is the biggest operator in the country and has a stabilised market share, which is close to 50%.

The customer's strategy has been to outsource system installation and commissioning services to the system suppliers. Thus, the scope of business is "telecom deployment" for the supplier.

- **Supplier, product and deliveries**

The product portfolio agreed with Nokia includes base station equipment and a limited amount of site solution material. The product portfolio is relatively small and fixed, as the operator uses quite standard product configurations.

The customer's representatives in the building project were very experienced since GSM operations started in 1992 for them. The network already covered the whole country when the BIRD processes were designed. The main focus in the project was to expand and optimise the capacity of the network. The delivery volumes for Nokia were quite small. Lead-time was not considered to be that critical by the project teams, but the delivery reliability was very critical due to the nature of this kind of swapping business. As the old equipment of base station sites had to be replaced by new equipment, installation often had to be done at night in order not to interfere with the traffic. One of the basic requirements of the customer was that a base station site was not allowed to be down longer than a few hours. It was agreed that the site call-off be made based on the extension implementation plan, since the implementation plan was considered quite reliable and possible delays are not that critical for the customer's business.

The site implementation plans are fairly reliable. This is also apparent in Figure 48.

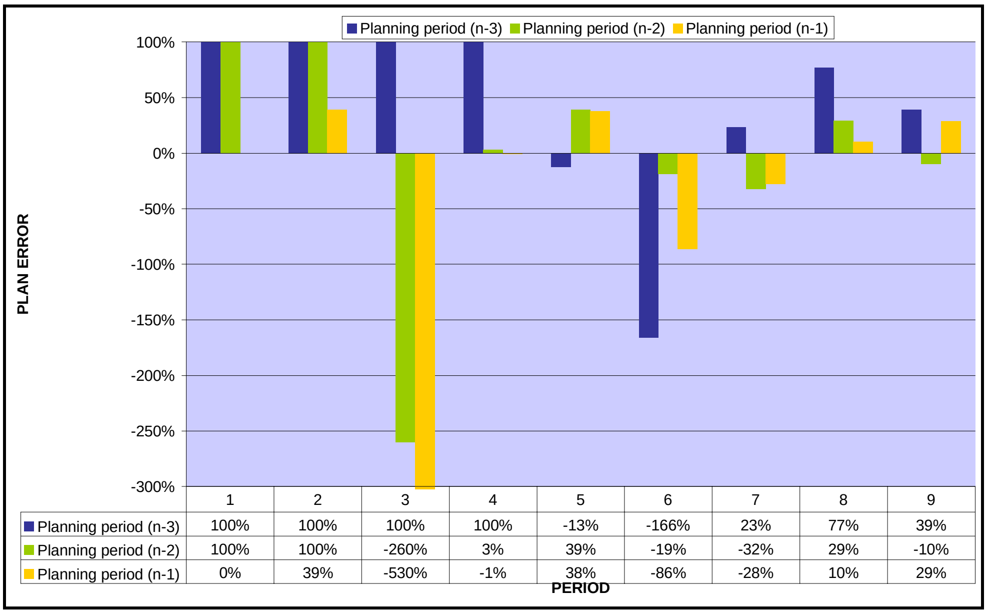


Figure 48: Operator G's demand plan error

As shown in the figure, the demand plan error fluctuates around 0% during the data analysis period. There is one month where the plans have been far too optimistic. This is linked to an individual problem in the customer's site implementation. Otherwise, the figures indicate that the project planning is systematically fairly reliable. The mean absolute error was 29% for the rolling 1-month demand plans.

In terms of on-time deliveries the situation looks good, as illustrated in Figure 49.

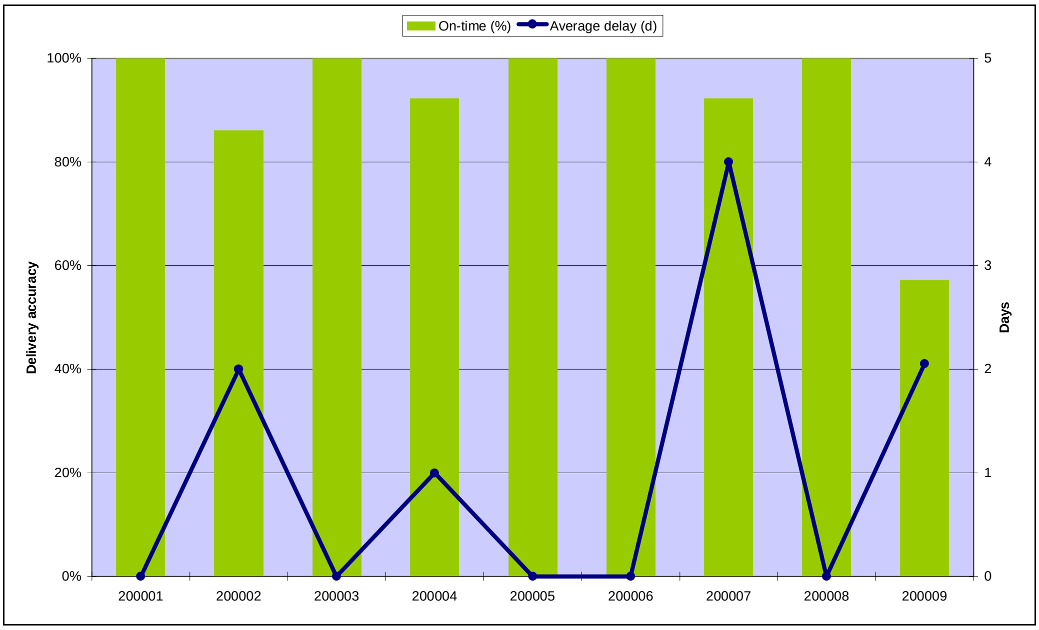


Figure 49: Delivery accuracy for operator G

Delivery accuracy has basically been at a satisfactory level during the data analysis period. Almost 90% of deliveries have been on time and the average delay has been 2.2 days.

- **Customer-supplier relationship**

Since the beginning of the network operations in the early 1990's, the customer had selected one sole system supplier (other than Nokia) to provide equipment for the network. However, at the end of the 1990's Nokia was selected as the main supplier for expanding the capacity of base station systems inside certain limited regions in the country. Included in this network extension project, Nokia was forced to swap out the old base station of the network for brand new ones.

The co-operation started only in 1999, and thus the relationships were very fresh when the BIRD processes were implemented. The communication was easily without problems stemming from any cultural differences. As the operator was experienced in the business, it understood from the beginning the importance of tight process collaboration with the supplier. The basic site implementation process was already in good shape and demand plans were reliable.

THE DIFFERENTIATION OF THE SUPPLY CHAIN

- **Value offering point**

  Site specific ordering was implemented at the beginning of the contract together with the customer. Ordering was done based on the existing rollout plan.

- **Order penetration point**

  The process was based on the assemble-to-order mode. The site call-off order was placed directly to the base station plant and material was delivered to the customer's regional drop-off point to await pick up by the installation team.

  The direct factory deliveries started successfully. The logistics postponement location was thus upstream in the supply chain.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

  According to the customer satisfaction survey, the customer is happy with the delivery performance and the supply chains.

  The lead-time was fixed at the beginning of the project. However, they did not consider a short lead-time in general to be an issue for them. The most important thing for them was the reliable lead-time.

- **Capital employment and total costs**

  The development of inventory levels, illustrated in Figure 50, clearly shows that there is no buffering in the supply chain; rather, the process is very straightforward with the direct factory delivery mode.

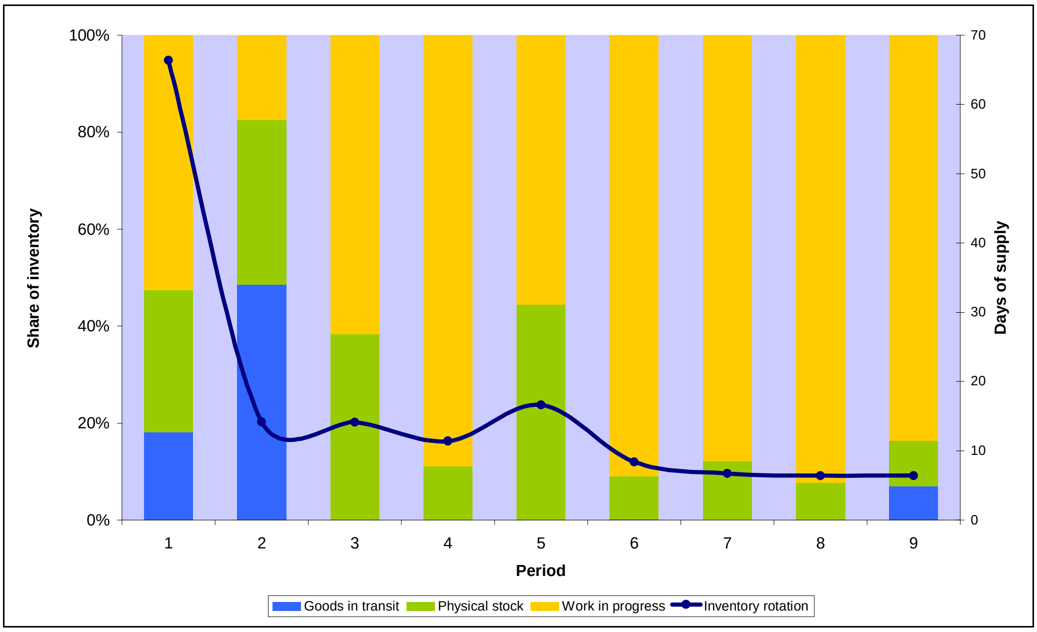


Figure 50: Inventory days of supply for operator G

After a couple of trial deliveries without any proper supply chain process agreed, the inventory days of supply is looking good and the customer is happy with the performance of the deliveries.

6.3.5. Operator H: Improve supply chain effectiveness

This case analysis represents a situation where the customer project aimed to improve the effectiveness of deliveries and remove all unnecessary buffers in the supply chain. The regional distribution centre mode replaced the existing, costly local warehouse mode.

The BIRD implementation and data analysis period was between P10/99 and P6/00.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

Operator H was the second GSM operator in a European country, launching its network in late 1998. The first operator had already been in the markets for over five years before the second operator entered the business. The GSM penetration was already rapidly growing at that time. Since then the growth has continued at approximately the same speed. In 2001 the penetration started to mature. This is also shown in Figure 51. The company is completely privately owned.

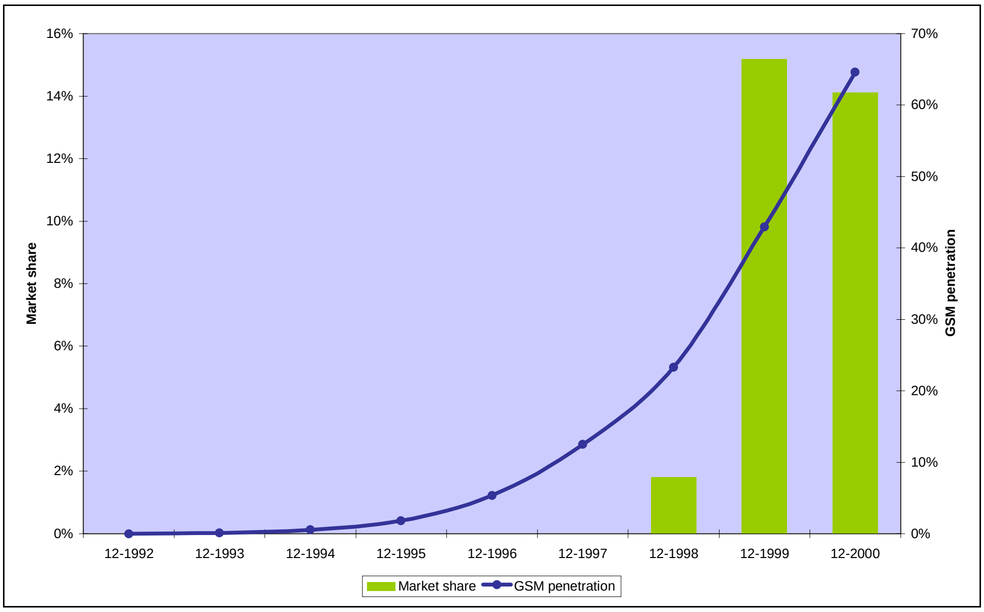


Figure 51: Market growth and operator H's market share

A third operator launched its GSM network only a few months after the customer. Therefore, the competitive situation for the customer has not been that easy. Market share increased to the 15% level right after the services were introduced. Since then it has remained the same, as illustrated in the figure.

To get the network up and running as fast as possible in the beginning, the operator outsourced the whole network project management to one sole supplier and also some parts of its operations. Since the first launch, the responsibility for network planning, site acquisitions and construction work has gradually been moved to the customer. The business scope is thus "telecom deployment".

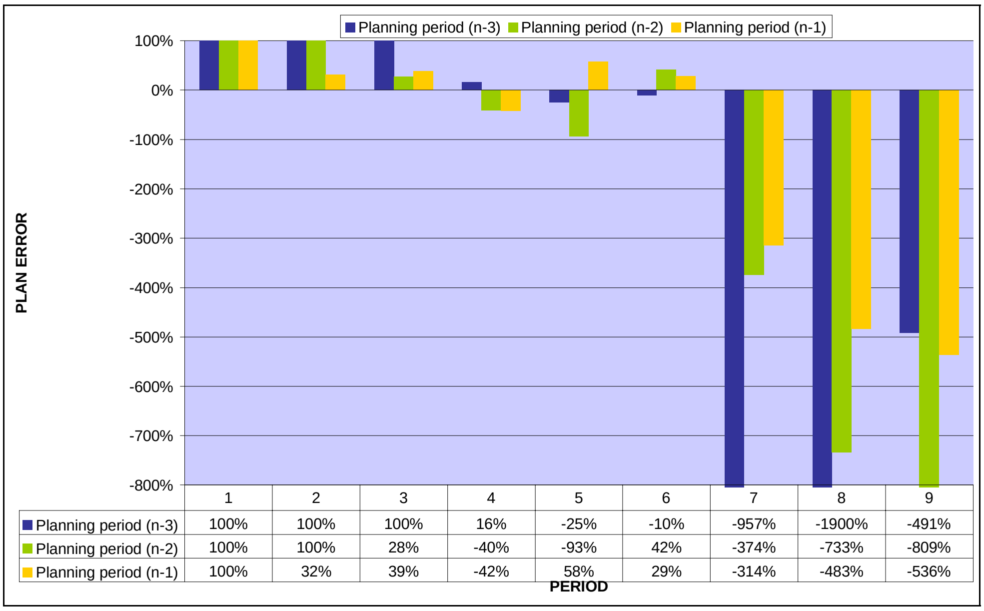
- **Supplier, product and deliveries**

Nokia provides a wide range of equipment to the operator, including base stations, radio links and site solution material. The delivery accuracy to the customer has been fairly good from the supplier's local warehouse.

At the time the BIRD process was implemented, the operator's network covered only a little more than half of the country, mainly the large urban areas and the motorways between these centres. The target was to increase the cover to 90% of the country within fifteen months.

The beginning of the network was very turbulent and there has been extensive pressure to get more network coverage. Therefore, the site implementation process has not been reliable. Earlier there was not any clear call-off trigger in the site implementation process agreed. As a part of the BIRD process implementation, a reliable call-off trigger was identified and implemented together with the customer.

The progress of the rollout fluctuates greatly due to a number of obstacles in the site implementation process. The site implementation is thus not reliable and stable, as it depends on many uncontrollable factors, including difficult geographic and climate conditions. Therefore, the demand plan error is also constantly changing, as illustrated in Figure 52.



	1	2	3	4	5	6	7	8	9
Planning period (n-3)	100%	100%	100%	16%	-25%	-10%	-957%	-1900%	-491%
Planning period (n-2)	100%	100%	28%	-40%	-93%	42%	-374%	-733%	-809%
Planning period (n-1)	100%	32%	39%	-42%	58%	29%	-314%	-483%	-536%

Figure 52: Operator H's demand plan error

During the data analysis period the mean absolute demand plan error was 122% for the rolling 1-month demand plans. This proves that project plans are constantly being updated.

The development of delivery accuracy during the data analysis period is shown in Figure 53.

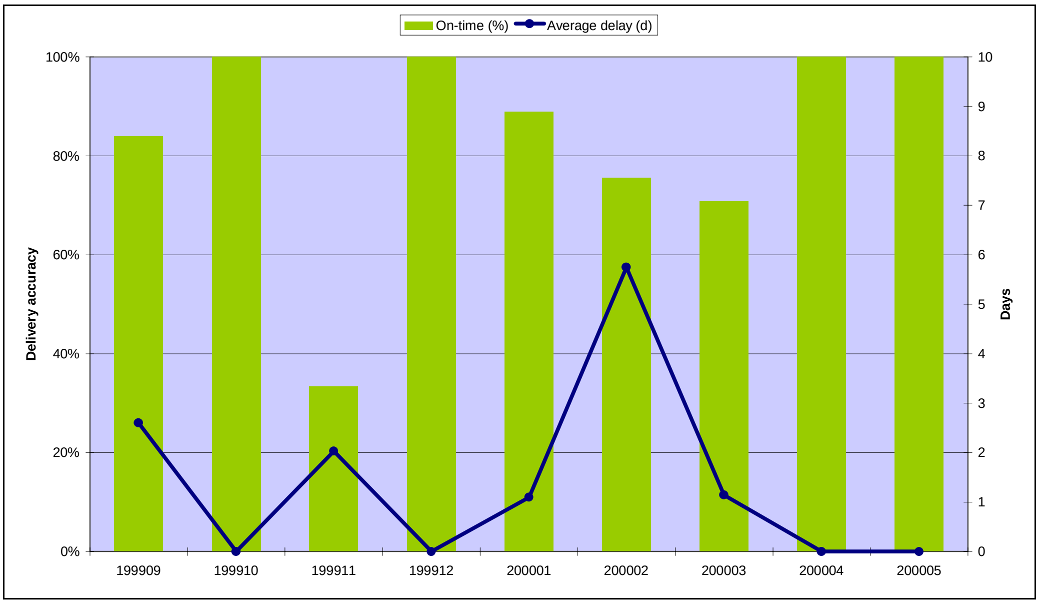


Figure 53: Delivery accuracy for operator H

Delivery accuracy has basically been at a satisfactory level during the data analysis period. About 84% of deliveries have been on time and the average delay has been 1.4 days. There is one month at the turn of the year that showed significant negative performance.

- **Customer-supplier relationship**

Nokia was selected as the customer's sole system supplier in spring 1998. The contract included a mobile switching system, base station system, and network management system. The deal was a full turnkey, meaning that the supplier is responsible for the network planning, site acquisitions, construction works, and network implementation. However, at the beginning of 2000 the customer took over the network planning and site acquisitions.

Since the start of network building, the co-operation has been very close and from time to time quite turbulent. The relationships are basically good, although the start-up phase for both parties was difficult. However, the process collaboration is working, for instance the demand planning process and the implementation of a reliable call-off trigger in the site process work.

THE DIFFERENTIATION OF THE SUPPLY CHAIN

- **Value offering point**

The starting point was that ‘site specific’ orders were made based on the existing rollout plans. As the site implementation process was not reliable, the planning accuracy was very poor. Due to the heavy rollout of the network, a huge inventory of base stations assigned to the customer accumulated over the last few years. High inventories have still not guaranteed smooth operations. The risks of obsolescence were significant to both parties.

Therefore, it was agreed to re-engineer the whole delivery process with the customer. The target delivery process was the regional distribution centre mode because the lead-time it provided was enough to support the process with a reliable call-off order trigger.

- **Order penetration point**

The starting point from the manufacturing and logistics postponement point of view was to have material deliveries from the local warehouse in STO mode. The end solution was to go further upstream and deliver material from the distribution centre in the ATO mode.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

Direct feedback from the customer clearly indicated positive experiences with the changes made during the BIRD implementation.

According to the customer satisfaction survey, they are impressed with the new equipment delivery system (BIRD), which Nokia has recently introduced. At the same time the quality of the rollout has improved.

The lead-time reduction has been around 50%.

- **Capital employment and total costs**

The development of cost-efficiency since the BIRD processes were implemented has been good. The development of inventory levels is illustrated in Figure 54.

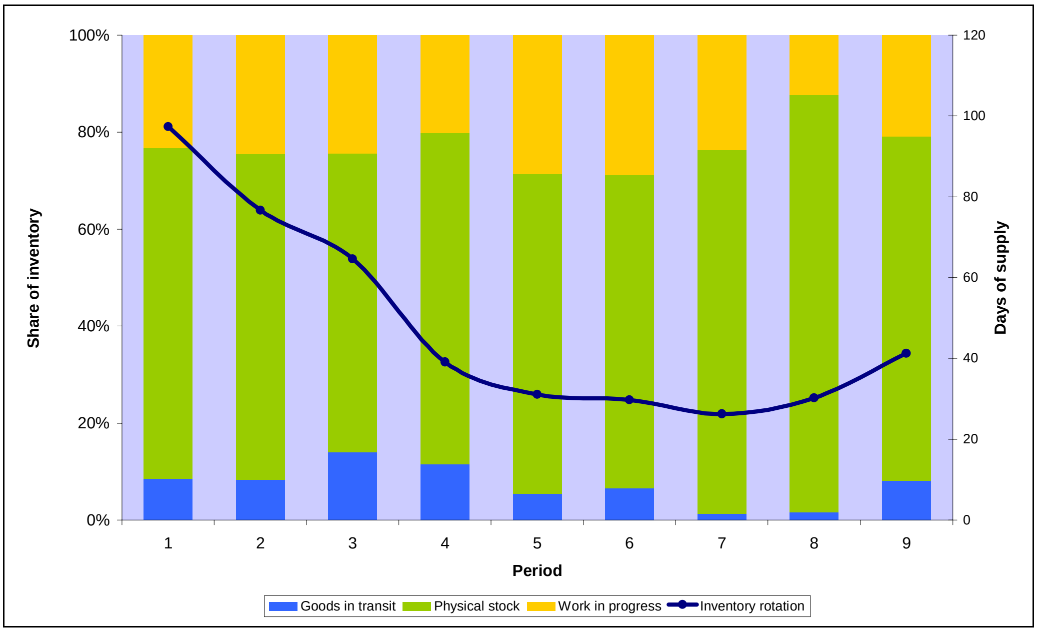


Figure 54: Inventory days of supply for operator H

As the country warehouse is not needed anymore, the savings in inventories and tied up capital were significant. Inventory days of supply for the customer reduced by 60 percent. The response capability and service level towards the rollout project has also increase at the same time.

6.3.6. Summary

These customer cases show that there is not a single supply chain mode that suits all "telecom deployment" customers. There were customers, operators F and G that were clearly satisfied with the direct factory delivery mode. Other customers, operators D and H, wanted to streamline the delivery process, but did not accept the lead-time of the direct factory delivery mode. Actually, these latter two cases became the first customers of the regional distribution centre. Another customer, operator E, needed a local warehouse mode to ensure customer satisfaction and the progress of its rollout.

6.4. "Turnkey" customer cases

6.4.1. Operator I: Maximise the project's efficiency

This case analysis represents a situation where the direct factory delivery mode was first implemented for the start-up customer project. The target was to implement the most streamlined supply chain possible in order to maximise the project's efficiency. However, after a few months trial it became obvious that this delivery mode was not the best fit for the customer and did not provide the efficiency required. Therefore the delivery mode was later changed to the regional distribution centre mode, which better tackles the project targets.

The BIRD implementation and data analysis period was between P2/99 and P10/99.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

  Operator I is the fifth GSM operator in a European country, launching its network in early 1999 a few months after the fourth operator introduce its services. The market entry was made in the middle of a fast growth phase, as shown in Figure 55. The GSM-penetration in the country had already reached the maturity phase in 2001.

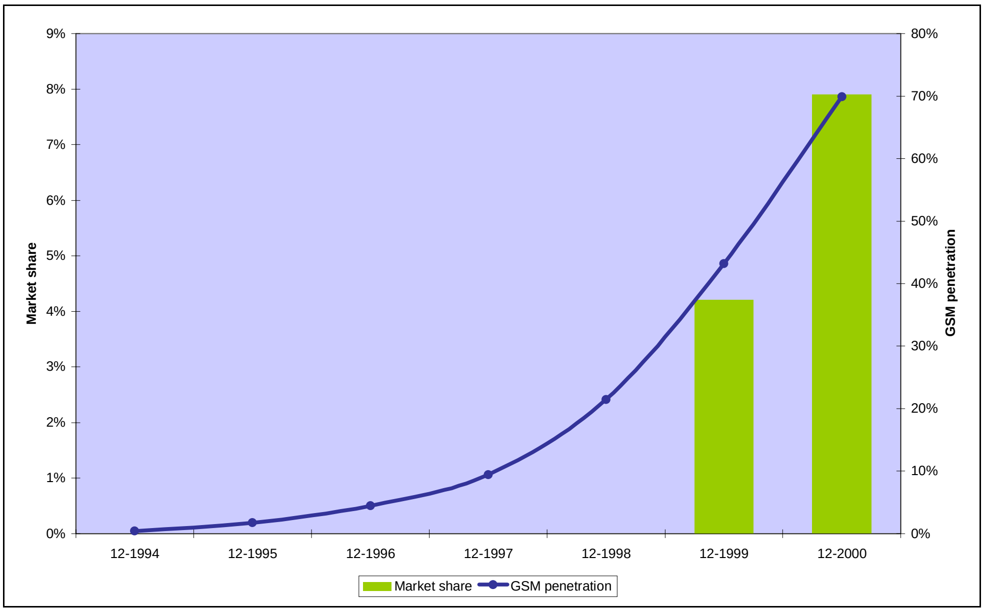


Figure 55: Market growth and operator I's market share

The competition is extremely tight, as there are five players in the same markets. The customer's market share has constantly increased, but still remained under ten percent. The operator is still a start-up company.

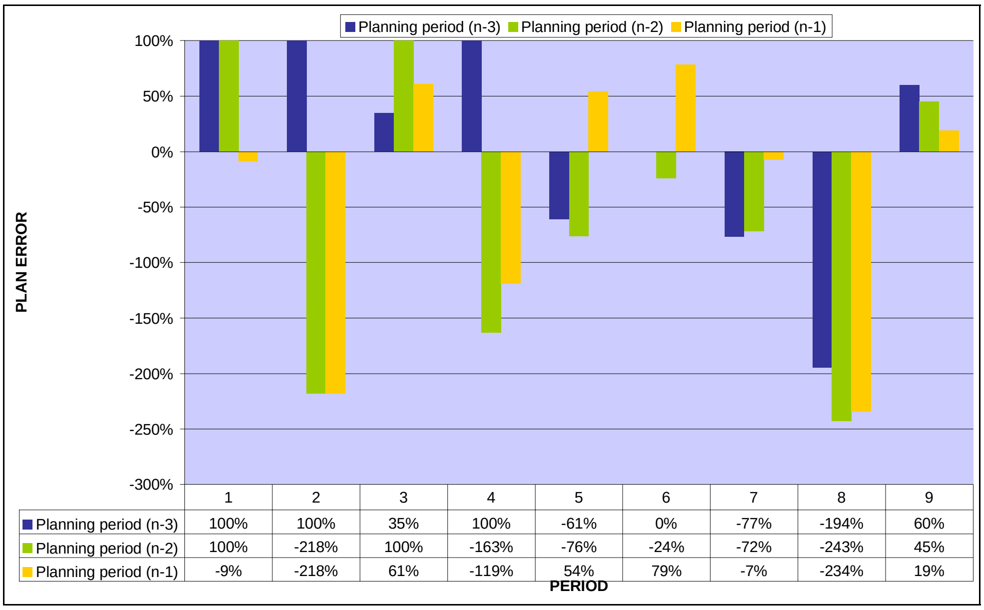
The customer's value chain leads the business scope to be defined as "turnkey", as it has outsourced network planning, site acquisitions, construction work and installation to the system supplier. This is quite understandable since the customer's strategic objective is to increase market share as fast as possible.

- **Supplier, product and deliveries**

Nokia provides a wide range of equipment to the operator, including base stations, radio links and site solution material.

The building project is only in its early phases. At the time when the BIRD project was activated, there were approximately 190 base station sites on air. The project was divided geographically into 12 zones, each of them managed by a zone manager. The average rollout speed is twenty base stations and microwave radios a week. The target is to have around 1,700 sites on air within months, which would be an average of thirty new sites on air per week.

However, the problem lay in the site implementation plan, which is constantly changing. For example, the original rollout plan was to cover 50% of the transmissions with radio links, but it turned out to be around 90 %. No wonder that the demand planning accuracy has been fairly poor all the time. There has also been a lack of competence and experience among installation subcontractors. Mistakes in installations have caused rework and many site visits. These problems are also visible in the demand plan error, as illustrated in Figure 56.



	1	2	3	4	5	6	7	8	9
Planning period (n-3)	100%	100%	35%	100%	-61%	0%	-77%	-194%	60%
Planning period (n-2)	100%	-218%	100%	-163%	-76%	-24%	-72%	-243%	45%
Planning period (n-1)	-9%	-218%	61%	-119%	54%	79%	-7%	-234%	19%

Figure 56: Operator I's demand plan error

As shown in the figure, the demand plan error fluctuates around 0% during the data analysis period; that is, the plans are not skewed. However, the changes are relatively high, since the mean absolute error was 86% for the rolling 1-month demand plans.

The development of delivery accuracy during the data analysis period is shown in Figure 53.

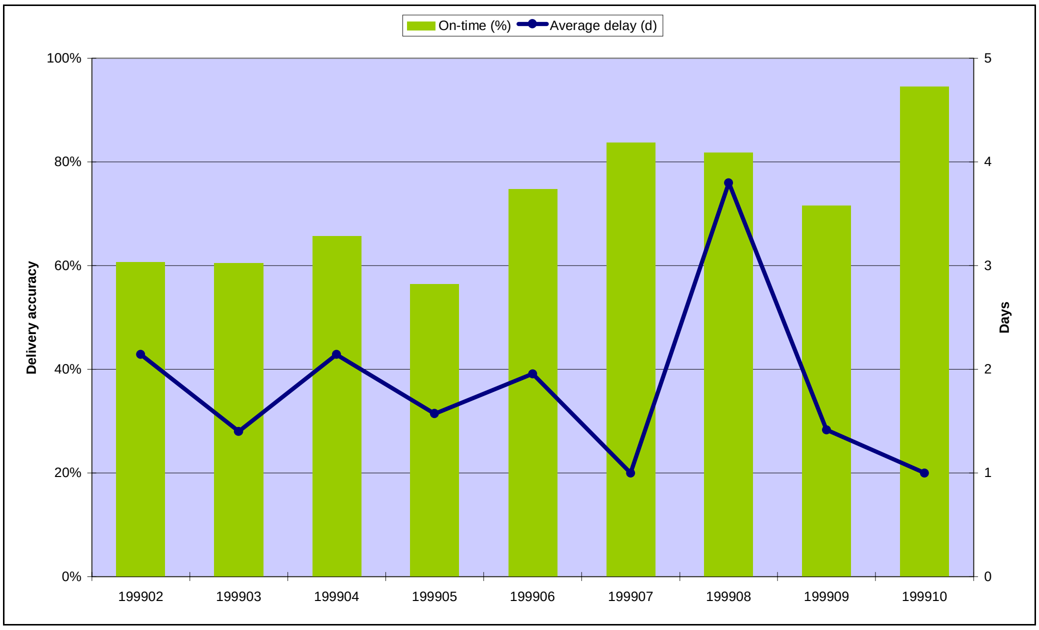


Figure 57: Delivery accuracy for operator I

Delivery accuracy has basically been at a satisfactory level during the data analysis period. About 74% of deliveries have been on time and the average delay has been 2.1 days.

- **Customer-supplier relationship**

The network is still in its construction phase, and therefore the relationships between the customer and the supplier can also be considered to be relatively fresh. The co-operation had last only a few months when the BIRD process implementation started.

The customer criticises the slow pace of project rollout, which left some white spots when full coverage was expected.

THE DIFFERENTIATION OF THE SUPPLY CHAIN

- **Value offering point**

At first direct factory deliveries were implemented and ordering was done based on project planning. After a few months it became evident that the lead-time was not short enough to make a reliable call-off order without risking the installation schedule. Therefore, orders were made based on the rollout plan. This did not work. The wrong material arrived at the wrong locations far too early. The supply chain performance in terms of both customer satisfaction and cost-efficiency were ruined.

After a year the mode was switched to a regional distribution centre mode. Another process implementation was needed.

- **Order penetration point**

At first the logistics postponement location was meant to be in the plant. In practise, it was at the drop-off point. Therefore, the regional distribution centre mode is the best solution.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

Direct feedback from the customer was really bad.

According to the customer satisfaction survey, the customer was not that satisfied with the delivery situation. Mainly because there were shortages, as wrong material arrived to base station sites.

- **Capital employment and total costs**

In terms of inventory levels, the direct factory delivery mode did not work properly because material piled up at the drop-off points. This is clearly shown in Figure 58.

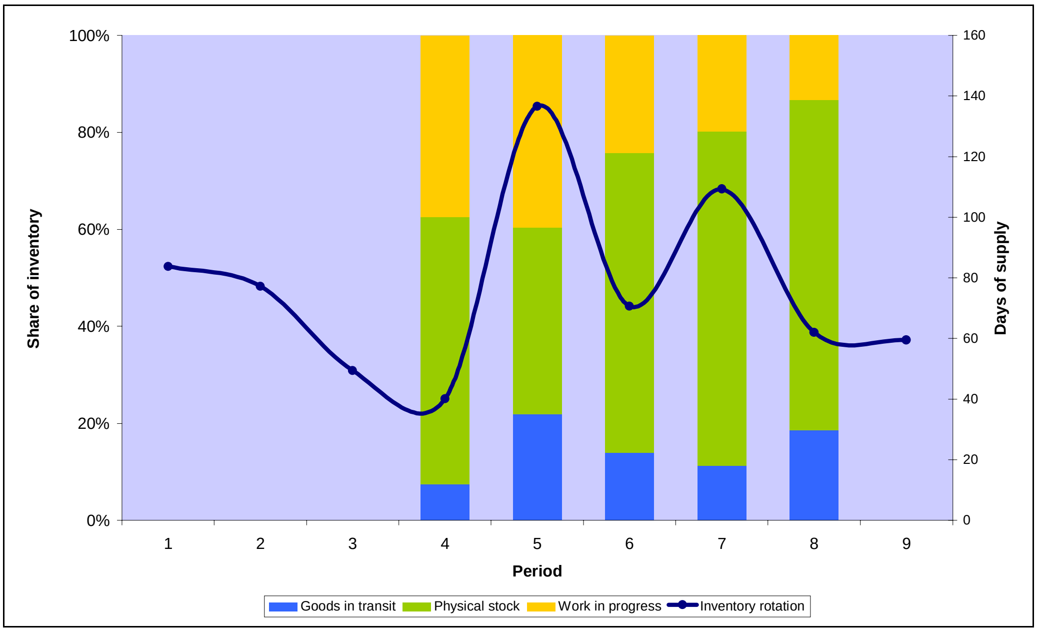


Figure 58: Inventory days of supply for operator I

Nor has the customer been very happy, but satisfaction has been maintained with the material buffers at the drop-off point. Later the delivery mode was switched to regional DC mode, which worked much better.

6.4.2. Operator J: Guarantee high product availability

This case analysis represents a situation where the country buffer mode was first implemented for the start-up customer project. The target was to guarantee high product availability to ensure the project rollout targets. This solution became highly costly, and therefore the supply chain was switched to the regional distribution centre mode, as the most hectic rollout phase in the customer project was over.

The BIRD implementation and data analysis period was extended to cover the time between P11/99 and P12/00.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

Operator J is in a Southern European country and was the third GSM operator in that country. The customer is clearly a challenger, as its network was launched only in early 1999. The development of GSM penetration in the markets, as illustrated in Figure 59, indicates that the market entry took place at the beginning of the actual boom of the markets. Since then the penetration has rapidly grown to the 70% level. The operator is a completely privately owned company.

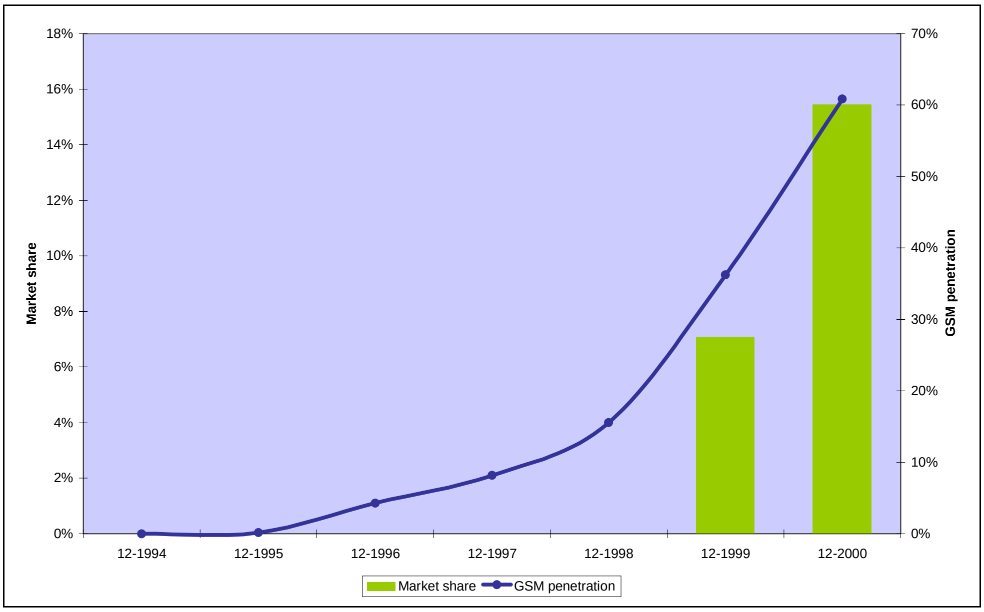


Figure 59: Market growth and operator J's market share

The positive development in the market share was remarkable in the beginning. However, the growth has evened out, as shown in the figure. Nowadays, the market share is on the 15-20% level, but when the BIRD project was implemented the relative market share was below ten percent.

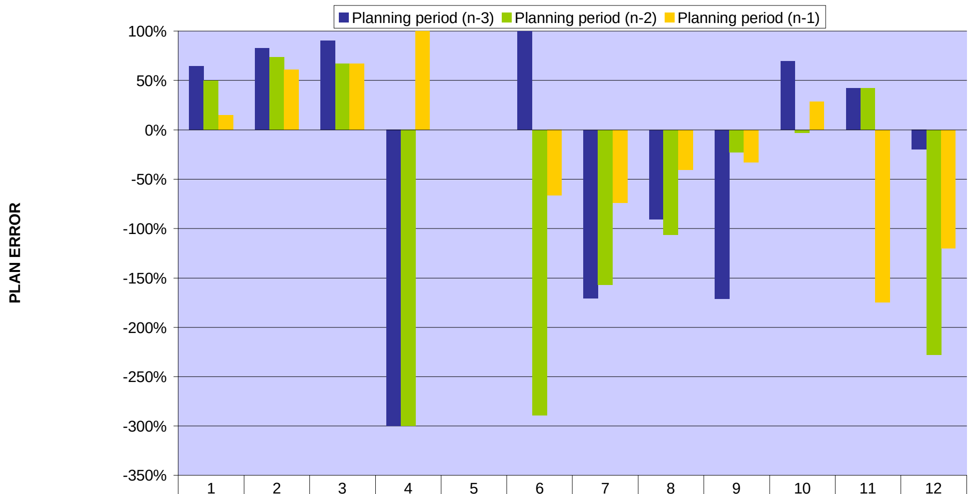
In order to rapidly improve its competitive position and increase market share, the operator has selected an aggressive strategy to build the network as fast as possible. The customer has selected a few system suppliers, which are fully responsible for building the network coverage in dedicated areas of the country. It basically includes everything, from network to site integration to the network. Therefore, the scope of business is “turnkey” for the supplier.

- **Supplier, product and deliveries**

Nokia provides a wide range of equipment to the operator, including base stations, radio links and site solution material.

The geographic and political conditions of the network area that was Nokia’s responsibility were difficult. Furthermore, the target schedules and deadlines set by the operator were extremely tight. Due to these challenging conditions, the project team was stressed and faced lots of changes in the project organisation. For the first launch the project deadlines were not met.

In the beginning the site implementation process did not work properly as people and responsibilities changed. First, the plans systematically underestimated to a very significant degree. After a few months the situation turned the other way around, as the plans were too optimistic. This skewing caused lots of problems in the logistics process. The development of demand plan error is shown in Figure 60.



	1	2	3	4	5	6	7	8	9	10	11	12
Planning period (n-3)	65%	83%	90%	-300%	0%	100%	-171%	-90%	-171%	70%	42%	-20%
Planning period (n-2)	50%	74%	67%	-300%	0%	-289%	-157%	-106%	-23%	-3%	42%	-228%
Planning period (n-1)	15%	61%	67%	100%	0%	-67%	-74%	-40%	-33%	28%	-175%	-120%

Figure 60: Operator J's demand plan error

The mean absolute error was 65% for the rolling 1-month demand plans. However, a positive thing is to notice that the planning seems to become more accurate the closer it gets.

The development of delivery accuracy is shown in Figure 61.

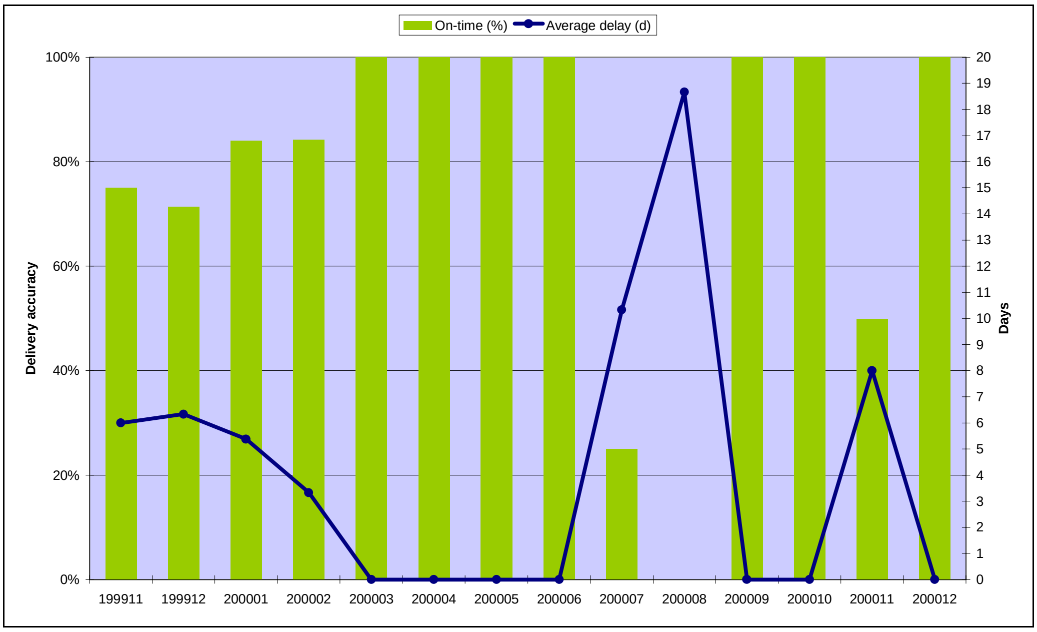


Figure 61: Delivery accuracy for operator J

About 74% of deliveries were on time and the average delay was 8 days. For two months (as shown in the figure), the performance was exceptional low due to material shortages in the buffers. This explains the occasional poor performance.

- **Customer-supplier relationship**

The relationship is very fresh without prior experience between the companies. The customer's strategy of selecting three system suppliers to start building the network was also quite a difficult situation for all the suppliers. Nokia was the "late-comer" of the three suppliers with fairly low volumes and little room for negotiation about target setting and schedules. Thus, it cannot be called a partnership yet.

In the beginning the process collaboration around supply chains with the customer was not the essential issue, as Nokia had full responsibility for planning and executing the network-building project. The important parties for the process collaboration were zone managers, the network planner and the installation subcontractors.

THE DIFFERENTIATION OF THE SUPPLY CHAIN

- **Value offering point**

The BIRD process implementation was initiated at the same time as the actual network-building project started. It was agreed to start with a local warehouse delivery mode, and after the first launches were successful to consider other more streamlined options for the supply chain.

The local warehouse was established to support the rapid start-up of the network. Although it was not a cost-efficient solution, it best served the project's demand targets to have the network launch done as promised to the customer and the markets. The second step was to switch to the regional distribution centre mode after the most critical start-up phase was over. That was carried out as a separate process implementation.

- **Order penetration point**

The manufacturing and logistics postponement locations were first downstream in the country to proved fast deliveries. Later it was moved further upstream to regional distribution centre.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

  Customer was quite dissatisfied with the delays in the project schedule. However, the delays were not because of selected supply chain. Problems in network planning and site acquisitions caused the delays in the project. In fact, the country buffer mode acted as a safety buffer towards changes in the project plans. The project manager was satisfied with the logistics as the material was available when needed.

  Lead-time was very short for the project to contribute to the maximum throughput of the project.

- **Capital employment and total costs**

  In the beginning the inventory levels were extremely high because material was ordered for the local warehouse based on the original rollout plans and deadlines given by the customer. However, the reality proved that the original schedules were far too optimistic and the progress of the rollout was hindered by many local factors making the network planning and site acquisitions more difficult.

  The development of inventory levels is shown in Figure 62.

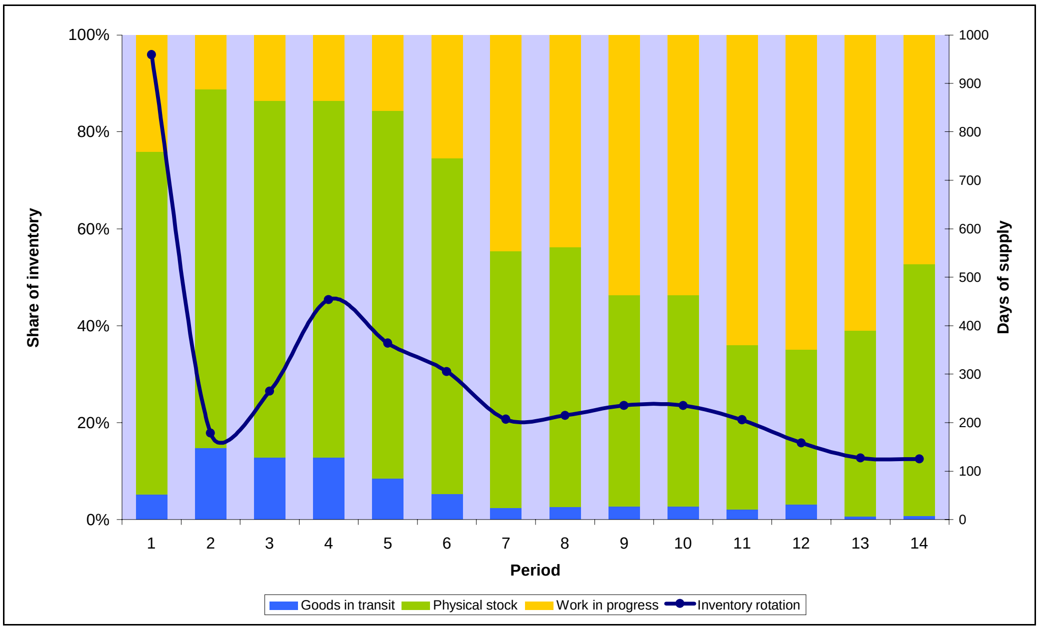


Figure 62: Inventory days of supply for operator J

After the months of hectic rollout, the delivery process also stabilised. The switchover to the regional distribution centre happened during period ten in the figure. This enabled the project to operate in much more cost-efficient manner.

6.4.3. Operator K: Maximise the project's throughput

This case analysis represents a situation where the country buffer mode is implemented for a start-up customer project. It is an example of supply chain where buffering was considered a pre-requisite for successful project rollout. The customer's target was clearly to maximise the project's throughput.

The BIRD implementation and data analysis period was between P12/99 and P8/00.

CONDITIONS FOR SUPPLY CHAIN SELECTION

- **Customer and markets**

  Customer K is the third GSM operator in an Eastern European country, launching its network in late 1999. The market entry was made in the middle of the fast growth phase, as shown in Figure 63. The penetration in the country is still growing fast.

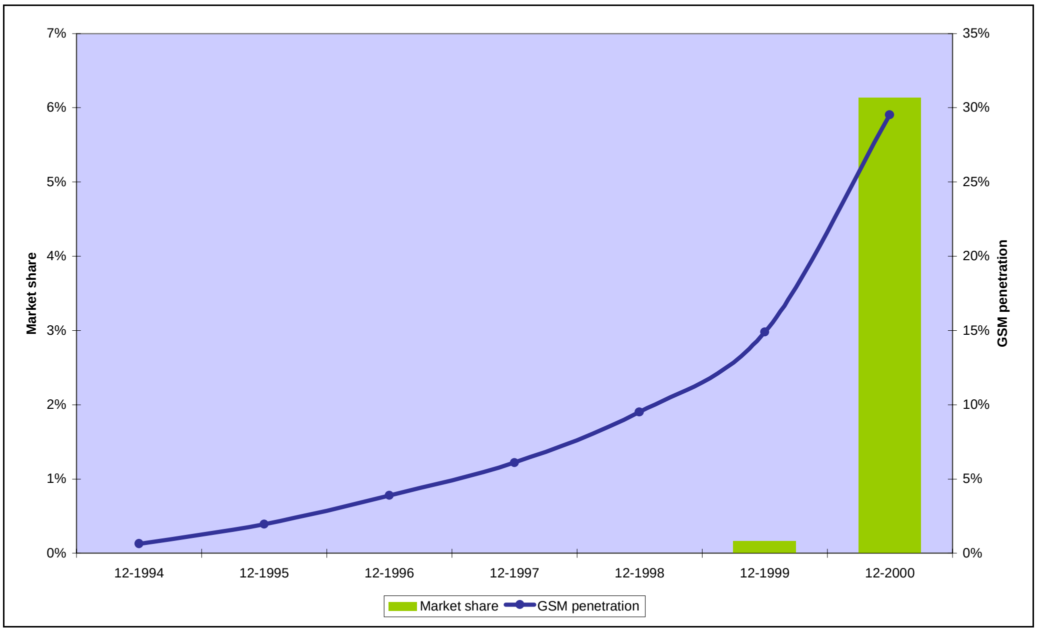


Figure 63: Market growth and operator K's market share

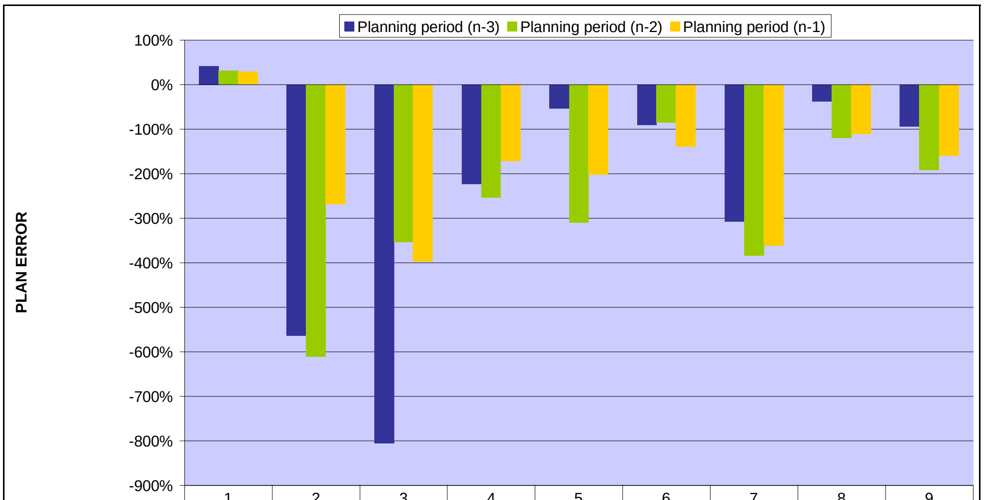
There are three operators in the markets, and the customer is clearly the smallest player. Its market share has risen to around 8% after two years. There are a little bit more than 300,000 subscribers in the network.

The operator's strategy has been to build the network as fast as possible, and to outsource the whole project management, including network planning, site acquisitions and installation, to one supplier. Thus, the business scope is "turnkey".

- **Supplier, product and deliveries**

Nokia provides a full range of equipment to the operator, including base stations, radio links and site solution material.

The main focus in the building project was to get coverage in the main cities and interconnecting highways. Fast rollout was clearly priority number one. The project was in an early stage in many way: the whole organisation had to be built, the site acquisition process had to be created, commercial agreements had to be made with a number of subcontractors, basic delivery processes had to be established etc. All site implementation and demand planning processes had to be designed from scratch. The demand plans were constantly changing, as the basic processes were still being learnt by everybody. The development of demand plan error is shown in Figure 64.



	1	2	3	4	5	6	7	8	9
Planning period (n-3)	42%	-563%	-805%	-223%	-53%	-90%	-307%	-38%	-94%
Planning period (n-2)	31%	-611%	-354%	-254%	-309%	-85%	-383%	-120%	-192%
Planning period (n-1)	29%	-268%	-397%	-171%	-201%	-139%	-362%	-111%	-159%

Figure 64: Operator K's demand plan error

The mean absolute demand plan error was 204% for the rolling 1-month demand plans. It shows highly skewed plans that are constantly oversized.

According to the agreed site implementation process, one of the important milestones is the point when the site is ready for construction to begin. In practise, it is defined as a signed lease, having a detailed site design ready, permit granted and when the connecting site in the onion peel inside is also ready for construction. At this moment the configuration is frozen. This information is used for demand planning purposes and to reserve picking capacity in the warehouse. The actual site call-off was made only when the construction work was finished and a pre-installation meeting held with an installation team. According to the project manager, from that moment the smooth progress of the roll out requires an equipment lead-time of 18-24 hours. The development of delivery performance is illustrated in Figure 65.

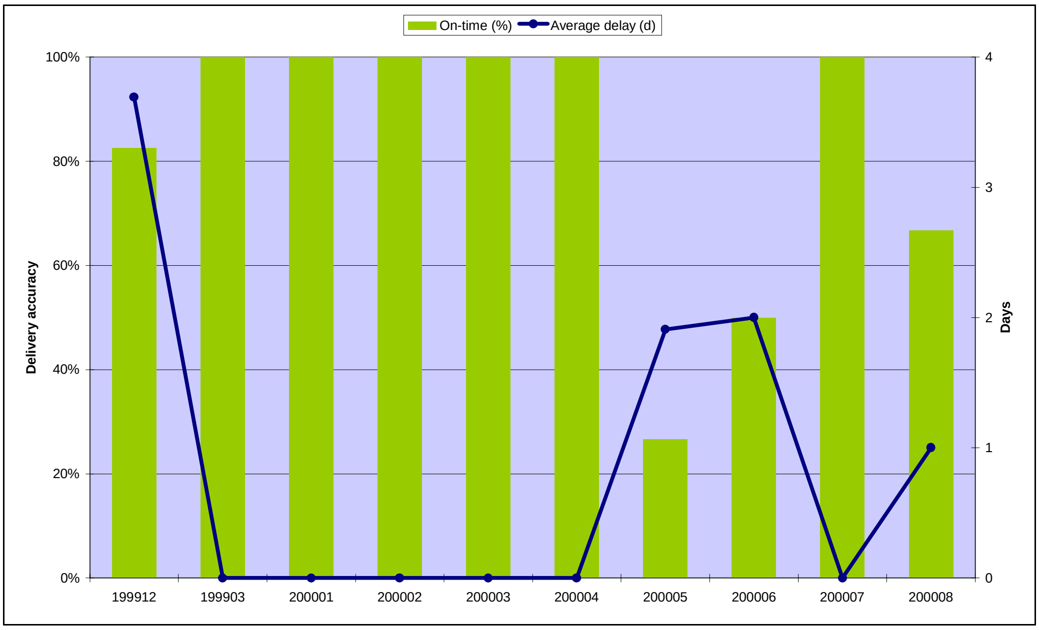


Figure 65: Delivery accuracy for operator K

Delivery performance of the country buffer looks pretty good. About 83% of deliveries have been on time and the average delay has been less than one day. Lead-time was only a few days. In this mode the supply chain obviously supports the progress of project rollout well.

- **Customer-supplier relationship**

Nokia was selected as the sole system supplier for the network to supply a complete turnkey GSM1800/GSM 900 system, including the required equipment and services. The contract includes mobile switching systems, base station systems and a network management system.

The network is still in its early construction phase, and therefore the relationships between the customer and the supplier can also be considered to be relatively fresh. The co-operation had last only a few months when the BIRD process implementation started. The situation has been quite tense due to the hectic start-up period of the network.

Delivery process collaboration was basically not an issue, as Nokia had full responsibility for the network planning, site acquisitions, construction work, equipment deliveries, installation, commissioning and integration into the network. The important parties for the process collaboration were zone managers, the network planner and the installation subcontractors.

THE DIFFERENTIATION OF THE SUPPLY CHAIN

- **Value offering point**

The BIRD process implementation was initiated at the same time as the actual network-building project started. It was agreed with the project manager that the delivery process should be planned to start with a local warehouse delivery mode, and after the first launches were successful to consider other more streamlined options for the supply chain.

- **Order penetration point**

A local warehouse was established to support the rapid start-up of the network. Although it was not a cost-efficient solution, it best served the project's demand targets to have the network launch done as promised to the customer and the markets.

THE SUCCESS OF THE SUPPLY CHAIN

- **Customer service**

According to the discussions with project management, the logistics were considered to be one of the key factors that made meeting the agreed schedule possible. The equipment deliveries did not cause delays to the project rollout schedule and therefore everyone in the project was happy about the processes. However, the project manager could not neglect the costs of the inventory levels, although it was not his key concern.

Lead-time reduction is irrelevant because this was a start-up customer case. However, the short lead-time was highly appreciated by the project teams.

- **Capital employment and total costs**

The development of inventory levels clearly shows the turbulence in the project rollout. This is illustrated in Figure 66.

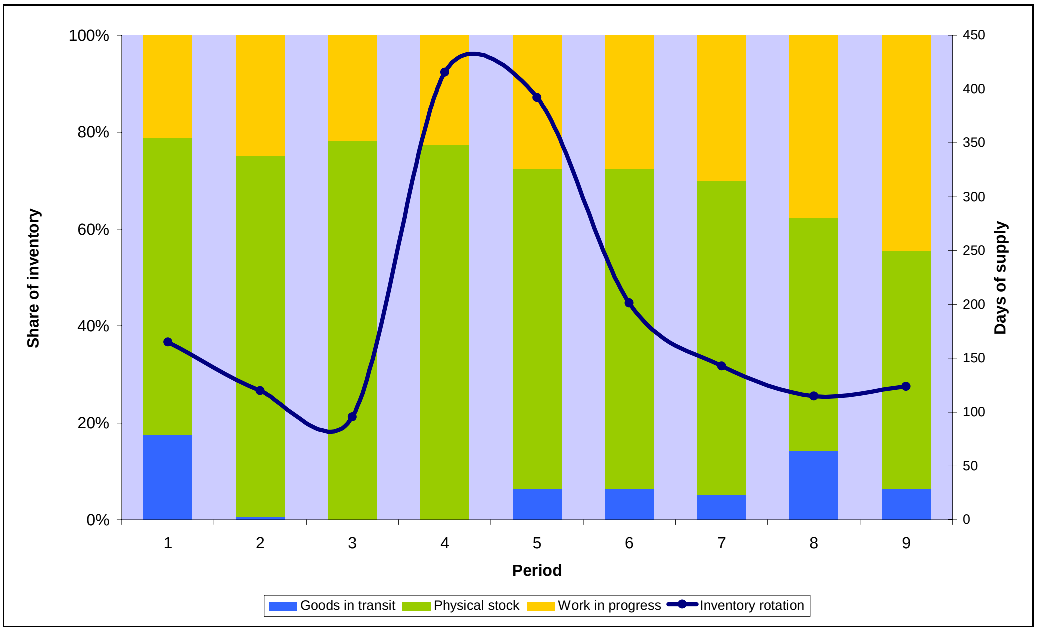


Figure 66: Inventory days of supply for operator K

The high peak in the figures was due to the fact that the rollout suddenly stopped for a while. That was a surprise to everybody, including the warehouse manager who placed replenishment orders based on the old plans.

6.4.4. Summary

First, an interesting aspect is that all these "turnkey" customer cases were more or less start-up projects where the operator wanted to enter the new markets as a new challenger. The most important thing for the customer was to launch the network and start taking market share from its rivals. All these operators were looking for a turnkey type system supplier who could build the entire network as fast as possible and help to start operating the network. Everybody focused on the throughput of the project rollout, not so much attention was paid to the costs at this stage of the network life cycle. The supply chain was obviously designed to maximally support the targets of the project rollouts.

Second, these start-up cases are all characterised by extremely tight schedules, which caused much confusion and uncertainty in the site implementation process. As the schedule was set too tight, the probability that some activities would be delayed increased. When this happened, the whole implementation plan had to be rescheduled. This caused even more pressure on project teams to meet the final deadline set by the customers. According to the project managers it was not possible to wait a day for equipment deliveries. The actual lead-time requirement was really short, more like hours instead of days or weeks. Case H showed that if the site equipment ordering was made based on the plan, the process was not working.

Third, when the most hectic rollout phase was over, the focus was moved to a more cost-efficient and standard process. This was a clear development path in all these start-up cases.

6.5. Cross-case analysis

The next step is to conduct a cross-case analysis from the in-depth customer cases. The analysis is conducted by analysing how each operational measure behaves in different customer cases. This is carried out in the following tables.

Table 5: The situational factors of the in-depth cases

	CASE A	CASE B	CASE C	CASE D	CASE E	CASE F	CASE G	CASE H	CASE I	CASE J	CASE K
CUSTOMER AND MARKETS											
(1) GSM penetration	· above 60%	· around 70%	· almost 40%	· around 40%	· around 20%	· less than 40%	· almost 70%	· around 40%	· around 30%	· around 40%	· less than 20%
(2) Market growth	· getting already matured · 39% (1998) · 41% (1999)	· slowing down · 93% (1999) · 50% (2000)	· growing very fast · 110% (1999) · 128% (2000)	· growing still significantly · 117% (1998) · 81% (1999)	· growing very fast ·121% (1998) · 89% (1999)	· growing still significantly · 96% (1998) · 84% (1999)	· slowing down · 41% (1999) · 35% (2000)	· growing still significantly · 86% (1998) · 84% (1999)	· growing very fast · 127% (1998) · 101% (1999)	· growing still significantly · 132% (1999) · 68% (2000)	· accelarated growing · 57% (1998) · 93% (1999)
(3) Market share (P12/2000)	· stabilised to 65-70% · strong market leader	· come down to 40% · still market leader	· slightly declined to 50% · still market leader	· dropped to 50% · still market leader	· rapidly increased to 30% · second position	· stabilised to 35% · second position	· stabilised to 50% · strong market leader	· stabilised to 15% · third position	· rapidly increased to 8% · fifth position	· rapidly increased to 15% · third position	· rapidly increased to 6% · third position
(4) Business scope	· "Box delivery"	· "Box delivery"	· "Box delivery"	·"Telecom deployment"	·"Telecom deployment"	·"Telecom deployment"	·"Telecom deployment"	·"Telecom deployment"	· "Turnkey"	· "Turnkey"	· "Turnkey"
SUPPLIER, PRODUCT AND DELIVERIES											
(5) Product portfolio	· base stations	· base stations · some SiSo material	· base stations · a few SiSo items	· base stations · SiSo material	· base stations · SiSo material · microwave radios	· base stations	· base stations	· base stations · SiSo material · microwave radios	· base stations · SiSo material · microwave radios	· base stations · SiSo material · microwave radios	· base stations · SiSo material · microwave radios
(6) Demand plan error (mean absolute %-error)	· 15% · plans fluctuate slighly around the zero level	· 18% · plans fluctuate slighly around the zero level	· 147% · plans constantly overly optimistic	· 65% · plans lightly overly optimistic	·191% · plans higly oversized	· 41% · plans fluctuate around the zero level	· 29% · plans fluctuate slighly around the zero level	· 122% · plans fluctuate highly around the zero level	· 86% · plans fluctuate higly around the zero level	· 65% · plans fluctuate around the zero level	· 204% · plans higly oversized
(7) Delivery accuracy	· 80% on time · delay on average 1 day	· 86% on time · delay on average 2.2 days	· 65% on time · delay on average 1.8 days	· 86% on time · delay on average 1.7 days	· 81% on time · delay on average 1.9 days	· 91% on time · delay on average 2.3 days	· 89% on time · delay on average 2.2 days	· 84% on time · delay on average 1.4 days	· 74% on time · delay on average 2.1 days	· 74% on time · delay on average 8.0 days	· 83% on time · delay on 0.9 days
(8) The characters of project	· favorable business conditions, despite geographical difficulties	· difficulties in radio planning due to geographical and climatic conditions	· favorable business conditions	· favorable business conditions	·Challenging conditions due to high variances between different regions	·Challenging conditions due to high variances between different regions	· favorable business conditions	· difficulties in radio planning due to geographical and climatic conditions	· favorable business conditions	·Challenging conditions due to high variances between different regions	· difficulties in getting site acquisitions done in the schedule
(9) The stage of project	· launch in mid1993	· launch in end 1992	· launch in mid 1996	· launch in early 1994	· launch mid 1998	· launch mid 1993	· launch early 1992	· launch end 1998	· launch in early 1999	· launch early 1999	· launch in end 1999
(10) Site implementation process	· stabilized working practices with experienced project team · capacity optimization	· processes now getting stabilized - lots of problems earlier · capacity building	· no standardized working practices implemented and plans changing · coverage building	· constant delays in site acquisitions and construction works · capacity building	·no standard working practises implemented · coverage building	· getting stabilised due to long history learning and experienced project team · capacity building	· stabilized working practices with experienced project team · capacity optimization	· processes now getting stabilized - huge problems earlier · capacity building	· much efforts put to get standard working practises - not fully succeeded · coverage building	· standard processes are missing · coverage building	· much efforts put to get standard working practises - not fully succeeded · coverage building
CUSTOMER-SUPPLIER RELATIONSHIP											
(11) The mode of partnership	· 2nd supplier out of two · real partnership with open communication	· 2nd supplier out of three · fairly open communication with good local contacts	· 1st supplier out of two · long-term relationships with open and frank communication	· 1st supplier out of two · partnership, but some problems with daily communication practises	· sole supplier · new and fresh relationships with a fairly good beginning	· 2nd supplier out of three · long-term and working partnership in many different areas	· 2nd supplier out of two · fairly fresh relationships with a very good beginning (swop project)	· sole supplier · partnership, but network start-up caused nasty conflicts to relationships	· sole supplier · fresh relationships with a very good beginning	· 3rd supplier out of three · very fresh relationships with fairly arms-length approach	· sole supplier · fresh local contacts, but long global relationship - problems in start-up
(12) The length of cooperation	· started in early 1994	· started in 1997	· started in early 1990 (NMT-network)	· started in early 1996	· started in end 1997	· started in end of 1996	· started in mid 1999	· started in spring 1998	· started in early 1999	· started in early 1999	· started in mid 1999
(13) Process collaboration	· pretty straight-forward attitudes with mutual understanding on the process	· no remarkable collaboration in past, but now key focus areas agreed (promising)	· not properly working at the moment, due to busy situation in network roll-out	· much efforts put to process development, but uncertainty in project makes it complex	· much efforts put to process development, but uncertainty in project makes it complex	· very tight and fruitful process development, due to mutual targets (e.g. obsolescence risk)	· not very tight as the cooperation has just started	· much efforts put to process development, but uncertainty in project makes it complex	· constructive approach by customer and inside Nokia project collaboration very good	· very limited by customer and inside Nokia not enough focused efforts	· very limited by customer, but inside Nokia project collaboration very good

Table 6: The means and ends of in-depth cases

	CASE A	CASE B	CASE C	CASE D	CASE E	CASE F	CASE G	CASE H	CASE I	CASE J	CASE K
VALUE OFFERING POINT											
Order trigger	· project planning · site ordering based on project's roll-out plan	· project execution · site ordering based on agreed process milestone (extensions based on plan)	· project inventory mgmt · inventory replenishment ordering based on material consumption	· project planning-> execution · site ordering based on project's roll-out plan -> agreed process milstone	· project execution · site ordering based on agreed process milestone	· project planning · site ordering based on project's roll-out plan	· project planning · site specific ordering based on project's roll-out plan	· project execution · site ordering based on agreed process milestone	· project planning-> execution · site ordering based on project's roll-out plan -> agreed process milstone	· project planning-> execution · site ordering based on project's roll-out plan -> agreed process milstone	· project execution · site ordering based on agreed process milestone
ORDER PENETRATION POINT											
The strategy of manufacturing postponement	· assemble-to-order (ATO)	· assemble-to-order (ATO)	· assemble-to-order (ATO)	· first started in assemble-to-order (ATO), but then moved to pack-to-order (PTO)	· pack-to-order (PTO)	· assemble-to-order (ATO)	· pack-to-order (PTO)	· assemble-to-order (ATO)	· first started in assemble-to-order (ATO), but later moved to pack-to-order (PTO)	· pack-to-order (PTO)	· pack-to-order (PTO)
The strategy of logistics postponement	· factory (Finland)	· factory (Finland)	· factory (Finland)	· first started in factory (Finland), but then moved to regional DC (Netherlands)	· warehouse (local)	· factory (Finland)	· regional DC (Netherlands)	· factory (Finland)	· first started in factory (UK), but later moved to regional DC (Netherlands)	· first started in warehouse (local), but later moved to regional DC (Netherlands)	· warehouse (local)
CUSTOMER SERVICE											
Feedback on changes from the customer	· reliable lead-time is the most important	· process collaboration highly appreciated	· new processes looks promising, but no time to implement changes during hectic roll-out phase	· appreciation of proactive approach, but improvements focused too much on Nokia side	· appreciation of efforts to improve supply chain and willingness to participate changes	· impressed with new delivery system, as it brings clear benefits to both parties	· reliable lead-time is the most important	· impressed with new delivery system, as it brings clear benefits to both parties	· appreciation of efforts to improve supply chain	· do anything you can to meet roll-out targets	· satisfied with improvement in material deliveries, enabling better to guarantee roll-out schedule targets
Customer satisfaction survey	· overall satisfied with physical deliveries and process improvements made	· improvements in delivery system considered as a major advantage	· satisfied with deliveries and current process, but extra head-ache caused by its own inventory mgmt	· satisfied with flexibility	· flexible is on the satisfactory level, due to some cultural differences and miscommunication	·Check!	· very satisfied with performace of supply chain and logistics processes	· delivery performance has significantly improved due to new processes	· dissatisfied with delivery performace, as lead-time too long to have reliable process	· dissatisfied with delivery performace, deliveries not integrated to project roll-out	· dissatisfied with delivery performace as a whole; however flexible logistics pocesses appreciated
Lead-time development (on operational level, not commercially)	· reduced 50% (potential)	· reduced 50%	· reduced 50% (potential)	· increased 250% in the end	· no changes	· reduced 50%	· no changes	· reduced 66%	· reduced 66%	· increased 250% in the end	· no changes
CAPITAL EMPLOYMENT AND TOTAL COSTS											
Inventory levels	· no major issues · the share of physical stock: 0% -> 0%	· inefficient delivery process · the share of physical stock: 71% -> 28%	· customer holds stock · the share of physical stock: 14% -> 57%	· inefficient delivery process · the share of physical stock: 17% -> 2%	· ineffective delivery process · the share of physical stock: 82% -> 41%	· major obsolescence risk · the share of physical stock: 58% -> 46%	· inefficient delivery process · the share of physical stock: 29% -> 9%	· no major issues · the share of physical stock: 68% -> 71%	· ineffective delivery process · the share of physical stock: 55% -> 68%	· huge problems · the share of physical stock: 70% -> 44%	· short lead-time needed · the share of physical stock: 61% -> 49%
Inventory days of supply	· on average only 0.2 days · 0.2 -> 0.1 days · no changes	· on average 25 days · 38 -> 19 days · declining trend	· on average 10 days · 8 -> 7 days · no changes	· on average 17 days · 32 -> 27 -> 9 days · declining trend	· on average 46 days · 59 -> 27 days · declining trend	· on average 30 days · 56 -> 12 days · declining trend	· on average 17 days · 66 -> 6 days · declining trend	· on average 49 days · 97 -> 41 days · declining trend	· on average 77 days · 83 -> 60 days · fluctuating trend	· on average 354 days · 960 -> 236 days · fluctuating trend	· on average 197 days · 165 -> 124 days · fluctuating trend

7. RESEARCH RESULTS

This chapter presents the research results of this study. It is divided into four sub-chapters each of which focuses on providing answers to a particular research question that was introduced in chapter one. The research results drawn from the in-depth case analysis are as follows:

1. Three types of customer demand chains, distinguished by the position of the value offering point, can be identified among customers. These are (1) call for project planning, (2) call for project execution and (3) call for project inventory management.

2. Alternative supply chains are being used in different customer projects, quite intuitively, without a proper justification for the choices made. This is mainly due to contradictory target setting in project and supply chain systems (e.g., time buffers vs. material buffers) that makes it extremely complex to find the “right” supply chain solution for a customer.

3. The accuracy of project planning and the implementation of a pre-defined execution trigger for ordering are actually sufficient selection factors to specify the right combination of value offering and order penetration points. However, as these selection factors are on a highly operational level, it is difficult to estimate their behaviour in a project beforehand.

4. The technology life-cycle stage (which in this instance is represented by GSM penetration) and the level of the customer-supplier process collaboration are business conditions that can be used to estimate the behaviour of the selection factors in a project beforehand. Furthermore, these are considered to be necessary conditions in moving the value offering point further downstream in the chain.

Each of these conclusions is thoroughly explained in the following sections.

7.1. Three types of customer demand chains

The first research question was to identify the different types of demand chains that exist among the customers in the project business environment. Based on the customer case analysis, it became obvious that the individual demand chains of the customers are significantly different. Among the customer projects there is not any single logic for making purchasing decisions on base station equipment, rather this logic tends to be project-specific. Some customer projects place call-off orders based on their rolling project plans and some always wait until a certain milestone in their site implementation process has been reached. There was also a customer that places orders based on material consumption in its warehouse. Furthermore, there are examples of customer projects that, at certain points of time, did not have any agreed procedures in place, ordering was done on a case-by–case basis. Based on the in-depth analysis, we can conclude that customer demand chains, on a very detailed level, are always project-specific.

Nevertheless, there are fundamentally three different value offering points that can be used to distinguish the types of demand chains. These demand chain types are project planning, project execution and project inventory management. These alternative types of demand chains are also illustrated in Figure 67.

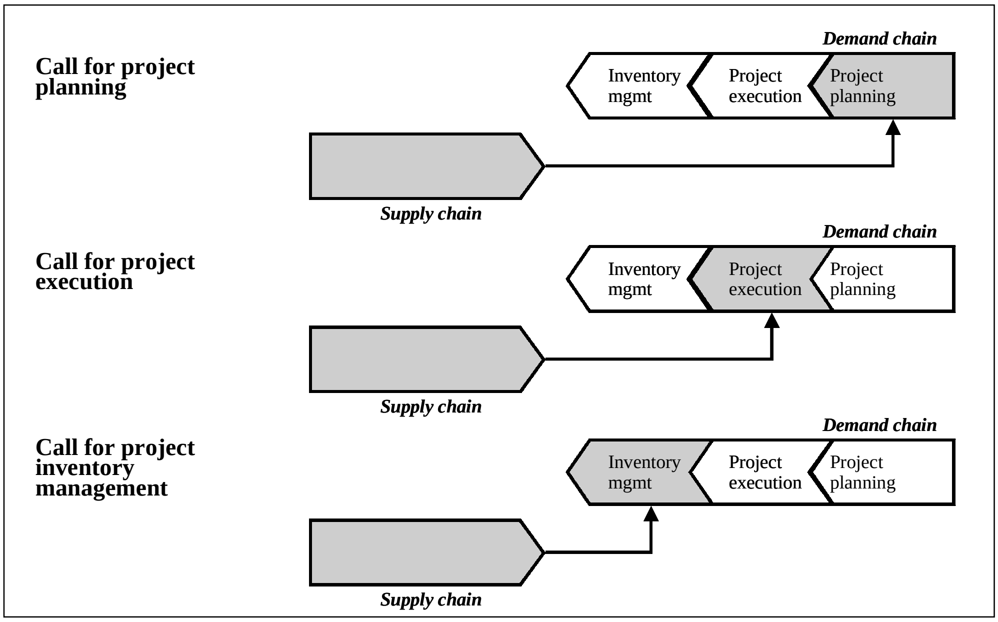


Figure 67: Three types of demand chains

According to Hoover et al. (2001), a supplier should always aim at moving the value offering point further downstream in the demand chain, since it adds more value to the customer and increases the supplier's time to respond. In the context of a project business environment, the first option for value offering, positioned furthest downstream in the chain, is the "call for project planning". Here, the customer orders configured products for a specific installation site, and the ordering is done based on the customer's existing project plan. The requested delivery date of the order is effectively calculated backwards from the estimated start date of the installation in the project's implementation plan. The supply chain is then built to serve the customer's planning process. This demand chain type is represented in customer cases A, B, F and G. This approach was also first tried for operators D, I and J in the early phase of the BIRD implementation.

The second option, the "call material for project execution", means that the customer orders a detailed product configuration for a specific installation site only when a certain pre-defined process milestone has been reached in the site implementation process; for instance, when the construction work for a particular base station site has ended. With this reliable execution trigger for material ordering, it becomes possible to integrate the supply chain seamlessly into the project's implementation process. The position of the pre-defined execution trigger and the earliest time of the installation start date basically determine the lead-time requirements for the supply chain. Thus, the chain should be built to respond to these requirements. This value offering point was gradually implemented for operators D, E, H, I, J and K.

In the third type of demand chain, the value offering point is positioned in the customer's project inventory management. In this "call for project inventory management" demand chain, the final product configuration, the site location and the start of installation are not known when material ordering is done for the supplier, the customer orders standard products based on the material consumption in its local project warehouse. The supplier's supply chain is built to serve the customer's inventory replenishment process. The project installation team places the actual material call-off order with the local warehouse where the final site delivery is created. This type of demand chain was typical in many customer projects before the BIRD implementation. Customer projects B, C, E, F, I and J operated in this mode earlier. Operator C also wanted to stay in this mode after the process re-engineering.

7.2. Contradictory targets in project and supply chain systems create complexity

The second research question was about describing how alternative supply chains are being used to meet these different customer demand chains. This is primarily to increase the understanding of the researched phenomenon in the context of the scoped business system. The study explicitly revealed how difficult it is in practice to find the right supply chain solution in different customer situations. There were several customer cases where the supply chain had to be revised a few times before it was considered successful by the customer and supplier; for instance operators D, I and J. In fact, it seems that supply chains often are being designed quite intuitively in the industry without a real understanding of the impacts of choices made concerning the chains. Furthermore, there is not any commonly accepted best-practise on handling supply chain management, rather everything seemed to work with the idea of having a fully customised supply solution to maximally serve the customer's implementation project.

To find an explanation for this kind of contingent behaviour, the first thing that should be understood is how the system really works. Based on the research, it can be concluded that, in fact, there are two separate systems always affected by the decisions on the supply chain solution: the project system and the supply chain system. The goal of the project system is to deliver the promised scope of product, on the agreed schedule with minimum costs. According to Leach (2000), the first focus of project managers is typically on delivering the project on time. This means that the primary goal is to complete all project related tasks on time – keeping on schedule for the customer. On the other hand, a supply chain system, according to many sources in the literature (e.g., Christopher, 1998), targets maximising cost-efficiency and minimising the capital tied up in the whole chain. In other words, project management focuses on ensuring the maximum throughput in the shortest possible time, whereas the emphasis of supply chain management is to minimise material buffering in the chain.

The research results indicate that it is a challenging – or in some circumstances even impossible – task for a project manager to achieve these two partly contradictory targets at the same time. The research consists of clear evidence showing that the supply chain only starts to behave in a chaotic manner when these two systems are forced to work together without either time or material buffering. Therefore, concessions should be made in either project schedules or material buffer levels. A very interesting observation is to see how many customer projects persistently tried to do exactly this by selecting the supply chain of direct factory deliveries (OPP furthest upstream) and therefore ordering equipment based on project plans (VOP furthest downstream), but most of them failed. As the product lead-time in the direct delivery mode was longer than reliable visibility in the project, the successful integration of these two systems failed. In practice, the project schedule was delayed and material buffers exceeded, as the situation became too complex to manage. The lesson learnt is that the improper use of the ideal delivery model only leads the supply chain to behave in a chaotic manner, if the business conditions are not suitable for it. The OPP location should not define the right VOP in the customer's demand chain; on the contrary, the VOP should specify the right OPP in the supply chain.

The conclusion drawn is that in some business conditions it may become extremely complex to match project and supply chain systems seamlessly together, and it is then better to compromise over conflicting target setting than to optimistically force the systems to interact. The force only increases the chaotic behaviour of the supply chain.

7.3. Sufficient selection factors

Based on customer case analysis, it can be concluded that there are actually two key operational level factors that can effectively be used in selecting the right supply chain for a customer. These are (1) the accuracy of project planning and (2) the realization of a pre-defined execution trigger. They are further explained below.

7.3.1. The accuracy of project planning

The customer cases show that those GSM network building projects where site implementation plans on average have been accurate can all operate successfully with the direct factory delivery mode. Our supply chain performance indicators show positive results in terms of customer service, total costs and capital employment dimensions. In the circumstances, the VOP can be positioned in project planning, which enables the customer to place orders early enough for the supplier to make the delivery from the plant. It seems that a short lead-time for base stations is not considered to be that critical by project managers in this case. Delivery times must only be standard to be able to synchronise logistics related activities with the rest of the site implementation process. These favourable conditions, where the VOP is in project planning and the OPP at the plant, are represented in customer cases A, B, F and G.

The customer case analysis also indicates that those projects where site implementation plans are constantly changing tend to fail from the supply chain management point of view. The site implementation plans can change in three ways, as there can be (1) adjustments in the installation schedules, (2) changes in the site locations or (3) modifications in the product configurations. Nevertheless, the end result is the same, and the supply chain performance indicators clearly show negative results. Operators C, K and J belong to this category, which is characterised by inaccurate project plans and poor supply chain performance. Actually, this was also the situation in customer cases D and I, when the direct factory delivery mode was first implemented.

One could easily conclude that the success of a supply chain is thus merely dependent on the accuracy of implementation plans. In other words, the more inaccurate the project plans are, the poorer the supply chain is. However, the research results clearly indicate that it is not that straightforward. An interesting point is that all customer cases with unrealistic site implementation plans do not fail. For instance, operators E and H indicate relatively good supply chain performance, although their site implementation process does not work properly and therefore the project plans are also constantly changing. Likewise, this is the situation with customer cases D and I after switching from the direct delivery mode to the regional distribution centre mode. Therefore, the original question about which supply chain to select is still valid for these customers.

The line of though discussed above is now illustrated in Figure 68.

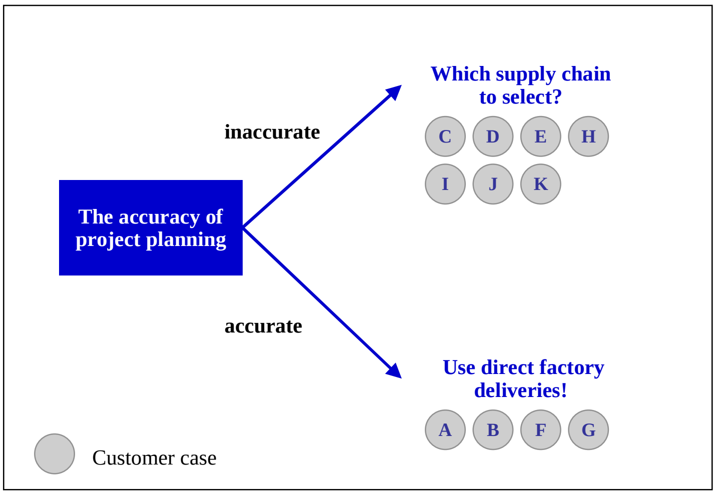


Figure 68: Accurate project planning enables the use of direct factory deliveries

The detailed implications of planning accuracy for supply chain selection are presented below.

- ***Accurate project planning***

The effective use of the direct factory delivery mode, when project planning is continually accurate, is based on the fact that detailed specifications for the deliveries can be fixed early enough in the site implementation process. In practise, the three dimensions of site deliveries (the schedule, site location and product configuration) are all known a few weeks before the scheduled start of installation. This makes it possible to seamlessly integrate equipment deliveries into the rest of the site implementation process with the factory lead-time in the customer project. Site-specific call-off orders are placed with the supplier’s plant and deliveries are requested directly to the final location a few days before the scheduled start date of the installation.

Accurate project planning motivates the VOP to be reliably positioned in project planning, which in turn enables the OPP be positioned furthest upstream. In the circumstances, it also becomes possible to integrate the target setting of the project and supply chain systems, because the basic rule for everybody is to keep on schedule. If the process details are working, this supply chain mode guarantees superior customer service with relatively low costs.

During the BIRD implementation, it was also noticed that although the basic processes work fine, there still is always a large amount of uncertainty embedded in project systems. Something occasionally goes wrong, either related to project activities or equipment deliveries, and the whole process suffers from it. As there are no local material buffers to protect against these unpredictable problems, there is a high risk of creating a mess in both the project and supply chain systems. Customer cases A, B, F and G, however, showed that those kinds of occasional problems (for instance, schedule postponements or minor product configuration changes) do not ruin the agreed processes. This observation can be explained by either the fact that there is no critical deadline date for the customer to get the base station site on air, or the fact that there is plenty of contingency reserved in installation, commissioning and integration schedules. Whichever one it is, it proves that the overall project implementation schedule cannot be very tight and that the network capacity that a base station adds is not that critical for the customer’s business.

- ***Inaccurate project planning***

When the site implementation process is not working properly - for one reason or another - the situation becomes much more complex, as the project planning becomes unreliable. The uncertainty level in the project system must obviously be higher than the situation described above. This does not only mean that the probability of activities being delayed increases, but also that the site location and product configurations may essentially change. Due to these constant modifications to the implementation plan, these projects typically are continuously running tasks on the critical path causing the general atmosphere among the people in the project teams to become highly stressed. This effect was clearly perceived in customer projects E, I, J and K. The level of pressure is directly dependent on the criticality of the project's due date for the operator to run its business with the network.

In the circumstances, the targets of the project and supply chain systems are clearly contradictory. The project installation teams and the personnel responsible for logistics look at the situation from two totally different perspectives. The customer cases showed how problematic the situation is for a project manager who needs to make decisions about whether to prioritise the potential of having maximum throughput over the risk of adding only extra supply chain costs. The original question of which supply chain to select is still valid in this case.

It was a typical failure among the customers that the project manager still ignored this question in this kind of situation and, basically, tried to achieve both the project and supply chain system targets at the same time. For instance, this happened at first in customer projects D and I, where the maximum progress of site implementation was primarily guaranteed with extremely tight (and frankly said unrealistic) schedules and, simultaneously, the maximum cost-efficiency of the supply chain was assured by using the direct factory delivery mode. In practice this led to a process where site-specific call-off orders were placed based on unrealistic plans. The results were predicable - exaggeratedly wrong equipment arrived at the wrong location at the wrong time. This kind of unreliable process did not help the situation at all; rather, it only added extra supply chain costs, caused unnecessary delays in deliveries, and most of all made the stressful situation even worse. Through these observations it became even more obvious that there is a great need among project managers and system suppliers to have some kind of analytical model to make successful business decisions about the supply chains.

In conclusion, accurate project planning enables the positioning of the VOP in project planning in the customer demand chain, which in turn makes it possible to move the OPP furthest upstream in the supply chain. However, when the planning is not accurate, the original problem of which supply chain to select is still valid.

7.3.2. The implementation of a pre-defined execution trigger

The second selection factor for the right supply chain is the implementation of a pre-defined execution trigger, which is needed if the project planning cannot be trusted. The in-depth customer cases showed that it is still possible to implement a successful supply chain solution for a customer, even if the accuracy of its project planning is constantly relatively poor. This can be carried out by moving the VOP one step further upstream in the customer demand chain to project execution, instead of trying optimistically to position it in project planning. In practice this means that a site-specific base station is ordered only after a pre-defined milestone has been reached in the site implementation process. The position of this milestone in the site implementation process unambiguously sets the material lead-time requirement, which, as a matter of fact, equals the time between that particular milestone and the estimated start of site installation. This lead-time requirement in turn specifies the required position for the OPP and thus determines the right supply chain solution for the customer.

The basic principle is that the progress of the project implementation is prioritised over the efficiency of the supply chain, as some material buffers may be needed in the chain to meet the lead-time requirement. During the BIRD implementation it was found that in the early stage of a network building-project it is actually more economical to pay extra for the supply chain in order to speed-up the implementation process and make it more reliable. In the circumstances, the savings in project management was much more than the investments in the supply chain.

This approach was first implemented for customers E, H and K - operator B also chose this approach for building new sites. Customers D, I and J also gradually moved to this mode, as they realised that their existing processes were not working properly.

The line of though discussed above is now illustrated in Figure 69.

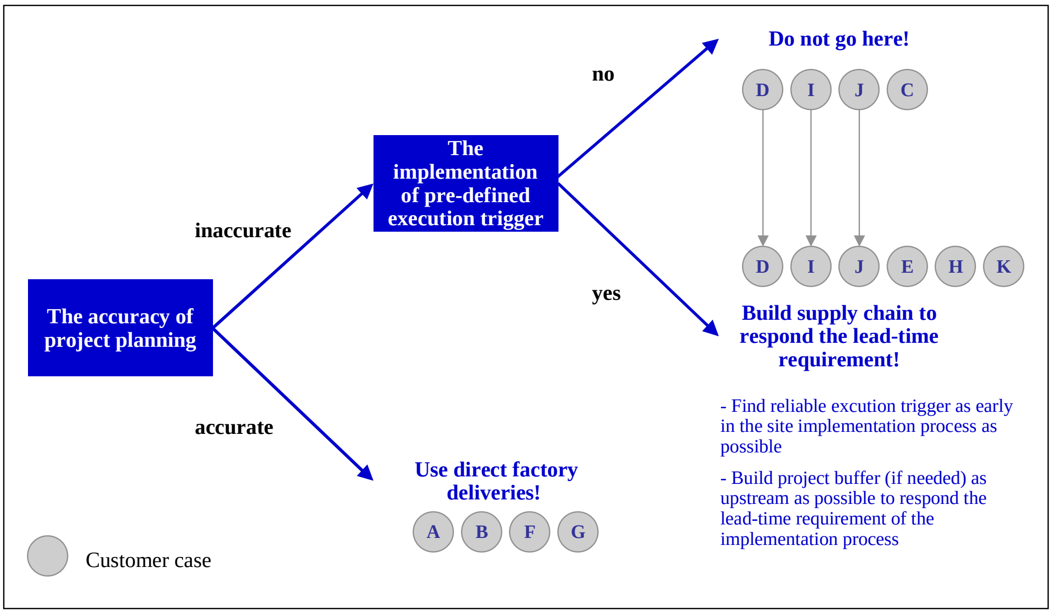


Figure 69: The implementation of a predefined execution trigger specifies the right supply chain

The detailed implications of a pre-defined execution trigger for supply chain selection are presented below.

- **Pre-defined execution trigger implemented**

  The implementation of a pre-defined execution trigger practically means that a project applies Just-In-Time delivery logic. Site-specific call-off orders are placed only after a reliable and pre-defined milestone in the site implementation process has been reached. For instance, in customer projects D, E and H, the end of site construction work was such a milestone, because only then could the final site location, product configuration and related installation instructions with a fixed schedule be agreed. It was the latest point in time when everybody in the project knew exactly which material was needed, where and when.

  In this “pull-mode” method, the main challenge, however, is to find a reliable execution trigger for ordering early enough in the site implementation process. Postponing the ordering too long in the process would mean that either the lead-time requirement becomes extremely short, or that the installation teams have to wait for material deliveries for a few days more. A short lead-time requirement, naturally, leads to local material buffering. Correspondingly, idle time for installation teams (or project time buffers by analogy) diminishes the project throughput time.

The customer cases indicate that the selection of the right supply chain is directly linked to this issue, if the project planning is not accurate. The earlier in the site implementation process this reliable execution trigger can be found, the better the chances for implementing the direct factory delivery mode. If the lead-time requirement is shorter than the factory lead-time, buffers are needed somewhere in the supply chain. If the lead-time requirement can be fulfilled with the lead-time of the regional DC mode, then that option is the right solution. If even the regional DC mode is not enough, then the ultimate solution for a customer is the local country buffer mode. Although this supply chain is not an optimised, cost-efficient solution, it still serves the customer’s needs best and most of all guarantees a reliable process.

Actually, there always is a certain kind of trade-off question for the customer between the service level (for instance lead-time) and the price (for instance inventory carrying cost) of the supply chain. There certainly is not one answer to this question; rather, the best solution depends on the project’s environment at that moment. Whether the customer wants to do everything to maximise the project’s throughput and get individual base stations on air as fast as possible, or whether the customer wants to primarily implement cost-efficient processes and streamlined supply chain is an important issue.

- **Pre-defined execution trigger not implemented**

In this case, the customer makes site-specific call-off orders based on the existing rollout plan, although it is known that a large degree of uncertainty is embedded in this practice. It is actually presumable that the details (for instance, site location, product configuration or installation schedule) will not be implemented as planned. However, the material ordering is done based on the basis of “the best guess”. This is done just to ensure that the project schedule is not delayed because the material is not available. This kind of thinking was actually very typical among several customer projects before the BIRD processes were introduced to them.

In real life this process starts with counting delivery schedules backwards in the project plan. The estimated start of the installation phase in the plan is normally taken as a fixed date for which base station deliveries are then scheduled. However, this is a very dangerous way for the customer project to manage its supply chain. First, normal human behaviour adds some contingency reserves to the schedules, so that the project team sets the requested delivery date to be days before the actual need. This is done to make sure that the material is available when the installation phase starts. Second, it is very likely that some modifications to the implementation plan were made while the equipment was delivered. These changes can consist of re-scheduling, product modifications or site locations.

If the schedule is only postponed, it means slower inventory rotation in practice and additional local costs with material handling and storage place. This is actually what happened at first in case D. If the site location changes, it typically requires a new installation schedule as well. In addition to the harmful effects of a postponed schedule, the new location requires extra transportation and order handling costs. These kinds of problems were faced in case I when direct factory delivery was first implemented. If the product configuration is changed or the whole site is not carried out at all, the effects can be very expensive due to the obsolescence risk. Case J basically represents the conditions where all these changes were taking place at the same time. When all these changes happen (the wrong material arrives at the wrong location at the wrong time), nobody in the project knows what to do with it.

The lesson learnt from these cases was that instead of neglecting the uncertainty of the project system, the right solution would be to accept the reality, to find a reliable execution trigger for ordering and to build the supply chain accordingly.

If the customer's project planning is not reliable, the supplier should move the VOP to project execution and adjust the OPP accordingly. A reliable and pre-defined execution trigger should be found as early in the site implementation process as possible, as it specifies the lead-time requirement for the customer. This requirement, in turn, determines the position of the OPP in the supply chain. Thus, it might be possible to implement a reliable process with the direct factory delivery, the regional DC or the country buffer modes. The main thing should be to guarantee an effective and reliable site implementation process. If an execution trigger is not implemented with the customer, the customer has to struggle with a project inventory.

7.4. Necessary business conditions

The two selection factors for the supply chain (the accuracy of project planning and the implementation of a pre-defined execution trigger) deal with quite operational level causal connections between the site implementation process and the supply chain. These factors were identified through months of process improvements, on a very practical level, with some failed trials. However, this kind of detailed information is not typically available when decisions about the supply chain are made. Therefore we also need to identify business conditions that can be used to estimate the behaviour of these selection factors beforehand.

The research results suggest that the technology life-cycle stage (GSM penetration) and the customer-supplier process collaboration level are business conditions that can be used to estimate the behaviour of the selection factors in a project beforehand. These are described below.

7.4.1. Technology life-cycle stage

The in-depth case analysis clearly shows that those customers that operate in rapidly growing markets with a low GSM penetration suffer from an unreliable site implementation process and inaccurate project planning. Similarly, those operators that are in the markets where the growth is not so drastic and the penetration already above 50%, have more accurate project plans and a fairly reliable site implementation process in place.

This is not a surprising observation. By definition, it is much easier to make reliable project plans when a network is already up and running, compared to the situation where everything starts from scratch. In the early phase of new GSM markets, rival operators naturally concentrate on being the first one to launch their GSM network and then bringing enough network coverage on-line for demanding subscribers. Speed and time-to-markets are certainly the key strategic objectives for all operators in these circumstances. These targets also set rigid requirements for the effectiveness (for instance, short lead-time) of supply chains. Whereas, when GSM penetration is already high, the main focus of the project has switched from network coverage building to capacity building. Time schedules in this case are not considered that critical for the business anymore; rather, it is now more the cost-efficiency of the implementation processes that matters for the operators.

These aspects became evident in many of the customer cases. Examples include operators A, B, F and G, who stated that a short lead-time is not so important for them, but a reliable delivery time is. These customers appreciated a reliable process and a cost-efficient supply chain instead of having fast deliveries in place. There is only one customer case, operator F, that does not necessary obey this rule. The customer has a fairly reliable site implementation process, although the markets were still growing rapidly. Taking a closer look at the customer case shows that the customer had earlier had huge problems with inventories during the time of rapid growth. It systematically wanted to prevent the risks of inventory obsolescence by improving the management of its supply chain. Therefore, the customer project team had been given a special task to better integrate equipment deliveries with the site implementation process. Furthermore, the operator had already long experience in the markets, as it started GSM operations in 1992.

The customer cases show that it is very difficult to implement the direct factory delivery mode in the early stage of GSM penetration. This condition is represented especially in cases C, E, I, J and K. The customer projects considered the lead-time from the factory too long to support the objectives of the project rollout. The main constraint (bottleneck) for an operator at the beginning of a technology life cycle is a network with insufficient capacity to meet the market demand. The bottleneck prevents the operator from making money from the investment and gaining market share against competitors. It is evident that those operators who are first on the markets get a competitive advantage against their rivals.

Therefore the throughput of the network building project must be maximised at any cost. Otherwise, there is a risk that the huge investment may not turn out to be a profitable business. In the early phases of a technology life cycle everybody wants to be in the markets first to be able to increase the customer base for the new technology. Supply chains should be built to serve the customer needs. This explains why project schedules are set so tight, often even unrealistically. Tight schedules mean that a risk of delaying one activity increases. When a delay happens, it ruins the whole schedule, as there is no contingency reserved for it. These constant changes in the site implementation schedule make the supply chain behave in a chaotic manner. If the lead-time were short enough, these constant changes in the project rollout plans would not interfere with the supply chain. If a short lead-time cannot be guaranteed from the factory, there needs to be a buffer in the chain to respond to the requirements from the project.

7.4.2. Customer-supplier process collaboration

The customer cases showed that when the customer-supplier relationships are working, it is easier to implement a reliable execution trigger for ordering. Furthermore, the trigger can be found earlier in the site implementation process, if the process collaboration is good. The earlier the execution trigger is implemented, the further upstream the OPP can be positioned. Cases E and J, where the process collaboration was not working with the customer (case E) and the project team (case J), indicate that the order trigger was difficult to implement before there was an installation team assigned to the work. It was so late that it practically meant that the requirement for equipment lead-time were almost in hours. This can be partly explained by the fact that the project team was in the middle of network start-up.

However, in cases D, H and I, the process collaboration was working with the customer and a reliable order trigger was found earlier in the site implementation process, in practice meaning around a one week lead-time requirement. Case J was also able to move the order triggering up earlier, as the whole process was revised after the hectic start-up phase was over. At the same time, it switched to regional distribution centre mode. Case K was not able to advance the ordering, although it was Nokia's internal project. This was because of the huge pressure from the customer of not risking the progress of the rollout at that point in time.

8. THEORY BUILDING AND CONCLUSIONS

The essence of this study is to create a normative decision-making model for companies to select the most successful supply chain solution for a customer in different business conditions. The new theory is explicitly built based on the eleven customer cases in the mobile communications infrastructure industry. Following the logic of inductive reasoning it is hypothesised that this model is applicable to the project business environment for innovative and high-tech products in general. The supply chain selection model consists of two distinct parts. The first part specifies the operational level rules to specify the right supply chain, whereas the second part further defines the underlying pre-conditions to apply the rules.

It can be concluded a set of highly operational level rules that actually specify the most appropriate supply chain for a customer in practice. They embed the three alternative value offerings that are particularly applied in the project business environment. Primarily, these rules provide direction on selecting the right combination of VOP and OPP. By identifying the sufficient selection factors, they also provide an explanation why one supply chain, in practice, is better suited than another.

Rules to specify the right supply chain:

1) If project planning is reliable, it effectively enables the use of the direct factory delivery mode.

⇒ *Position VOP in project planning and OPP furthest upstream*

2) If project planning is unreliable, the implementation of a pre-defined execution trigger should specify the right supply chain.

⇒ *Position VOP in project execution and adjust OPP accordingly*

3) If project planning is unreliable and no pre-defined execution trigger is implemented, the customer project ends up having a warehouse.

⇒ *Position VOP in project inventory management and OPP furthest upstream*

However, is not sufficient to know these rules to make the right business decisions about supply chains, because the behaviour of these highly operational level selection factors are not known beforehand. Therefore, we need to understand how these rules should be applied in different business conditions. The second major conclusion is the identification of dominant business conditions that predict the behaviour of the selection factors. These following are some underlying pre-conditions to apply the rules.

Underlying pre-conditions to apply the rules:

1) The technology life cycle stage in the markets explains the level of uncertainty in the project planning

2) Customer-supplier process collaboration significantly contributes to the successful implementation of a pre-defined execution trigger

The logic to draw these conclusions is explained in greater detail in the following sub-chapters.

8.1. Rules to specify the right supply chain for a customer

The different types of customer demand chains play a central role in the rules. A simple reason for this is that it does not make sense to make any choices between different supply chains without first understanding the value offered to the customer. According to Hoover et al. (2001), the primary two tasks in reconfiguring any demand-supply chain are always to first identify the customer's demand chain and second to define its potential value offering points. The value offering point is a way to distinguish different types of demand chains.

The VOP is a fairly new concept that was first introduced by Holmström et al. (1999), who defined it as the point in the demand chain where the customer allocates demand to a specific supplier. This definition is well suited for consumer businesses and is applicable for commodity products in a business-to-business environment, where the customer makes purchasing decisions occasionally or even only once. However, in a project business, where the customer-supplier relationships are much closer and the contracts are longer term, it is not that beneficial for the customer to allocate demand to a number of suppliers. Therefore, this definition is not applicable as such in project businesses.

This study noted that the VOP is actually the point in the customer's implementation process that triggers the material ordering. The triggering can be done based on project planning, execution or inventory management. Thus, we rephrase the definition of VOP for project businesses as the point in the demand chain where the customer triggers a specific order to the supplier. In other words, it is the point furthest downstream in the demand chain where the supplier identifies the real customer demand. According to Eloranta (1999), each demand-supply chain includes a demand trigger, which is a point where demand needs to be satisfied by supply. The location of VOP in the customer's demand chain represents this demand trigger.

Another speciality in using the VOP in project businesses is that the customers typically tend to prefer positioning the VOP in the project planning (furthest downstream), since they expect their suppliers to work flexibly according to their project plans in any case. - This is not the case in consumer type of business. - However, there is a significant hidden risk, as the customer's project planning may be unreliable. In these circumstances, suppliers might easily fall into a value trap. Instead, the customer and supplier should collaborate and work out together whether a more reliable process is achieved by moving the VOP one step upstream to project execution. If the process collaboration does not work, the end result is a project inventory.

This approach is embedded in the rules to specify the right supply chain for the customer in project businesses. These rules are illustrated in Figure 70.

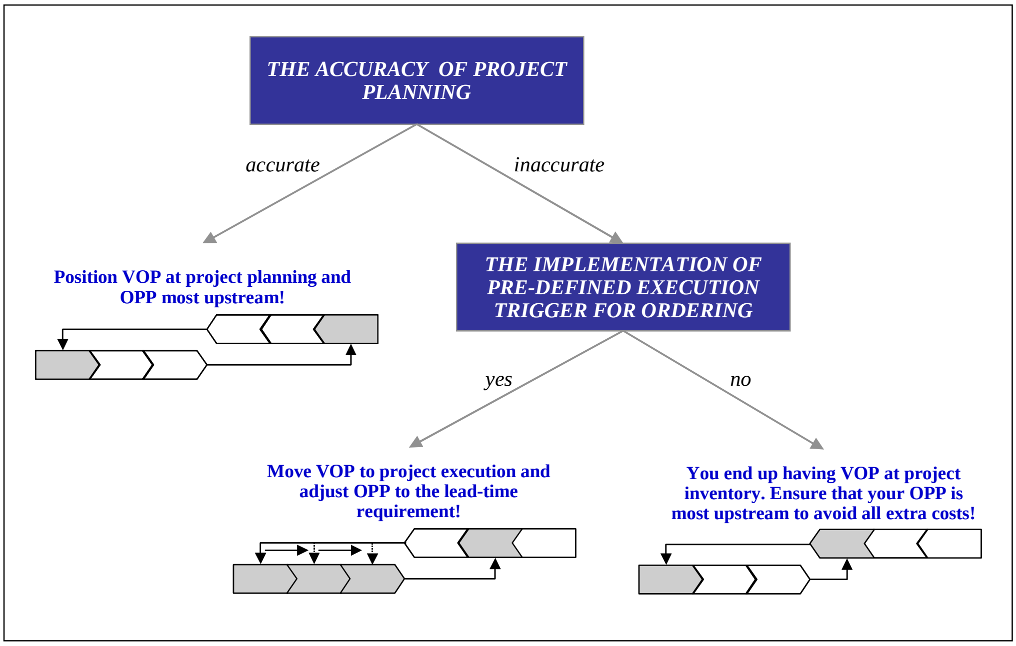


Figure 70: Rules to specify the right supply chain for a customer

The two supply chain selection factors are described next.

The accuracy of project planning

The research results clearly support the logical assumption that in those customer projects where the project plans are generally accurate, the value offering point can beneficially be placed in project planning. According to Hoover et al. (2001), having the VOP furthest downstream in the demand chain enables the order penetration point to be moved upstream to the plant, as the supplier's visibility and time to respond increase. Also according to Christopher (1998), improved demand visibility enables a more cost-efficient logistics process, as order (demand) penetration is moved upstream in the supply chain. In this study all those customer cases with relatively accurate project plans show positive performance in terms of customer service, capital deployment and cost-efficiency. Under these circumstances we thus conclude that the direct factory delivery mode is considered to be the most appropriate supply chain solution.

On the other hand, in those projects where plans are continually inaccurate, it is important to ensure that the value offering is **not** positioned in project planning. The VOP should be moved one step upstream in the demand chain. A typical trap is that the supply chain is unconsciously designed to serve the customer's planning process, although the plans are unreliable and cannot be trusted. The result is only an uncontrolled and chaotically behaving supply chain. This seems to be a very generic problem in integrating the project and supply chain systems, where the attempt is to maximise the targets for both systems at the same time.

Under these circumstances, the study concludes that the accuracy of project planning is considered to be a primary selection factor in determining the right supply chain solution for a customer. The customer cases in the research incontrovertibly demonstrate how accurate project planning is a sufficient factor to position VOP in project planning and to use the direct factory deliveries supply chain – naturally when the supplier's lead-time and delivery accuracy are at the agreed level.

The implementation of a pre-defined execution trigger

The second option, if the customer's project plans are inaccurate, is to have the value offering in project execution. At this value offering point, the position of the OPP is determined by two factors: (1) the positioning of a reliable process milestone that is used to trigger the material ordering and (2) the scheduled time for the installation start date. The lead-time requirement for the supply chain is the time between these two milestones. The aim is naturally to find a fixed trigger for ordering as early in the implementation process as possible to increase the time to respond for the supplier. However, whatever the time is, it is important to accept this requirement and build the supply chain accordingly, in order to have a reliable delivery process in place. This may require a very pragmatic approach from the supplier in order to find the right supply chain, as it may be possible to meet the requirement with the direct factory delivery mode, or it can mean the use of a regional distribution centre or it may even require local buffering of material. However, the main point is to have such a supply chain solution implemented that provides the lead-time required for the reliable process.

The implementation of a fixed process trigger for ordering is thus considered to be the second selection factor that determines the right supply chain for a customer in business conditions where project planning is inaccurate. It enables the supplier to provide the customer a successful supply chain solution, even if project schedules cannot be trusted. This is actually a practical way to apply JIT-delivery logic in project management that according to Steyn (2002) has been missing in the project management literature. The earlier in the implementation process a reliable process trigger is identified, the more cost-efficient a supply chain solution that can be implemented. Again, a decent level of supplier delivery accuracy is naturally a pre-requirement for all this.

From the supplier's perspective, the last controllable option to manage the supply chain, if a fixed process trigger is not implemented with the customer project, is to let the project hold inventory and take care of local warehousing. In practice, this means that the supplier's value offering is positioned in the customer's project inventory management. In this case, all orders to the supplier are triggered by material consumption in the warehouse, and the supply chain then serves this inventory replenishment process. From the customer project's perspective the supply chain solution is obviously now more costly, but at the same time it becomes much easier to manage and integrate with the project system, as the material decoupling point is moved close to the project team. The main difference with the "VOP at project execution" option is that the project and supply chain related processes can be locally integrated inside the project, without having external suppliers be involved in the project. The customer cases in the research showed that there might be several business reasons for the customer to prefer having its local warehouse instead of putting effort into integrating its processes with the supplier.

The research results also show that due to the high level of inventory holding costs, which is an inevitable consequence for the project, the use of the direct factory delivery mode is the only reasonable option for the supplier to replenish the inventory. Thus, the order penetration should be moved furthest upstream in the chain to avoid additional costs for the customer.

Summary

In summary, the first step in selecting the supply chain for a customer is to evaluate whether the customer's project planning is accurate or not. With accurate project plans, the right solution is to have the VOP in project planning (downstream) and OPP at the plant (upstream). If the plans are not accurate (which often is the case in real life), the most important thing is to ensure that the VOP is not positioned in project planning. Then, the next step is to move it one step upstream to project execution that, in other words, means that a reliable process trigger for material ordering is implemented.

In the second step, the aim is to find the trigger as early in the implementation process as possible in order to increase the supplier's time to respond. However, it is important to accept the lead-time requirement that is determined by the time between the process trigger and the start of installation, and to build the supply chain accordingly. The position of the OPP is determined by the lead-time requirement. If a process trigger is not implemented, it means that the customer project ends up having an inventory. Therefore, the supplier should first do everything to implement a process trigger with the customer. If that does not work out, the solution is to build the supply chain to serve the project's inventory replenishment process. To avoid additional costs, the inventory replenishment should be done from the factory; that is the OPP should be furthest upstream.

These two selection factors are on a highly operational level. It is thus very difficult to estimate the behaviour of these factors in a project beforehand. Typically, decisions on the supply chain are made when a project, or some phase of it, is started. At that time, there is no information available on whether the planning will be accurate or whether it is realistic to implement a fixed process trigger for material ordering. Therefore, some rules of thumb need to be found to say which business conditions determine the behaviour of these operational factors.

8.2. Underlying pre-conditions to apply the rules

Based on the research results, there are two major conclusions on how the rules should be applied. First, the technology life-cycle stage (GSM penetration) in the markets seems to be a necessary business condition for accurate project planning. Second, the customer-supplier process collaboration level enables, or prevents, the implementation of a fixed execution trigger for material ordering. These are illustrated in Figure 71.

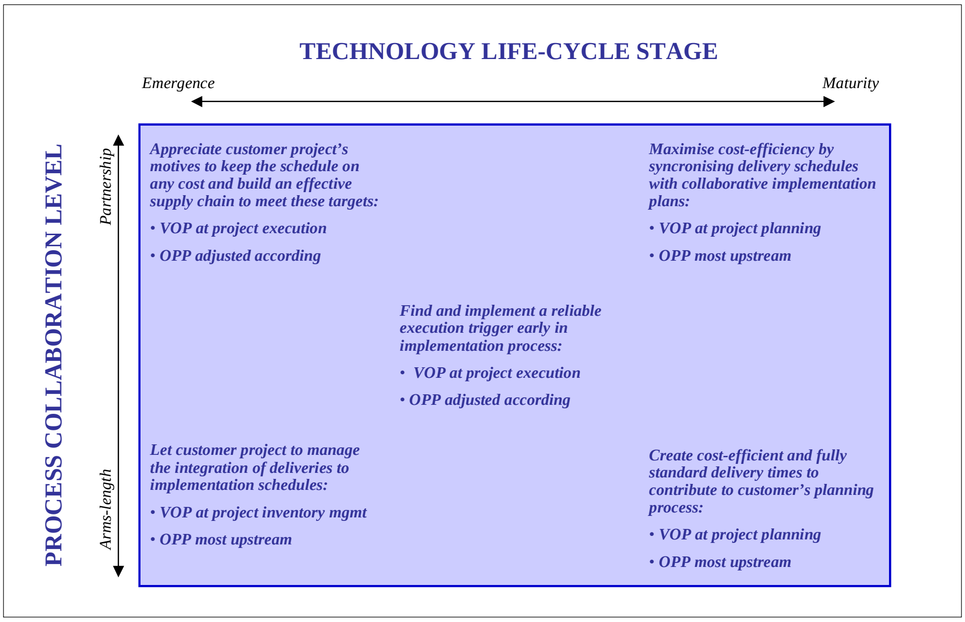


Figure 71: Underlying pre-conditions to apply the rules

These two determinant business conditions are described next.

The technology life-cycle stage

The research results show how difficult it is in the early stages of the life cycle (during emergence and accelerating growth phases) to plan for the near future. It is quite logical that the customers are not able to provide reliable plans to their suppliers during this emergent technology life cycle, as the whole market is still building up. According to Moore (1995), the early market phase is characterised by a time of great excitement when customers are technology enthusiasts and visionaries looking to be the first to get on board the new paradigm. This kind of over-positiveness easily leads to a highly competitive market situation where everybody wants to be the first one to conquer the market. In a project business environment, the main constraint (bottleneck) for a customer to start gaining market share in these circumstances is often the particular investment project. Therefore, deadlines for the project schedules are set to be very tight - or often even unrealistically tight. The main message to suppliers from the customer is that the throughput of the investment project must be maximised at any cost. The research results clearly indicate this kind of behaviour in GSM-markets. This approach, however, is very understandable because there is a significant risk that the investment may not turn out to be profitable for the business if the market entry takes place after the main competitors.

This behaviour explains why the project schedules are often made so tight in the early phases of the technology life cycle. As the plans are too tight, the risk that they are not realised according to the original schedule increases. This leads to a situation where the project planning accuracy becomes poor. As the technology life cycle moves ahead, it becomes possible to better estimate market behaviour and make realistic implementation project plans. The market situation evolves into a totally new environment, the mass-market period. It becomes possible to start working according to more realistic market assumptions and with more accurate planning information. However, according to Moore (1999) before the mass-markets phase, there is a time of great despair, called the *chasm*, when the early market's interest wanes but the mass-market has still not begun. This is a time when excess in project plans becomes a horrible reality to supply chain management, if the value offering has been positioned in project planning at the very beginning.

The customer-supplier process collaboration level

The customer-supplier process collaboration has a big impact on how easy it is to find a reliable execution trigger for material orders. The research results show that those customer projects with good relationships and process collaboration tend to implement the trigger early in the implementation process, which enabled the supply chain to work successfully without local buffering. On the other hand, in those cases where the collaboration is minimal, the process tends to require local buffers in order to be reliable.

8.3. Supply chain selection model for a customer

Our detailed supply chain selection model for a customer in project businesses is basically built upon the two sub-chapters above, i.e., the rules to specify the right supply chain and the underlying pre-conditions to apply the rules. The final presentation of the complete selection model is specified to fit into the technical norm framework, which was applied throughout the study. Therefore, the final model is composed of three elements and their interactions. The elements are the success of the supply chain (ends), the differentiation of supply chains (means) and the conditions for supply chain selection (situational factors). This is also illustrated in Figure 72.

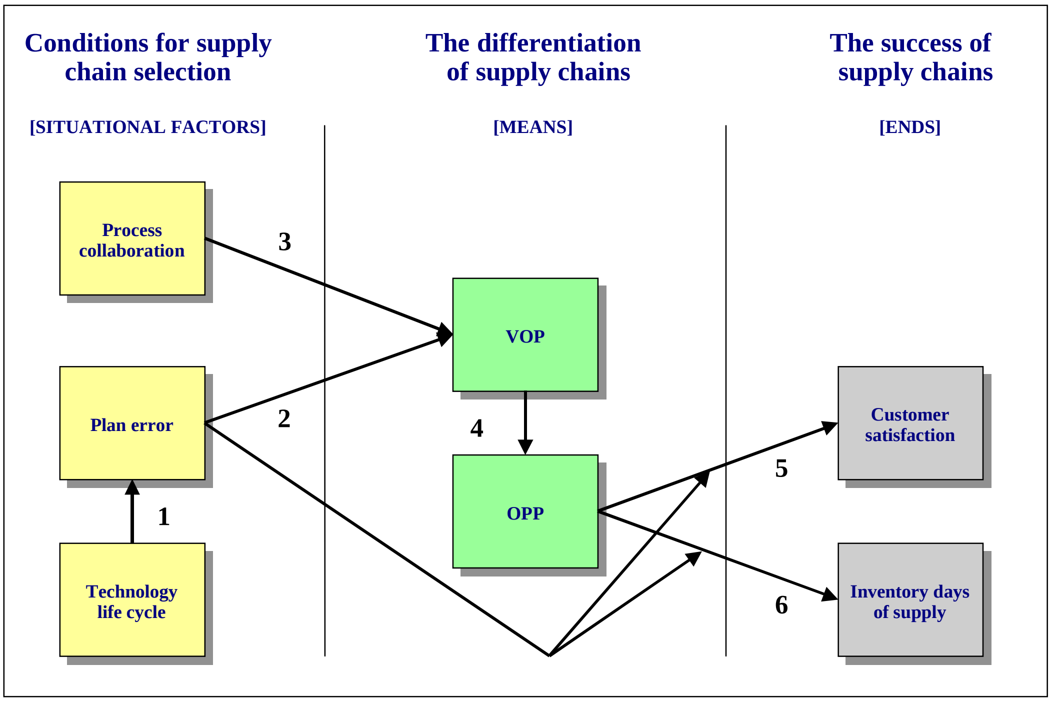


Figure 72: Supply chain selection model for a customer in project business

The different elements of the model and their interdependent relations are explained below:

- **The success of a supply chain (ends)**

Based on the literature review, it was concluded that overall supply chain performance consists of three discrepant dimensions: customer service, capital employment and total costs. In the research constructs the qualitative measurement of *customer satisfaction* indicated the level of customer service. Furthermore, it was concluded that for high-tech products *inventory days of supply (DOS)* represents both the capital employment and total costs dimensions, because most of their costs are allocated to supply chain inventories.

The final research results clearly support these assumptions. The measurement of customer satisfaction in the hypothesized model indicates how satisfied the customer is with the selected supply chain. It is obviously a highly qualitative measurement. In order to generalize the results to any wider context, it has to be converted into a quantitative scale. One practical way to do this is to match values to an ordinal scale, where new values are (1) satisfied, (2) ok and (3) dissatisfied. The measurement of DOS is already a pure quantitative data that can be measured with the ratio scale, from infinity to infinity.

- **The differentiation of supply chains (means)**

  The existing body of knowledge provided a framework to customize demand-supply chain solutions. Two effective means were identified: the *value offering point (VOP)* and the *order penetration point (OPP)*. In the research constructs it was concluded that order trigger specifies the position of VOP in the customer demand chain. Similarly, the levels of logistics and manufacturing postponement defined the location of the OPP.

  The research results point out that in project business there are actually three alternative VOPs: (1) call for project planning, (2) call for project execution and (3) call for project inventory management. Within the case study settings there were three OPP: (1) direct factory delivery, (2) regional distribution centre mode and (3) country buffer. Both these measurements can be easily matched to an ordinal scale for further validation.

- **Conditions for supply chain selection (situational factors)**

  Based on the systems theory it was concluded that there are three categories that form determinant conditions for supply chain selection. These were named as (1) customer and markets, (2) supplier, product and deliveries, and (3) customer-supplier relationship. In the research constructs these were developed further to a number of concrete factors that could be analysed.

  According to the research results *technology life cycle* and *process collaboration* are business conditions that fundamentally influence on the positioning of the VOP. Technology life cycle impacts via a *project plan error*. Within the case study settings the technology life cycle represents the GSM penetration in a country. The measurement is quantitative with a ratio scale from zero to infinity. Similarly, the plan error is also based on pure quantitative data that can be measured with a ratio scale from -100% to infinity. Customer-supplier process collaboration is a qualitative measurement and needs to be turned into a to an ordinal scale, e.g. (0) arms-length and (1) partnership.

- **Interdependent relations**

  The research results strongly indicate that the technology life cycle stage (GSM penetration) in the market explains the plan error level in the customer project. The bigger the penetration, the less the error in the project plans on average *(Relation 1).*

Based on the research results, it can also be concluded that accurate project planning enables the VOP to be positioned in project planning. In other words, when the plan error is small, the VOP should be positioned in project planning *(Relation 2).*

The customer-supplier collaboration enables the use of a pre-defined execution trigger, if the plan error is significant. If the process collaboration between the customer and the supplier is at a proper level, the VOP should be positioned in project execution. If the process collaboration does not exist, the customer project ends up having a local warehouse. In these circumstances, the VOP should always be positioned in project inventory management *(Relation 3).*

The research results indicate the rules for how the position of the VOP should specify the position of the OPP. If the VOP is positioned in project planning or in inventory management, the OPP should be positioned furthest upstream. However, when the VOP is in project execution, the OPP should be adjusted to respond to the lead-time requirements *(Relation 4).*

The position of the OPP together with the level of plan error affects customer satisfaction. If the plan error is small, the further upstream the OPP is positioned, the better the customer satisfaction is. However, when the plan error is large, the OPP should not be positioned upstream in order to keep the customer satisfied *(Relation 5).*

Similarly, the position of the OPP together with the level of plan error affects the inventory days of supply. If the plan error is small, the further upstream the OPP is positioned, the lower DOS is. When the plan error is large, positioning the OPP upstream does not guarantee a low DOS *(Relation 6)*

9. VALIDATION AND DISCUSSION

The research results and conclusions are explicitly drawn based on the eleven in-depth customer case analyses. This reasoning follows the selected action research approach that is thoroughly explained in the chapter of research methods. This chapter is now merely reserved for the validity evaluation and discussion on the applicability of the new model and potential further research areas. It consists of three subchapters. First, the validity and reliability of the new theory are evaluated. This part includes a further validation of the research results against all the BIRD customer cases (N=38). The second part includes discussion on the applicability of the supply chain selection model in four different project business industries. The third subchapter is to identify the need of further research on this theme.

9.1. The validation of the theory

Yin (1994) summarizes four complementary ways to judge the quality of empirical case study research: (1) reliability, (2) construct validity, (3) internal validity, and (4) external validity. Reliability refers to the ability to replicate the study by another researcher and it thus aims at minimizing errors and bias during the research process. Construct validity refers to the use of correct operational measures in the study. Internal validity means that causal relationships are established. External validity establishes the domain to which the results can be generalised. The appearance of these quality dimensions in the study are analysed in Table 7.

Table 7: Dimensions of research quality in the study

Quality dimension	Case study tactic (Yin, 1994)	Appearance in this study
Reliability	- Develop case study protocol - Develop case study database	- Based on the pilots a standard approach for implementing a customer specific re-engineering project was implemented - There is a well-structured database (Lotus Notes) that includes all documentation per individual customer. The list of research material is in appendix 1-5. Moreover, standard templates that are defined and used for main documents.
Construct Validity	- Use multiple sources of evidence - Establish chain of evidence - Have key informants review draft case study report	- Many sources used (see research material) - Lots of emphasis was put to derive the research constructs from the existing body of knowledge. Moreover, they explicitly follow the scientific reasoning (technical norm). - The BIRD mgmt team (4-6 persons) reviewed the main documents
Internal Validity	- Do pattern matching - Do explanation building - Do time series analysis	- That was included in the case analysis - That was included in the case analysis - Not included
External Validity	- Use replication logic in multiple case studies - Use case study protocol	- Replication logic was used in 11 customer cases. Otherwise, gGeneralisation in AR approach is very limited, within the case study settings 11 out of 38 cases were analytically selected - Research constructs were defined and used in 11 case analysis

The research results and conclusions are explicitly drawn based on the eleven in-depth customer case analyses. In addition to these customer cases, the BIRD program included a number of other customer projects where the supply chain was similarly revised. The complete research material consists of key operational measures from 38 different customers (including the eleven in-depth customer analysis). In order to enhance the external validity of this study, the research results are now further validated with those remaining 27 customer cases. This is done merely as a simple quantitative data analysis, where all research data - the 38 customers cases - is included. The purpose of this further-validation is merely to enhance the external validity of research results in the mobile communications infrastructure industry.

Quantitative data analysis of the model presented in Figure 72 is now conducted. The measurements are made operational as defined in the model description. The analysis was done in the SSP tool. The results of this analysis are attached in appendix 2. The following conclusion can be drawn:

- **Relation 1:** Regression analysis shows strong evidence that GSM penetration really explains the plan error in customer projects. The correlation is -0.650 and the coefficient -2.051. In practice, this means that when the penetration goes up one percent, the customer's plan error decreases 2.1 percent. This result is statistically significant.

- **Relation 2:** The plan error seems to explain the position of the VOP in the customer demand chain in a similar way as was concluded based on the in-depth case analysis. For instance, those customers that have positioned the VOP in project planning have on average an almost 30% smaller planning error than customers whose VOP has been positioned in project execution. However, this result is not statistically significant.

- **Relation 3:** The process collaboration between the customer and supplier does not seem to have any significance when the VOP has been positioned in project planning. However, most customers (69%) who have positioned the VOP in project execution have good process collaboration with the supplier. In addition, the customers (67%) the VOP of which is in inventory management tend not to have process collaboration in place. These observations are all in line with the conclusions drawn from the in-depth case analysis. However, they are not statistically significant results.

- **Relation 4:** This analysis clearly supports the logic drawn from the in-depth analysis that the VOP should specify the position of the OPP. All customers with their VOP in project inventory management and 89% of customers with their VOP in project planning have selected the direct delivery mode (OPP at plant). Whereas, the customers with their VOP in project execution are fairly equally split between direct factory delivery (38%), regional DC (44%) and country buffer (19%) modes. However, these results are not support by statistical evidence.

- **Relation 5:** The combined effects of the OPP selection and the plan error to the customer satisfaction do not show any clear quantitative evidence.

- **Relation 6:** The combined effects of the OPP selection and the plan error to the inventory days of supply seem to support the model. However, there is no statistical evidence.

These qualitative figures seem to support the research results that were derived from the eleven in-depth customer case analyses. However, as the statistical evidence remains very weak, no major conclusions can be made based on this, but further studies are needed. The applicability of the supply chain selection model in other project businesses is discussed next.

9.2. Discussion on the applicability of the model

This subchapter is to discuss the applicability of the new theory in other types of project business environments. The purpose is merely to consider whether there are clear analogs to the findings made in the mobile communications infrastructure industries. These discussions were separately done with representatives of four different project-oriented companies. These companies represented power transmission and mobile networks industry (Eltel Networks), construction service industry (Skanska), civil and environment engineering (SCC/Viatek), and elevator and escalator industry (Kone). The logic in selecting these industries is to have a representative case from a combination of functional vs. innovative products and one site vs. multi-site project environment.

The discussions with interviewees started with a short presentation on the action research study and the conclusions made. Based on that the applicability of the presented supply chain selection model was discussed. The summary of these occasions and interviewees is attached in appendix 3-1.Although the discussions were not meant to be any formal or structured, a clear agenda was still followed via pre-made questions. These leading questions for the discussion are attached in appendix 3-2. The applicability of the model is considered below.

ELTEL NETWORKS

Eltel Networks, a former IVO Transmission Engineering, is a company with expertise both in electrical and telecommunications networks. Eltel's operations are divided into three strategic business units: electrification projects, mobile networks, and network services. It has customer projects globally, but its main focus region is the Nordic-countries. The company is clearly specialized in project business e.g. in construction of power transmission networks, railway electrifications, civil works of masts and towers, and installation of shelters and antennas. It employs a total of 1500 people and had 192 MEUR net sales in 2001.

Eltel represents an industry with innovative products in multi-site project environment. This is pretty much similar to the business environment of the case study. High-tech equipment is delivered to an installation site where it is implemented to an electrical or telecommunications network. Intuitively, our supply chain selection model should fit into to environment pretty well. During the discussion this assumption was partly confirmed. Especially in the mobile networks business customers' project plans are constantly changing, that causes significant challenges to Eltel's operations. Mr. Rönkkö said: "High velocity customer markets and the multi-site environment obviously make it extremely complicated to manage the supply chain – not only for physical products but especially for services (human resources). Therefore, it is our clear target always to have real collaborative processes agreed and implemented with our customers. Actually, all parties involved in the customer's implementation project should have same target setting and same guidelines for incentives. There are lots of things that can be learnt from more traditional industries, e.g. from paper industry. Technology and competences in building mobile networks are so new."

However, in the construction of power transmission networks customer's project plans are relatively accurate and no changes take place. "A stable process that is based on customer's plans can be much easier implement and", continued Mr. Rönkkö, "everything around supply chains is much more straightforward." As an analogue to the supply chain selection model this behaviour could be explained by the technology life cycle. However, although customer plans changed in this business, it would not mean huge supply chain costs because material in is not that costly to buffer.

In summary, it seems that our model basically can be useful in this kind industry but does not perfectly match in the electrical networks.

SKANSKA

Skanska is a global construction services group committed to finding innovative solutions for its clients. Combining global presence with local expertise, Skanska offers a broad range of services: from project development, to construction and facilities management. The Group currently has 75,000 employees and permanent operations in 23 markets. Sales for 2001 totaled USD 15.9

billion. In Finland, Skanska is the leading construction company in the residential, office, business and infrastructure sectors.

Skanska represents an industry with pretty functional products in one-site project environment. Thus, it differs from the case study's business environment in a way that product markets are more established and customer projects typically take place in one physical location. Otherwise, the project business environment has many analogs to the mobile network business. Mr. Muurimäki clarified: "In the model Skanska basically represents a GSM operator who builds the network for its customers - for end-users. Similarly, in the construction industry there are a number of equipment suppliers that provide products to an implementation project. Here it is Skanska's role to manage the overall projects like the operators in your industry. There are naturally different types of contracts that are made with building owners." Thus, it is concluded that our supply chain selection model is actually not meant here for Skanska but its suppliers. Despite the fact Mr. Muurimäki identified potential applicability of the model in the industry. He continued: "Sometimes when a critical activity of our projects is delayed, it may cause significant problems to the suppliers to manage their deliveries. For instance, specifically designed precast elements that are delivered in make-to-order mode can be very problematic, because their buffering in the factory or in the construction site is very difficult. Also for some high-tech equipment with automatic features it becomes highly expensive to wait for the installation – an elevator is an excellent example. Products like these need to have a well-defined ordering procedures in place. Implementing these kind of procedures requires close collaboration with the supplier."

There are clearly some elements of the model that can be applied in traditional construction industry, too. For instance, the importance of process collaboration when project plans are changing is considered extremely important. Similarly, the need to integrate supply chain to a customer's project schedules is evident. Still, the supply chain is generally much easier to manage as the site location is always fixed and products are more standardised, although much variations do exist. For construction service companies the usefulness of the model is perhaps not that important, but for their equipment suppliers the model may be applicable.

SCC/VIATEK

Scandiaconsult, with 2000 employees in 50 locations in Sweden, Norway, and Finland, is one of the major actors in infrastructure-engineering consulting in the Nordic market. The Group, with annual sales of SEK 1.5 billion, offers comprehensive solutions in all technical disciplines from concept and analysis, planning, design and project management to operation and maintenance. Scandiaconsult's technical competence is combined with solid knowledge in the fields of environment, and sustainable use of natural resources. Infrastructure projects of today and the future require a mature perspective on the interaction between the environment and urban development.

SCC/Viatek represents an industry with very functional products in extremely multi-site project environment. It is an excellent example of project business where the location of implementation sites is constantly changing – similar to mobile networks. Because of products, it is however very much different from the case study's business environment. Infrastructure projects include environmental engineering, urban planning, landscape architecture, transport, road and railway engineering. Mr. Siren explained: "Managing supply chains in our industry is quite original, since it might basically mean anything between the sky and the earth. For instance, it can mean the movement of gravel from one part of a road to another or it can mean deliveries of designed bridge beams." Naturally, building high ways, railways or new residential blocks is certainly project business, where project scheduling and managing site locations are also very important. Actually, it has surprisingly many similarities with mobile networks, including a type of network planning, site acquisitions and permitting processes. Despite Mr. Siren concluded: "This industry does not include a real option for supply chain differentiation, since it simply does not bring any value. Supply chains should be as efficient as possible."

It can be concluded that our supply chain selection model is not valid in this kind of infrastructure project business where products are highly functional and inexpensive. The supply chain should be built as efficient as possible.

KONE

Kone is one of the leading companies in the global elevator and escalator business. It develops, manufactures, installs, modernizes and services elevators, escalators and auto walks. It has more than 23,000 employees and operations in some 800 locations in over 40 countries. KONE supplies more than 20,000 new elevators and escalators annually. Besides it services 500,000 elevators and escalators as well as 140,000 building doors.

Kone represents an industry with highly innovative and high-tech products in a pretty fixed site project environment. However, there are also multi-site customer projects where elevators are delivered to a number of buildings within some region. In addition to delivering new elevators Kone is also a service company with maintenance and modernization services. Mr. Länsiö pointed out: "In this kind of service-oriented business environment it is especially important to have the supply chain seamlessly integrated to a customer's implementation project. To respond to changing customer specifications we have built alternative supply chains for different product segments: standard products are delivered from our factories, products with some variations are stored and delivered from DC, and products with high-customization are stored close to the customer project." The logic seems to be the same than in the mobile network industry. When the configurations of high-tech products can be altered, it is frozen so late in a customer project that the delivery lead-time required (without postponing project schedule) is only a few days or even hours. Mr. Länsiö continued: "Although we are actively involved in designing and planning elevator solutions to the customer, it is very typical that the customer's project plans are changing. In such circumstances, the material ordering from our factories should not be made based on those plans. Rather, we have agreed a 'non return point' after which it is not possible to make any changes in the order. There is actually a certain checklist agreed with customers to ensure the readiness of elevator site. Successful implementation of these processes is very much dependent on the existing customer relationships." This is completely analog to the findings made in the thesis.

It seems that our supply chain selection model matches surprisingly well to Kone's business environment.

9.3. Further research

This study provides companies with a useful tool to implement successful supply solutions for individual customers in project businesses. Although the new theory is explicitly built based on the eleven customer cases in the mobile communications infrastructure industry, following the logic of inductive reasoning it is hypothesised that the supply chain selection model would be applicable to the project business environment for innovative and high-tech products in general. However, this hypothesis should be studied further with more extensive data.

The supply chain selection model consists of a set of normative rules to specify the right supply chain for a customer and defines the underlying pre-conditions to apply the rules. In addition to these normative results, the study provides new insight on the existing body of knowledge on integrating equipment deliveries into a customer's implementation project. From this perspective, the research results are relevant not only for practitioners, but also for scholars to enhance their understanding of how the project system and the supply chain system interact under different business conditions. It seems that this has been a fairly untouched area in the literature.

This thesis is also the first empirical study to apply the VOP-OPP framework in project businesses. It concludes that the customer's implementation process actually forms the demand chain to which the supply chain should correspondingly be linked. In project businesses there are effectively three possible VOPs in the demand chain: project planning, project execution and project inventory management. A totally new kind of value offering, specific to project businesses, is to integrate the supply chain into the customer's demand chain in project execution. The basic idea is to find a pre-defined and reliable execution trigger that activates the supply chain in the customer's implementation process. All customer-specific delivery processes are postponed until this triggering point is reached. Actually, this is a practical way to apply JIT-logistics in project management.

This thesis is a new theory-building case study approach. Therefore, the research results are only valid within the case study settings. The next step would be to verify the results with extensive research material.

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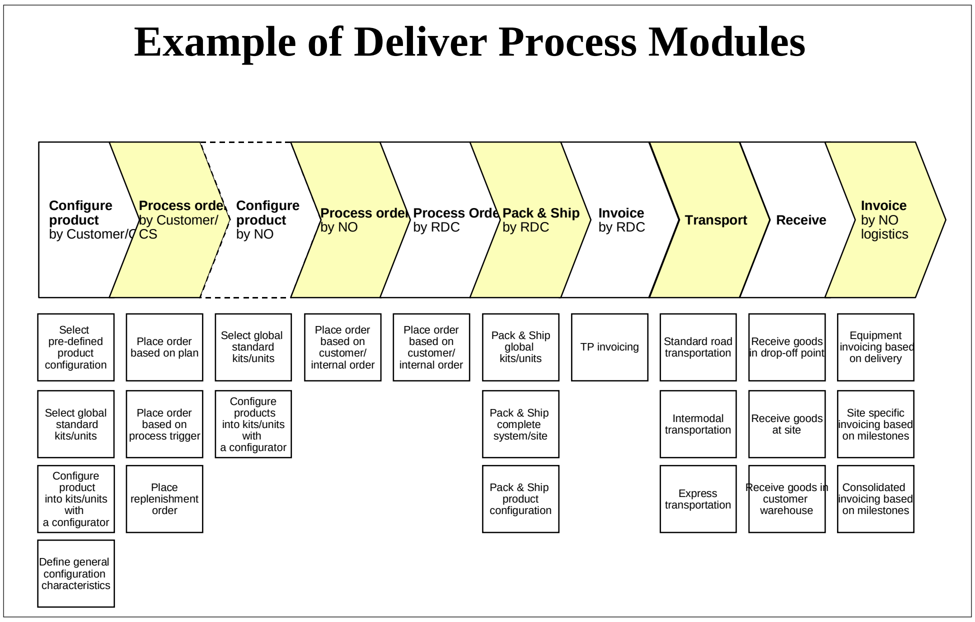
APPENDIX 1-1: Template for project plan

1. INTRODUCTION
    1.1. Targets
    1.2. Standard processes for Direct Delivery / Regional Distribution Center / Country Buffer
    1.3. Customer status
    1.4. Benefits
2. APPROACH
    2.1. Scope and products
    2.2. Roll-out phases and schedule
    2.3. Organisation
    2.4. Status reporting
    2.5. Documentation
3. TARGET PROCESSES
    3.1. Customer proposal
    3.2. Demand Planning
    3.3. CS Project - Logistics integration
    3.4. Deliver process
    3.5. Logistics service partner management
    3.6. Metrics
    3.7. Other issues
4. CLOSING
    4.1. Ending criteria
    4.2. Handover plan
    4.3. Follow-up

APPENDIX 1-2: Template for process description



APPENDIX 1-3: Template for final report

1. STARTING POINT IN ACCOUNT
    1.1. Products and lead-times
    1.2. Deliver process
    1.3. Targets for the project
2. ACHIEVEMENTS OF THE PROJECT
    2.1. Monetary savings
    2.2. Metrics
3. CHANGES IMPLEMENTED
4. DESCRIPTIONS OF FINAL PROCESSES
    4.1. Deliver process
    4.2. Demand planning process
5. HANDOVER
    5.1. Closary meeting
    5.2. Follow up period
6. KEY LEARNINGS
    6.1. Implementation
    6.2. Process content
7. ATTACHEMENTS
    7.1. Project closing summary

APPENDIX 1-4: Template for account analysis

1. PURPOSE

The purpose of the document is to collect needed data to define target BIRD concept for the account and to assist in prioritization of accounts in the program level.

2. GENERAL BUSINESS

2.1. Customer Profile

When and where did the operator first launch?

What is the order of the operator in terms of when it was established in the country (e.g. 3rd operator)?

Is the customer local or part of a global company?

Does the company have strong links to another telecom company?

Customer's decision making process, organization and leadtime, e.g. who are real decision makers within the Customer?

What is the relationship with the customer (e.g. partnership, arms-lengths)?

What competitors are supplying what equipment to the customer?

What are the key buying factors for the customer, i.e. is it speed, cost, quality, expandability, …?

How much has been sold to the account during the last year?

What is the LE for the coming year?

What is the rollout plan going forward (incl. No of sites/month)?

How is the customer project organized?

What are the main issues/problems currently, e.g. does customer have any requirements for their supply chain?

2.2. Contract

Has the contract been reviewed as part of the BIRD contractual review and if so what where the conclusions?

Are there penalty clauses for late delivery of equipment or sites on air?

Does the contract include any logistics clauses and if so what are the main points?

When will the contract expire and are there any contract revision/re-negotiations planned prior to the contract expiration?

Is the case subsidiary mode or direct export mode?

2.3. Products and Lead Times

What BSS products are sold to the account (BS, MWR, SiSo, BSC)?

What other products are provided by NET?

How many different configurations are sold and isit the customer or NET that defines the configurations?

Are products provided as kits/units or as configurations or as complete sites?

Does customer require configuration specific testing?

What SiSo is bought locally versus from global SiSo?

How aligned is local SiSo (kit contents and coding) with global SiSo?

What are the plans for moving to global SiSo?

In what factories are the different products produced?

What are the current lead times per product between customer order and delivery?

What are the required lead times per product between customer order and delivery?

3. CS PROCESS

3.1. Transmission plan

What percentage of links are leased lines versus MWR links?

How often does the transmission plan change?

3.2. Site acquisition

How long does site acquisition normally take?

3.3. Implementation and integration

What is the scope of NETs services (e.g. telecom installation, turnkey)?

Are the same sub-contractor used for BTS and MWR installation?

What is the relationship with the sub-contractors, i.e. partnership or not?

What different types of sites are there (e.g. roof top, greenfield) and what is the split between them?

In what percentage of cases are crane lifts required?

In what percentage of cases are other special site arrangements needed and what are these?

Is any pre-fabrication done at the sub-contractor prior to delivery to site?

Are sites constructed as soon as they become available or according to a cluster principle or as late as possible given resource constraints?

How many sites can be constructed per week and what drives this constraint?

What is the throughput time between start of constructions and site on air?

How sites are integrated?

How is network elemet integration done (i.e. remote integration)?

4. LOGISTICS PROCESSES

4.1. Demand Planning

Is the new demand planning/latest estimate process in place?

To what extent is the customer involved in demand planning?

How accurate are demand plans?

4.2. Ordering

How long before the start of the telecom installation is the exact equipment to be installed known and how often does this change?

Is there a possibility to increase the visibility of what equipment is needed either through process changes or closer cooperation with the customer?

What is the order triggering point for telecom equipment?

4.3. Delivering

Where are goods delivered for site works (e.g. site, drop-off point, sub-contractors facilities)?

Are all products delivered jointly to the site?

4.4. Transportation & Forwarding

What are the transportation lead times from factory to country?

What are the in-country transportation lead times?

What are the delivery frequencies between factory and country and inside the country?

Which transportation companies are used in the whole chain from factory to site?

How long does it normally take to make the import forwarding & customs clearance?

4.5. Inventory

What are the current inventories: Goods In Transit, Physical Stock and Work in Progress?

Why are inventories kept?

Are inventories held as configurations or units/kits?

What are the inventory replenishment principles?

Who is running the warehouse?

4.6. Invoicing

When are goods invoiced to the customer?

What system is used for invoicing (e.g. MLS)?

5. SYSTEMS AND METRICS

5.1. IM systems

Is MLS in use and if not when will it be implemented?

When will Trilogy SC be implemented?

What system is used for milestone follow-up in the CS process?

What system is used for CS order specification and ordering?

What system is used for work time recording?

5.2. Metrics & Reporting

What metrics have been put in place and are regularly followed-up?

How well are the current metrics aligned with NET global metrics?

6. CONCLUSION

Evaluate the business impacts:

- Expected savings (in inventory value)?
- How much sales is covered ?

Evaluate the complexity of BIRD implementation:

- How long would BIRD roll-out take ?
- How many resources is needed ?

What is the target BIRD concept?

What are the risks?

When can BIRD roll-out start?

APPENDIX 1-5: Summary of research material

Research material	Customer cases										
	A	B	C	D	E	F	G	H	I	J	K
E-mails, notes, minutes	x	x	x	x	x	x	x	x	x	x	x
Project plan	x	x	-	x	x	x	x	x	x	x	x
Customer proposal	x	x	-	x	x	x	-	x	-	-	-
Process description	x	x	x	x	x	x	x	x	x	x	x
Final project report	x	x	-	x	x	x	x	x	x	x	x
Audit report	-	-	-	-	x	x	-	x	x	x	x
Account analysis	x	x	x	x	-	-	x	x	-	x	x
CSSS 1999	x	x	x	x	x	x	-	x	x	-	-
CSSS 2000	x	x	x	x	x	x	x	x	x	x	x
Audit interviews	-	-	-	-	x	x	-	x	x	x	x
Inventory composition	x	x	x	x	x	x	x	x	x	x	x
Inventory rotation (DOS)	x	x	x	x	x	x	x	x	x	x	x
Delivery accuracy	x	x	x	x	x	x	x	x	x	x	x
Delivery lead-time	x	x	x	x	x	x	x	x	x	x	x
Demand plan error	x	x	x	x	x	x	x	x	x	x	x
GSM penetration	x	x	x	x	x	x	x	x	x	x	x
Market share	x	x	x	x	x	x	x	x	x	x	x
Nbr of GSM subscribers	x	x	x	x	x	x	x	x	x	x	x
ARPU	x	x	x	x	x	x	x	x	x	x	x

APPENDIX 2-1: Technology life cycle and plan error (relation 1)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.650[a]	.422	.407	.4269

a. Predictors: (Constant), GSM penetration

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.189	1	5.189	28.468	.000[a]
	Residual	7.108	39	.182		
	Total	12.297	40			

a. Predictors: (Constant), GSM penetration

b. Dependent Variable: Forecast error

		Unstandardiz Coefficien		Standar ze Coefficie ts		
1	(Consta	B	Std. .38	Bet	t	Sig .00
	GSM					

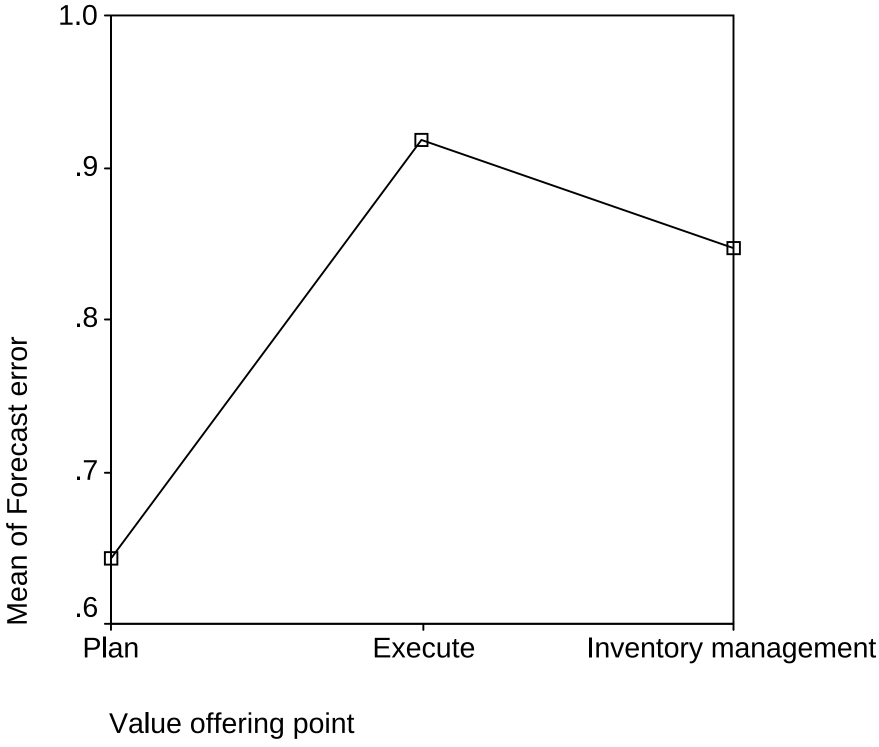
a.

APPENDIX 2-2: Plan error and VOP (relation 2)

ANOVA

Forecast error

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.693	2	.347	1.135	.332
Within Groups	11.603	38	.305		
Total	12.297	40			



APPENDIX 2-3: Process collaboration and VOP (relation 3)

Value offering point * Process collaboration Crosstabulation

Count

		Process collaboration		
		No collaboration	Collaboration	Total
Value offering point	Plan	10	9	19
	Execute	5	11	16
	Inventory management	4	2	6
Total		19	22	41

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.765[a]	2	.251
Likelihood Ratio	2.818	2	.244
Linear-by-Linear Association	.000	1	.992
N of Valid Cases	41		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.78.

APPENDIX 2-4: VOP and OPP (relation 4)

Value offering point * Order penetration point Crosstabulation

Count

		Order penetration point			Total
		Direct delivery	RDC	Country buffer	
Value offering point	Plan	17		2	19
	Execute	6	7	3	16
	Inventory management	6			6
Total		29	7	5	41

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.445[a]	4	.002
Likelihood Ratio	19.698	4	.001
Linear-by-Linear Association	.186	1	.667
N of Valid Cases	41		

a. 7 cells (77.8%) have expected count less than 5. The minimum expected count is .73.

APPENDIX 2-5A: OPP and customer satisfaction (relation 5)

Order penetration point * Customer satisfaction Crosstabulation

Count

		Customer satisfaction			Total
		Good	Ok	Dissatisfied	
Order penetration point	Direct delivery	9	13	7	29
	RDC	4	2	1	7
	Country buffer	3	1	1	5
Total		16	16	9	41

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.796[a]	4	.592
Likelihood Ratio	2.813	4	.590
Linear-by-Linear Association	1.414	1	.234
N of Valid Cases	41		

a. 6 cells (66.7%) have expected count less than 5. The minimum expected count is 1.10.

APPENDIX 2-5B: OPP, plan error and customer satisfaction (relation 5)

Tests of Between-Subjects Effects

Dependent Variable: Customer satisfaction

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.496[a]	3	.832	1.444	.246
Intercept	5.850	1	5.850	10.158	.003
OPP	.200	1	.200	.347	.559
FORECAST	1.526	1	1.526	2.650	.112
OPP * FORECAST	1.587	1	1.587	2.755	.105
Error	21.309	37	.576		
Total	161.000	41			
Corrected Total	23.805	40			

a. R Squared = .105 (Adjusted R Squared = .032)

Parameter Estimates

Dependent Variable: Customer satisfaction

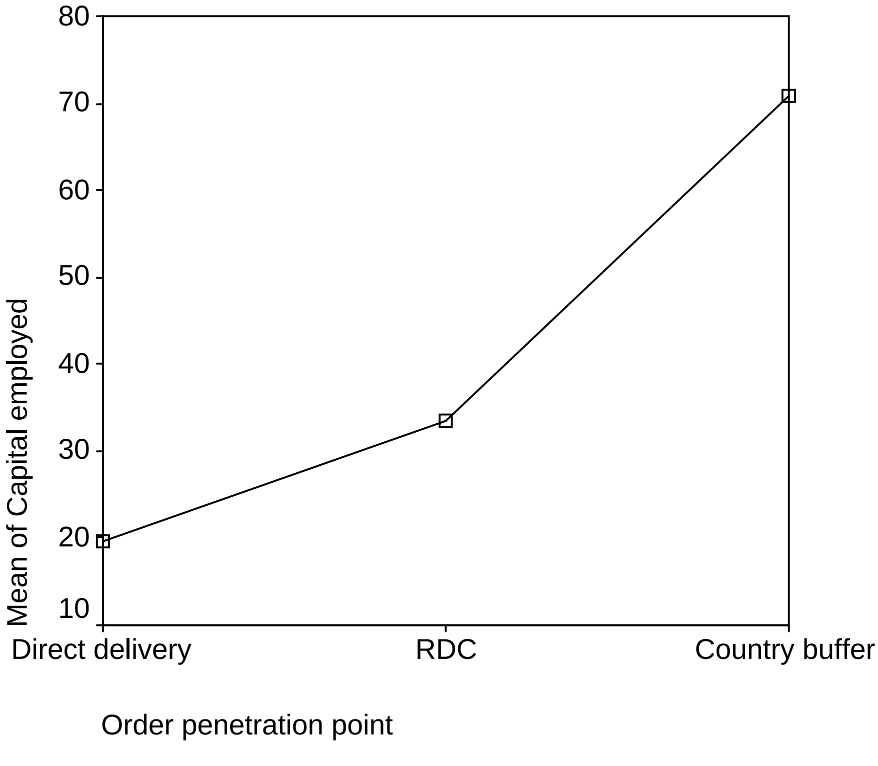
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	1.483	.465	3.187	.003	.540	2.425
OPP	.170	.289	.589	.559	-.416	.756
FORECAST	.767	.471	1.628	.112	-.188	1.722
OPP * FORECAST	-.422	.254	-1.660	.105	-.937	9.316E-02

APPENDIX 2-6: OPP and capital employed (relation 6)

ANOVA

Capital employed

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5089.572	2	2544.786	3.610	.043
Within Groups	16917.242	24	704.885		
Total	22006.814	26			



APPENDIX 2-6B: OPP, plan error and capital employed (relation 6)

Tests of Between-Subjects Effects

Dependent Variable: Capital employed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7434.665[a]	3	2478.222	3.912	.022
Intercept	1665.597	1	1665.597	2.629	.119
OPP * FORECAST	476.774	1	476.774	.753	.395
OPP	4350.804	1	4350.804	6.867	.015
FORECAST	1369.170	1	1369.170	2.161	.155
Error	14572.149	23	633.572		
Total	38759.746	27			
Corrected Total	22006.814	26			

a. R Squared = .338 (Adjusted R Squared = .251)

Parameter Estimates

Dependent Variable: Capital employed

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Intercept	-31.189	19.236	-1.621	.119	-70.981	8.604
OPP * FORECAST	-17.733	20.443	-.867	.395	-60.022	24.555
OPP	33.998	12.974	2.621	.015	7.160	60.835
FORECAST	38.692	26.320	1.470	.155	-15.756	93.140

APPENDIX 3-1: Summary of discussions on the applicability of the model

Company / Industry:	ELTEL NETWORKS / power transmission and mobile networks industry
Interviewee:	1) Mr. Tuomo Rönkkö, 2) Mr. Mika de la Chapelle, 3) Mr. Sten Nordman
Position:	1) President & CEO, 2) Director (products), 3) Global Rollout Manager
Time of interview:	21st November 2002

Company / Industry:	SKANSKA / construction-related services and project development
Interviewee:	Mr. Jarkko Muurimäki
Position:	Quality Manager
Time of interview:	21st November 2002

Company / Industry:	SCC/VIATEK / consulting engineering industry
Interviewee:	Mr. Jukka Siren
Position:	Head of Logistics Consultancy
Time of interview:	22nd November 2002

Company / Industry:	KONE / elevator and escalator industry
Interviewee:	Mr. Harri Länsiö
Position:	Manager, Major Project Unit (global)
Time of interview:	25th November 2002

APPENDIX 3-2: The Applicability Of The Supply Chain Selection Model

Company / Industry: ____________________

Interviewee: ____________________

Position: ____________________

Time of interview: ____________________

Leading questions for the discussion:

1. What is the position of your company in the industry, i.e. which part of value chain/system?

2. Characteristics of your product(s)?
   - Technology/product life-cycle
   - Average contribution margin in the industry
   - Product variety (no of product variants)
   - Level of average forecast errors
   - Average stock-out rate
   - Avergage forced end-of-season markdown as percentage of full price
   - Lead-time required for made-to-order product

3. How is your product's implementation project organised?
   - What are process steps?
   - How is reesponsibile for which parts?
   - Are the project plans on average reliable? If not why?
   - What is triggering customer'ordering? Any alternatives?
   - How important is the collaboration with your customers? And why is it important?

4. How is the supply chain designed at the moment?
   - Primary purpose (relevancy to customer/efficieny/effectiveness)
   - Manufacturing focus (capacity utilisation)
   - Inventory strategy (days of supply)
   - Lead-time focus (criticality)
   - Approach to choosing suppliers (cost/quality/speed/flexibility)
   - Product-design strategy (customisation/differentiation)

5. Main challenges in integrating equipment deliveries to your implementation process?

6. What is your honest opinion about the model? Can it be applied in your industry / company?
   - Why/why not?