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**SUPPLIER EVALUATION USING ANALYTICAL  
HIERARCHY PROCESS**

**This Master's thesis has been left for inspection for the degree of Master of  
Science in Helsinki 03.02.2009**

**Examiners: Professor Tuomo Kässi, Professor Markku Tuominen  
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## ABSTRACT

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**Name of the thesis:** Supplier Evaluation using Analytical Hierarchy Process

**Faculty:** Faculty of Technology Management

**Year:** 2009

**Place:** Helsinki

Master's thesis. Lappeenranta University of Technology.

108 pages, 11 figures, 1 chart, 3 pictures, 25 tables, 1 formula and 12 appendices

Examiner:

1st examiner professor Tuomo Kässi

2nd examiner professor Markku Tuominen

**Keywords:** Analytical hierarchy process, AHP, supplier evaluation, EADS, purchasing, quality, performance, forecast

The goal of the thesis is to make a supplier evaluation using analytical hierarchy process. Before the supplier evaluation is performed there will be introduced the principles of purchasing which gives a viewpoint to the supplier evaluation and management. The thesis will also give an overview on quality, performance and forecasts which are very important to the supplier evaluation and future improvements. The chapter which describes analytical hierarchy process will show the reader what exactly is analytical hierarchy process and how can it be utilized in supplier evaluation. In the later stages, thesis will provide information about the case company EADS Secure Networks Oy, the processes applied there towards purchasing and how the analytical hierarchy process is applied in practise. In the end of the thesis there will be an overview about each supplier's strong and weak points as well as some comments and ideas about developing also EADS Secure Networks procedures to a direction which would benefit the whole customer-supplier-chain.

## TIIVISTELMÄ

**Tekijä:** Mikael Johannes Bogdanoff

**Työn nimi:** Supplier Evaluation using Analytical Hierarchy Process

**Osasto:** Teknistaloudellinen tiedekunta. Teknologian johtaminen.

**Vuosi:** 2009

**Paikka:** Helsinki

Diplomityö. Lappeenrannan teknillinen yliopisto.

108 sivua, 11 kuviota, 1 ruudukko, 3 kuvaa, 25 taulukkoa, 1 kaava ja 12 liitettä

Tarkastaja(t):

Ensimmäinen tarkastaja professori Tuomo Kässi

Toinen tarkastaja professori Markku Tuominen

**Hakusanat:** Analyyttinen hierarkiaprosessi, AHP, toimittajan arviointi, EADS, osto, laatu, tehokkuus, ennusteet

Tämän työn tavoitteena on suorittaa toimittajan arviointi hyödyntäen analyttisen hierarkia prosessin menetelmää. Ennen toimittajan arviointia työssä käydään läpi perusteet ostamisesta sekä siihen liittyvistä tekijöistä, joista on apua toimittajan arvioinnissa sekä hallinnassa. Tämä työ antaa myös lukijalle yleiskuvan siitä, mitä oikeastaan kirjallisuudessa laadulla, tehokkuudella ja ennusteilla oikein ymmärretään. Näiden tekijöiden ymmärtämisen tarkoituksena on auttaa toimittajien arviointia sekä kehittää niiden toimintaa. Tämän jälkeen työssä tutustutaan analyttisen hierarkiaprosessiin ja siihen, kuinka sitä voidaan hyödyntää toimittajien arvioinnissa. Työn lopussa tutustutaan case-yrityksenä toimivan EADS Secure Networks Oy:hyn, sen ostoprosesseihin sekä kuinka analyttistä hierarkia prosessia voidaan käytännössä soveltaa yrityksen toimintaan. Lopuksi työssä kuvataan jokaisen toimittajan vahvuudet ja heikkoudet sekä annetaan kommentteja sekä ideoita siitä, kuinka EADS Secure Networks Oy voi kehittää toimintaansa niin, että se hyödyntää koko asiakas-toimittaja-verkkoa.

## **OPENING WORDS**

This thesis has been a result of numerous of hours spent on the literature and practical findings. The finishing of the thesis certainly was much harder than expected and it wouldn't have been possible without my lovely and wonderful wife Veronika, who gave me a huge amount of support and courage to accomplish this project. For the support and patience she gave me, I will be always grateful to her! Special thanks also goes to parents Boris and Irina, and to my brother Kari, who have all supported me throughout these years!

From Lappeenranta University of Technology I would like to thank my professor Tuomo Kässi for providing me his assistance and the idea of using analytical hierarchy process in the thesis.

I feel also very privileged to be able to work with all of the great people inside EADS Secure Networks Oy. Hannu Heikkinen, Sami Heteaho and Michel Gapin have provided me their valuable knowledge and support throughout the whole project and without their contributions this thesis wouldn't have been possible. Thank you!

Inside EADS Secure Networks my special thanks also go to Tommy Fjällberg, Marko Hakkarainen, Ilona Jämsä, Hannele Kananen, Petri Laitinen, Virva Liimatainen, Tuomas Syrjänen and Mark Vrieling for assisting me in acquiring all the needed information for the thesis!

In Helsinki, 02.02.2009.

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## **ABBREVIATIONS**

AHP	Analytical Hierarchy Process
ALD	Average Late Days
BPB	Best Practice Benchmarking
CEO	Chief Executive Officer
CPM	Customer Perception Measurement
CRD	Customer Request Date
DOA	Dead On Arrival
DQA	Defect in Quality on Arrival
EDI	Electronic Data Interchange
ETSI	European Telecommunications Standards Institute
FEAHP	Fuzzy Extended Analytical Hierarchy Process
ISO	International Organization for Standardization
KPI	Key Performance Indicator
MAUT	Multiattribute utility theory
OPD	Original Promised Date
P25	Project 25 or APCO-25. Suite of standards for Digital Radio
PAMR	Public Access Mobile Network
PMR	Professional Mobile Radio
R&D	Research and Development
RFID	Radio Frequency Identification
ROA	Return On Assets
TAT	Turn Around Time
TETRA	Terrestrial Trunked Radio
TETRAPOL	Digital Professional Mobile Radio standard

# **1 INTRODUCTION**

This introduction chapter is going to give some background information about the subject and describe the reasons why it is important. Later on will be described objectives and limitations to the thesis as well as description about each of the chapters.

## **1.1 Background**

During the past decades there has been an increasing trend to outsource some of the production of the final product to some suppliers. The outsourcing of the production rate has been increasing and due to that there has been also developing an increasing need to evaluate the suppliers from many different aspects using different analytical methods. The supplier evaluation is a field which has increased its importance over the years as they provide valuable information about the suppliers and help the customers to perform supplier management.

As the supplier evaluation has become more and more important factor for the supplier management, there has been also an increasing amount of methods used for measuring the suppliers performance. These methods can consist of hard quantitative information or the methods can be also qualitative by their nature.

The case company of this thesis is EADS Secure Networks which offers a high quality mission critical products, systems and services to its customers. Due to the outsourcing of the production, EADS Secure Networks has faced an increasing need to evaluate the state of its key suppliers. The result of the evaluation should help the company to develop its supplier's strengths and proactively help address the weaknesses of the suppliers.

EADS Secure Networks has seen that it would need a supplier evaluation which would evaluate different parts of the suppliers. To be able to accomplish this goal in a balanced way it was decided that the evaluation would be performed with a tool called analytical hierarchy process. This tool would be an ideal selection for the supplier evaluation using quantitative and qualitative information.

## **1.2 Objectives and limitations**

The main goal of this thesis is to execute supplier evaluation using analytical hierarchy process, provide the analysis about the state of each supplier and suggest improvements for each of them.

To be able to compare suppliers with each other there is going to be gathered a large number of data about the suppliers. This data will be quantitative and qualitative and will be gathered from both external and internal sources. The data will be used later on to build up different matrixes used in analytical hierarchy process. Due to different confidentiality and security reasons the data which is gathered during the research is not going to be revealed in public use.

As EADS Secure Networks is a large and multinational company producing different PMR products, it was decided that the supplier evaluation will be performed only to EADS Secure Networks Oy which is concentrating on the TETRA-standard. Inside EADS Secure Networks it was noticed that there are five suppliers which are playing a bigger role than the others. This thesis will be therefore concentrating in the evaluation of the five most critical and important suppliers.

The usage of analytical hierarchy process model also creates its own limitations to the thesis. The analytical hierarchy process model will compare the suppliers only against each other rather than against some fixed grade. Therefore the results

achieved in the end can give only a clue about the weaknesses and strengths of each of the suppliers compared to each other.

### 1.3 Structure of the thesis

The following chart 1 will show the input and output for each of the chapters.

Chart 1: Input-output chart.

<b>Source information</b>	<b>Name of the chapter</b>	<b>Output</b>
Introduction to the purchasing	Purchasing	Purchasing - Definition - Objectives - Function - Process - Additional value
Knowledge of purchasing and supplier management	Measuring the suppliers quality and performance	Knowledge about - Suppliers quality - Suppliers performance - Forecasts and their effects towards suppliers
Information about supplier evaluation	Analytical hierarchy process	Knowledge of analytical hierarchy process and - Structure - Calculation - Criticism - Supplier evaluation
Theoretical background about suppliers, purchasing, quality, performance, forecasts and analytical hierarchy process	Case: EADS Secure Networks Oy	Executed supplier evaluation for EADS Secure Networks key suppliers
Results about supplier evaluation	Discoveries made about suppliers and EADS Secure Networks	Analysis about suppliers and conclusions about supplier evaluation

This thesis is going to be building up from five different chapters which are going to give a reader a solid knowledge about supplier evaluation performed at EADS Secure Networks. In the beginning of the thesis is going to be described the meaning of purchasing and what kind of objectives it currently has. This chapter is going to give the reader a knowledge about purchasing and its relation to suppliers.

The next chapter is going to concentrate on the more on the suppliers quality and performance aspects. The chapter is going to give information about the definition of performance and quality as well as showing how these terms are understood in the literature. This chapter is also going to introduce forecasting to the reader and describe how it is used in the customer – supplier field. By understanding all of the performance and quality aspects, it is going to be easier to build up a harmonized supplier evaluation model which would note many different criterias.

The next chapter will be introducing the analytical hierarchy process to the reader. The chapter will be going through the definition of the analytical hierarchy process model and show what kind of criterias there are for a good model. The later part of this chapter will be showing how the analytical hierarchy process is used in practise and what kind of limitations it has.

The next chapter is going to be the starting point for the practical part of the thesis. It will be introducing the case company EADS Secure Networks for the reader and describe the business it is involved in. This chapter will also show to the reader what kind of process is used for supply chain management inside EADS Secure Networks and also address the importance of the forecasting to the company. In the later part of this chapter will be performed all the calculations needed for supplier evaluation and the end result will be a table showing the best supplier by each of the main criteria.

After the AHP calculations have been made, the last chapter is going to show the conclusions about the supplier evaluation. The chapter will start by analyzing the strong and weakpoints of each supplier and describing how the performance could be enhanced. The later part of the chapter will be also describing the procedures used at EADS Secure Networks and comment about the changes needed also inside the company for a better supplier performance in the future.

## **2 PURCHASING**

There are many different functions in organizations and one of them is purchasing. But what exactly is purchasing involved in? How is it defined in the literature? What kind of objectives the purchasing have? What kind of purchasing functions, processes and the organizations usually have and what kind of additional value it creates? These are the topics that this chapter will try to address and provide answers to.

### **2.1 Basic definition of purchasing**

Purchasing is one of the basic functions of each company and it is essential for a company to work in its business environment. But what would be a good definition for the purchasing function? There is no correct answer for this question as there are many different definitions for it and they also try to complete each other. However it is often said that the objective for the purchasing is "to acquire the right quality of material, at the right time, in the right quantity, from the right source, at the right price". (Baily, 2005, p.3) Though this definition is describing the basic principle of the purchasing it also simplifies the whole process too much as it is very hard to actually say what kind of quality is the "right quality" for the product. Also how can one really say what could be the "right price" for the product or service? If the price would seem to be "right" for the supplier it doesn't automatically mean that it is also the "right" price from the buyer's point of view. Therefore it is also good to take a look for the more concrete definitions and objectives for the purchasing.

## 2.2 The objectives of purchasing

This chapter will be concentrating in finding the key objectives purchasing function has in the company. There will be also description of the the strategic roles the purchasing has as well as some key questions which the purchasing managers are dealing with in the current moment.

### 2.2.1 The key points in purchasing

In addition to the definitions mentioned above it is good to take a look to the different objectives set for the purchasing function and process. Robert Monczka et al. have approached the defining the purchasing process by using the model of six objectives set for purchasing function. These objectives are described in their book of Purchasing and Supply Chain Management. These objectives can also be seen as the basis for the definition of purchasing and are therefore important to understand.

**The first objective** which is described by Monczka et al. is that purchasing must support operational requirements. This means that purchasing should be able to provide the goods, services and other requirements to the internal customers who are working within the company. Also it is important for purchasing function to take care of the daily purchases of basic components, raw materials and such to support the continuing of the daily functions. If the purchasing function fails to comply its internal customer with these basic needs it might also create a situation where the internal customer will start to negotiate directly with the supplier passing the purchasing function. (Monczka, 2005, p.30–31)

**The second objective** for the purchasing function is to manage the purchasing process efficiently and effectively. This objective can be managed by determining the right staffing levels, developing and adhering to administrative budgets and providing some professional training with different kind of career opportunities for the employees. Efficiency and effectiveness can be also be achieved when

purchasing improves the systems which are in the background of the decision making and productivity improvements. (Monczka, 2005, p.31)

**The third objective** which Monczka et al. describe is related to supply base management. The supply base management can be seen to consist of three different factors of supplier excellence which are

- to ensure the competitiveness of the current supplier
- to identify any new potential supplier who would like to have any closer relationships
- to improve the competitiveness of the current suppliers

(Monczka, 2005, p.31–32)

**The fourth objective** described by Monczka is the need for purchasing to develop strong relationships with other functional groups. This has become a very important factor during the 1990s when the meaning of cross-functional communicating was understood. This means that for purchasing it is important to communicate with different internal customers and marketing to ensure that the quality and pricing of the products will be at the right level. (Monczka, 2005, p.32)

**The fifth objective** identified by Monczka is the need to support organizational goals and objectives. It has been identified as the most important objective of the purchasing as it implies that purchasing has the ability to affect the total performance of the organization. If purchasing does succeed in this matter it will create a powerful competitive advantage for the whole organization against its rivals. (Monczka, 2005, p.32)

**The sixth objective** of purchasing is to develop integrated purchasing strategies that support organizational strategies. This objective can be seen a bit more wider than the previous-ones and it also requires that the top management is looking at the purchasing in the right way. If it is seen as a vital function which can bring a

benefit for the company and the needs of purchasing is included in the strategies of the whole organization, the outcome will be benefitting the whole company. Purchasing department can also actively get involved with corporate planning process and provide its knowledge about supply-market and contribute to the strategic planning. (Monczka, 2005, p.32–33)

Peter Baily & et al. have described in the book of Purchasing Principles and Management a more modern view about the purchasing. Baily has suggested that the purchasing consist of five basic points. (Baily, 2005, p.4)

**Purchasings five basic points:**

- To supply the organisation with a flow of materials and services to meet its needs.
- To ensure continuity of supply by maintaining effective relationships with existing sources and by developing other sources of supply either as alternatives or to meet emerging or planned needs.
- To buy efficiently and wisely, obtaining by an ethical means the best value for every pound spent.
- To maintain sound co-operative relationships with other departments, providing information and advice as necessary to ensure the effective operation of the organisation as a whole.
- To develop staff, policies, procedures and organisation to ensure the achievement of the objectives.

Baily also describes that there could be also some more specific objectives in addition for the above. For example the purchasing objectives could include the selection of the best suppliers in the market and also the monitoring for the supply market trends. However the five bullet points shown above are the most critical and the main attention should be drawn to them. (Baily, 2005, p4)

Leenders et al. have described their view of the objectives of the purchasing and found that there are a total of nine different objectives for purchasing to handle.

**The nine objectives are:**

- 1) Provide an uninterrupted flow of materials, supplies, and services required to operate the organization.
  - 2) Keep inventory investment and loss at minimum.
  - 3) Maintain and improve quality.
  - 4) Find and develop competent suppliers.
  - 5) Standardize, where possible, the items bought.
  - 6) Purchase required items and services at lowest total cost.
  - 7) Achieve harmonious, productive working relationships with other functional areas within the organization.
  - 8) Accomplish the purchasing objectives at the lowest possible level of administration costs.
  - 9) Improve the organization's competitive position
- (Leenders, 2002, p.41–43)

### 2.2.2 Purchasing two strategic roles

Axelsson and Håkansson have identified in their researches that purchasing can be summarized into two different strategic roles: the rationalization role and the development role. (Håkansson, 2001, p.8)

**The rationalization role** can be seen as the daily work for purchaser where he will try to decrease the costs for the company by introducing some cost-saving solutions from the technical point of view or by commenting how the goods are produced or delivered. Inside rationalization role, purchaser may have three main types of roles of which the first comes to questions: what needs to be purchased, should it be purchased or manufactured in-house, how to increase effectiveness by desing, how to react to development and production changes? (Håkansson, 2001, p.8–9)

The second role comes to rationalizing the logistical flow and it includes well timed manufacturing and distribution. The third rationalization role for purchaser includes developing procurement routines which includes not only optimizing one single purchase, but the whole buying routine. (Håkansson, 2001, p8–9)

**The development role** is the second strategic role identified by Axelsson and Håkansson. This role has increased its value over time as it has been discovered that suppliers can also provide important resources for technical development. This path usually takes to a closer relationship between buyers and suppliers R&D functions. Supplier development is also an important factor when companies try to shorten the lead times and reducing the costs of final product as studies show that more than 80 % of total cost of new products are determined in the designing phase. (Håkansson, 2001, p.9–10)

### 2.2.3 Key questions for purchasings decision makers

Leenders et al. have made many books and articles about purchasing and according to them from the decision makers inside the purchasing function can be asked some key questions which can then show the benefits and credits of purchasing.

**The key questions** according to Leenders et al. are:

Should we:

- Measure how purchasing affects efficiency and effectiveness in our organization?
- Develop an in-house training program
- Calculate the effect on our organization's ROA at various purchasing savings levels

How can we:

- Get top management to recognize the profit-leverage effect of purchasing/supply management?
- Determine appropriate salary levels for our purchasing personnel?
- Show how supply can affect our firm's competitive position?

(Leenders, 2002, p.2)

The last three questions are quite common in the current state of the purchasing, as the top management still is not recognizing the full potential of the purchasing organization inside the company. This same issue will be also addressed later in the following chapters as it is one of the future points that should be carefully analyzed and changed.

### **2.3 The purchasing function**

The purchasing function can be seen as a context which includes several different points which are acquiring raw material, components, goods and services for conversion, consumption or resale. In addition to this, there is also a different purchasing department which is supposed to carry out this function. However there is an increasing trend so that purchasing would be a part of a larger group such as materials, logistics and supply chain. (Lysons, 2006, p.4)

Purchasing function also has various different responsibilities. In a modern global world which requires fast actions, purchasing should have people in its function who have the ability to take the responsibility of the purchasing action which is also referred as span of control. According to Monczka et al. the most critical responsibility of the purchaser is to evaluate and select suppliers. This often requires also a help from different departments to determine the quality of the products. The second important responsibility of the purchaser is to review material specification. This is not always an easy task as it requires a lot of resources from the purchaser to study carefully the products and to determine their

requirements. This is also an area in which the purchaser might be involved in a conflict between the engineering department, because he/she has the right to question how the product works and what it requires. (Monczka, 2005, p.33).

Leenders et al. have also identified nine key tasks in which the purchasing should be deeply involved. The most obvious of them is of course the buying which can include contract making, managing the key purchasing processes and so on, but purchasing should be also having more involvement in purchasing research. The purchasing research is a more strategic approach in where the purchasing is trying to be more involved in identifying better supply management techniques, identifying long term market changes and other trends. The inventory control and transportation management are more traditional purchasing areas, but environmental tasks are on the other hand just entering to the world of purchasing. Leenders et al. also say that forecasting and planning, outsourcing and subcontracting are something that should be having more purchasing involvement in the present and the future. Also purchasing should be taking much more involvement in the non-traditional production or service purchases to create more cost savings as well as handling the supply chain management. (Leenders, 2002, p.55)

One of the historical parts of purchasing and supplier relationships is that the supplier should be in contact with the purchaser. In a modern world, the flow however moves as well the other way around and the purchaser is seen as a person who needs to contact its suppliers. Also it is not prohibited that some other persons from firm are contact with the supplier. As a last responsibility towards a supplier is to determine how the purchasing can determine the awarding of the purchase contracts. The methods which are commonly used are competitive bidding, negotiations or a combination of these two. The most important thing here is that though other people can or might be involved in this, the purchasing should always be the one which leads the overall process and negotiates about the prices. (Monczka, 2005, p.34)

During the recent years purchasing has increased its role inside the company and also showed that by using its potential, company can achieve significant cost reduction as well as increased customer satisfaction. The time where purchasing was responsible only for the purchases is over and the newest trends show that purchasing is more and more involving into the strategic planning inside the company. Karrus has described quite well the development of purchasing through out the years and it can be seen in the figure 1. This figure shows that purchasing is going to be headed more and more towards managing the external resources and developing the supplier network which should be then be able to respond to more increased customer demands. (Karrus, 1998, p.205–206)

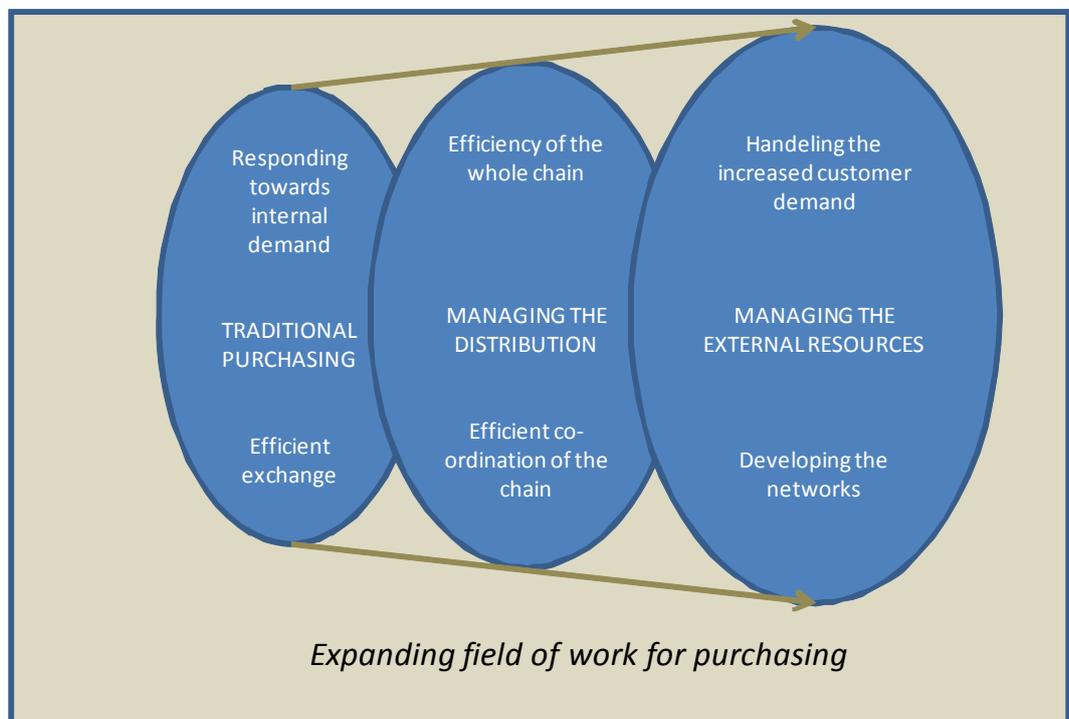


Figure 1. Figure shows how the field of work has expanded for the purchasing (Karrus, 1998, p.205–206)

Leenders et al. have taken a role of showing the increasing importance of purchasings and supply managements in the coming decades. They have listed six points which they think will be the key points which purchasing would be facing: (Leenders, 2002, p.28)

**1) Business-to-Business E-Commerce:** A new era of advanced technological tools is entering the markets relating to the business-to-business transactions. These tools can help supply managers to streamline the purchase of lower-value and lower-risk goods through the supply chain which would help them to free up their time to more strategic matters. (Leenders, 2002, p.28–29)

**2) Supply chain management:** Organizations would need to produce their products or services more effectively and this causes the pressure to the key suppliers in terms of deliveries, innovative design, production, new ideas, etc. The co-operation throughout the whole supply chain must be pushed all the way down to the last supplier to achieve more effective results on supplier's total performance. (Leenders, 2002, p.29)

**3) Measurement:** At the moment many of the purchasing measurements are not accurate enough for senior management. This is due the complex nature of purchasing and supply management. A newer and better measurements need to be done so that purchasing would receive the desired recognition. (Leenders, 2002, p.29)

**4) Purchase of non-traditional goods and services:** Traditionally purchasing has been dealing mostly with raw materials, special and standard production items, maintenance, repair and operating supplies. Many more non-traditional purchases such as real estate, resale items, advertising, health benefits and such should be also assigned to purchasing. This would increase dramatically the savings potential inside the company. (Leenders, 2002, p.29–30)

**5) Contribution to corporate strategy:** Although purchasing is responsible of handling very large sums of money it would seem clear that it would be also involved in corporate strategic planning. At the moment this is not the case and the purchasing should have an increased role/responsibility/involvement in such activities as corporate mergers/acquisitions/alliances, technology planning, new product development, etc. (Leenders, 2002, p30)

**6) Recognition by senior management:** "We don't get any respect!" is an often phrase you can hear from the purchasing department. The future challenge for the purchasing function is to provide a better understanding to the CEO-level what purchasing can do and what it is actually doing. This way it can increase its influence inside the company. (Leenders, 2002, p.30)

## 2.4 The purchasing process

There are quite many different ways to describe the basic purchasing process. Maybe one of the most common descriptions is done by Kenneth Lyons and Brian Farrington in the book of Purchasing and Supply Chain Management. The purchasing process described by them is based on various sub processes which create the purchasing process chain. This process chain can also be viewed by a series of different information of what should be done next. The purchasing process chain described by Lyons is shown below in figure 2. (Lyons, 2006, p.4)



Figure 2. The purchasing process chain (Lyons, 2006, p.4)

As it can be seen from the figure 2 the basic purchasing process chain is quite simple and is easy to handle. It is divided only into six different sections from which the first two points can be seen to be a part of order-receiving. The negotiation with the suppliers and placing the order can be seen as the second category which is related for the order placing towards the supplier. The receiving the supplies and making the payment can be seen as the third category which is related to the finalization of the order towards supplier. (Lyons, 2006, p.4)

The process which is described in figure 2 is a very abstracted kind of process. Leenders et al. have described a bit more wider process which includes more than just the simple purchasing performed in companies. According to Leenders et al. there are nine essential steps which need to be taken before the purchasing and supply management process can be complete. The figure 3 below represents the nine steps which are to be taken in the more advanced purchasing process. (Leenders, 2002, p.80)

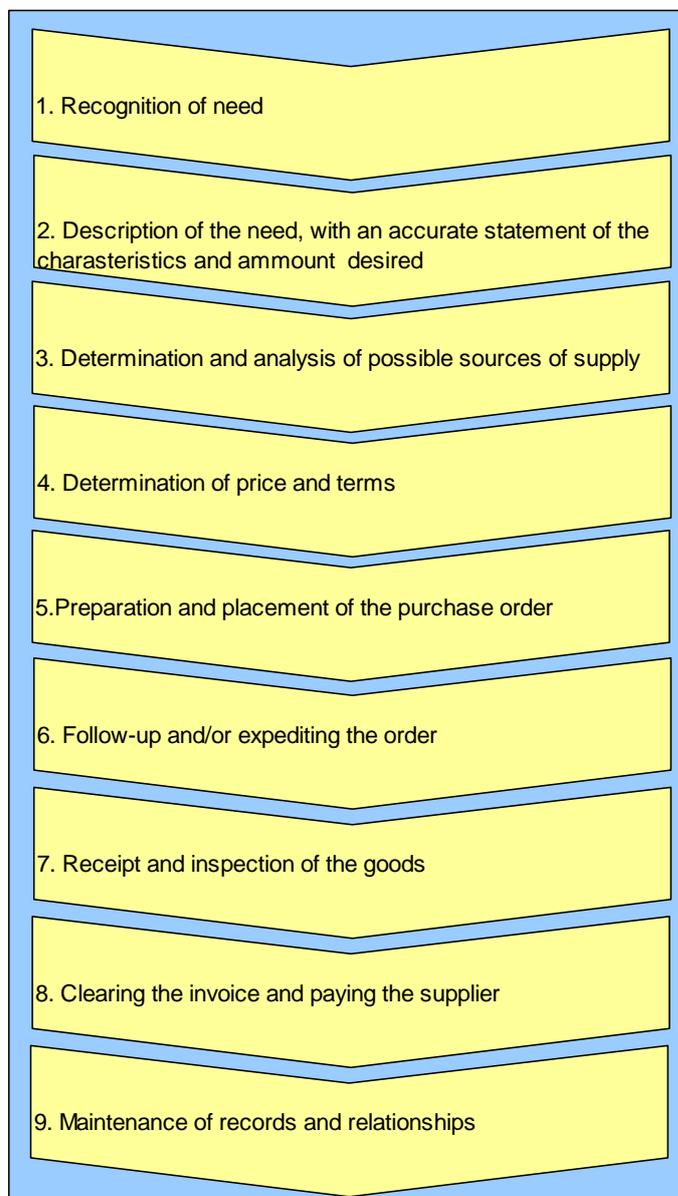


Figure 3. Advanced purchasing process. (Leenders, 2002, p. 80)

Though the principle of this purchasing process is simple, it should be also noted that for example figure 2 is also a quite heavy abstraction of the whole purchasing process chain. A better understanding of the complexity of the purchasing process and its many sub processes can be seen on Monczkas purchasing process which describes a more detailed version of the same process, although more details can always be added to this process too. This Monczkas process also takes to account the newest possibilities of the e-procurement which means making the traditional way of purchasing in the electronic form with all the electronic documents. Monczkas purchasing process is described below in figure 4.

According to Monczkas process there are 6 steps in the purchasing process and they are:

- Identify user need for product or service
- Evaluate potential suppliers
- Bidding negotiation and supplier selection
- Approve purchase
- Release and receive purchase requirements
- Measure supplier performance

(Monczka, 2005, p.35)

The process itself is looking very similar to the process shown in figure 2 although the newer process is also taking a more modern view of the purchase so that the work with the supplier does not end in the payment part, but it still continues in measuring the supplier's performance and therefore providing some data to management also.

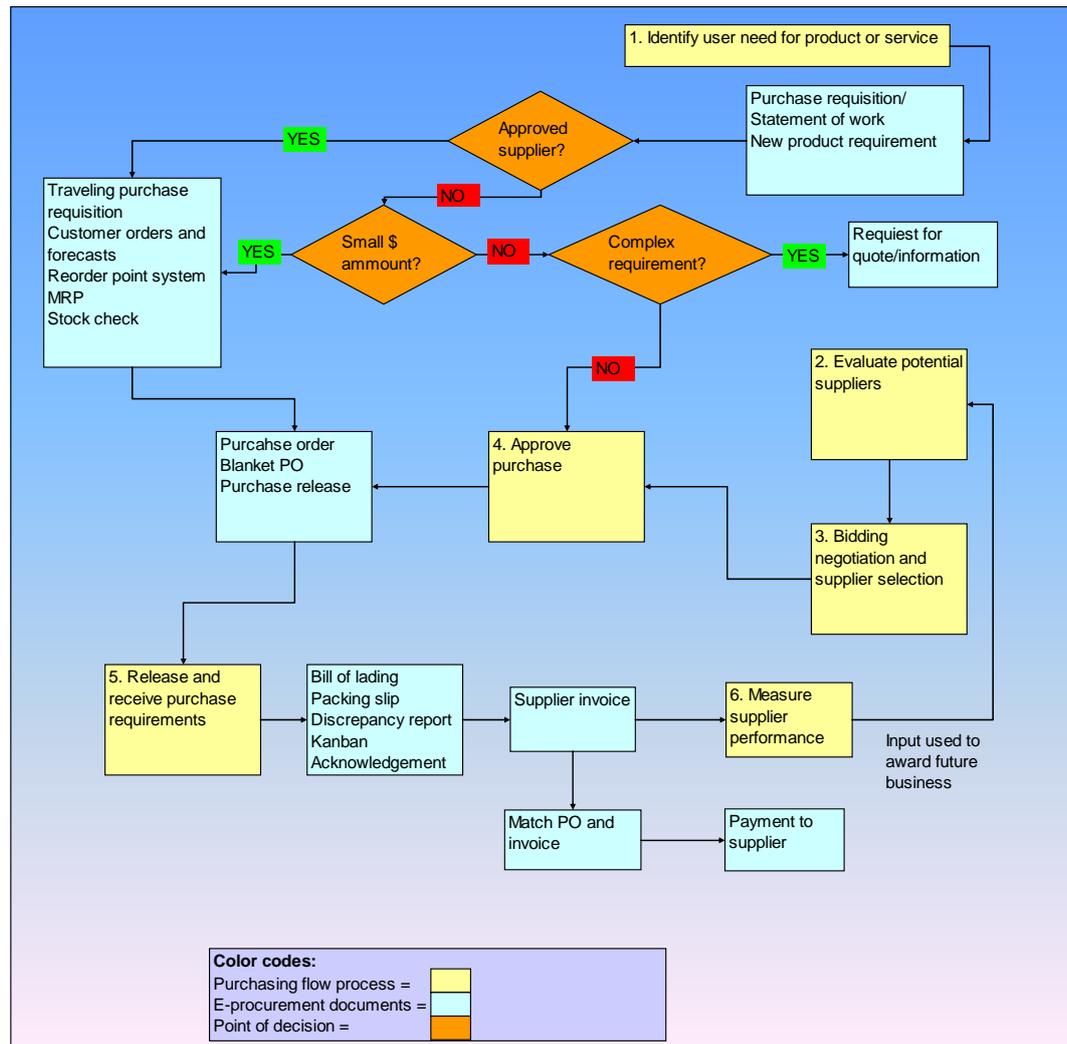


Figure 4. The purchasing process according to Monczka (Monczka, 2005, p.35)

## 2.5 Additional value created by purchasing

As described in the earlier chapters, purchasing has been earlier seen only as function that creates additional costs for the company. This kind of approach is old and doesn't show the real value which purchasing brings to the company. Koskinen describes well that the real value of the purchasing function comes from its responsibility to be in the frontline of the company's development. The role of the purchaser has grown from creating a cost to being able to see different kind of visions and develop and accomplish them to customer friendly solutions. Table 1

below shows the different kind of visions which purchasing has in the larger timeframe. (Koskinen et al., 1995, p.24–26)

Table 1: Different visions and purchasing actions (Koskinen et al., 1995, p.26)

<i>Purchasing to be part of</i>	<i>Time frame</i>	<i>Action</i>
Market-vision	For next 5-10 years	- Sourcing new technologies and anticipate them
Business-vision	For next 3-5 years	- Companies role as a part of network - Acquiring new technologies
Company-strategy	For next 1-3 years	- Develop co-operation - Create a sourcing strategy
Manage purchasing	Now	- Selecting supplier - Buy or manufacture - Cost, quality, time

A more modern way to look of purchasing is looking it through value adding factors. The value which it creates can be seen through the following figure 5. According to it, by reducing the costs of goods it the profitability of the company can be improved. By achieving this, purchasing function also creates value addition by enhancing the satisfaction of the customer which can be seen also by lower cost of the final product. (Koskinen, 1995, p. 26–27)

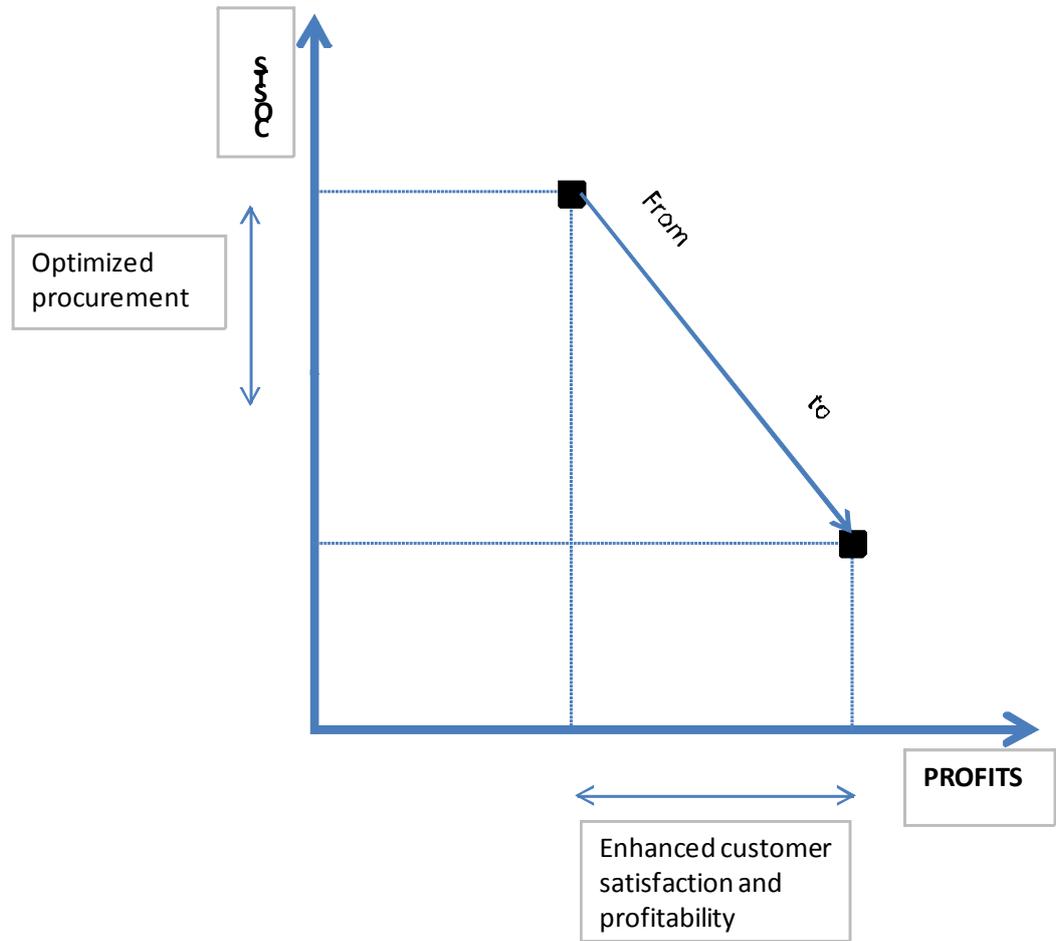


Figure 5. Achieved profitability by purchasing. (Koskinen, 1995, p.27)

### **3 MEASURING THE SUPPLIERS QUALITY AND PERFORMANCE**

The usual way to look at the supplier goes through the quality and the performance delivered by the supplier. However the terms quality and performance are two very different areas of study and should be carefully analyzed and defined. This chapter also provides some information about the forecasting which is an essential tool to achieve a good performance in supplier network.

#### **3.1 Quality**

This chapter will address the different parts of the quality. The main points in this chapter are the nature of the quality and definition of the quality.

##### **3.1.1 The nature of quality**

In his researches Garvin has identified five approaches for defining the nature of the quality and eight dimensions of what quality can be understood to be.

The quality is not something that can be defined very easily and it can be understood to be many different points and include several of different criteria. Garvin has made it also clear that quality doesn't have any single nature, but the definition of quality can be often understood by observing the nature of the quality in which the definition has been made. According to Garvin there are total of five different approaches to this question and the quality approaches can be seen below. (Lysons, 2006, p.266)

The five approaches of quality definition are:

1) **The transcendent approach:** quality is absolute and universally recognisable. The concept is loosely related to a comparison of product attributes and characteristics.

2) **The product-based approach:** quality is a precise and measurable variable. In this approach, differences in quality reflect differences in the quantity of some product characteristics.

3) **The use-based approach:** quality is defined in terms of fitness for use or how well of the product fulfils its intended functions.

4) **The manufacturing-based approach:** quality is "conformance to specifications" – that is, targets and tolerances determined by product designers

5) **The value-based approach:** quality is defined in terms of costs and prices. Here, a quality product is one that provides performance at an acceptable price or conformance at an acceptable cost.

(Lysons, 2006, p.266)

As it can be seen from all of these natures quality has, it is easy to understand why the definitions of quality can overlap or even be in a conflict with each other as it can be seen in the next chapter 3.1.2. There are many factors starting from segmental factors and product changes which might affect the total quality in many ways and therefore all the natures of the quality should be well understood when the quality measurements are made. Also the overall quality should also take to account as many as possible of the qualities natures.

(Lysons, 2006, p.266)

### 3.1.2 The understanding and definition of the quality

Quality is a word which can be understood in many different ways and therefore it depends on the context what it includes. Bialy has described that quality is often understood to be "whatever the customer says it is" and has described that it is enough to define quality to be "as the whole set of features and characteristics of a product or service that are relevant to meeting requirements. (Baily, 2005, p.108)

Robert Monczka quoted several different total quality management experts who have described that the most important function of quality is to meet customer's demands. However according to Monczka this is not entirely the case anymore in a modern way of thinking about the quality. At the moment it is more popular to think that quality is not only meeting the requirements or expectations of the customer, but to actually exceed them. (Monczka, 2005, p.239)

Monczka has also made an important note about the relationships between purchaser and the supplier affecting the quality of the service or item bought. An old way of thinking about acquiring item or service was that the purchaser is the king and he can act like one towards his suppliers. This kind of selfish way of looking at the purchasing doesn't create a supportive atmosphere for the supplier to make the best effort towards the customer. So according to Monczka's view it is also very important for the purchaser and the supplier to create an atmosphere which has a customer-supplier relationship, but also to create an atmosphere where both parties enjoy making business with each other. A fruitful atmosphere between both parts is the one to create good quality products as both parties expect it because of their special relationship. (Monczka, 2005, p.240)

Garvin has (according to Lysons) quoted that quality is not forming up from any single point, but it can be a combination of many aspects. Garvin comments that the quality can consist from the following eight points:

- Performance – It is understood to be the product's operating characteristics
- Reliability – The reliability has been determined to be the probability of a product surviving for a specified period of time under stated conditions of use
- Serviceability – The speed, accessibility and ease of repairing the item or having it repaired
- Conformance – Measures the profected use available from the product over its intended operating cycle before it deteriorates
- Durability – Measures the profected use available from the product over its intended operating cycle before it deteriorates
- Features – "The bells and whistles" or secondary characteristics that supplement the product's basic functioning
- Aesthetics – Personal judgements about how a product looks, feels, sounds, tastes or smells
- Perceived quality – Closely identified with the reputation of the producer and, like aesthetics, it is personal evaluation.

(Lysons, 2006, p.266)

According to Lysons it is commonly noted that the most common factors mentioned in the Garvin's eight quality points are the performance, reliability, conformance and serviceability. In addition to the Garvin's eight quality dimensions Lysons also suggest that "the right quality" also includes following factors (Lysons, p.266–267):

1) Price – as the competitive selling price of the product in which the item is to be incorporated will determine the prices paid for bought-out items. (Lysons, p.266–267)

2) Customer specifications – or those laid down by statutory or similar organisations. (Lysons, p.266–267)

3) Durability – this influences the quality specifications for components as, if the expected life of the final product is only three years, for example, there is a little point in incorporating a component with a life of five years where cheaper alternatives are available, though the reputation of the product must, however, be a paramount consideration. (Lysons, p.266–267)

### **3.2 Performance**

This chapter will describe the nature of performance measurement, the internal performance measurement and the external performance measurement. It also will take a look about what kind of different ways are there to measure performance, are there any differences between them and what kind of characteristics does a good performance indicator have.

First of all we can take a look at the different points of measuring the performance. Companies measure the performance of their supply chain and their suppliers in a different way and with different kind of meters. There are no simple ways to describe why has the performance field become so wide, but it might be due to the fact that there are so many ways to measure the different variables which come up in different part of the logistic flow.

The supplier performance is something that every organization with suppliers should be doing. It is one of those key elements which show the true performance of the supplier and also show the purchaser's organization the true capability of its supplier. Robert Monczka has described that “supplier performance measurement includes the methods and systems to collect and provide information to measure, rate, or rank supplier performance on a continuous basis“. (Monczka, 2005, p.269–270)

### 3.2.1 The correct points of performance measurement

One of the interesting questions in performance measurement is the decision what to measure. It is not an easy task to decide the functions which are under measurement as criteria can also vary the difficulties of measurement and also the relevance of measurement.

Monczka has divided the ways to measure into three different categories which are the delivery performance, quality performance and cost reduction. These are usually also factors which can be described to be more quantitative factors, but in addition there are also various factors which can be taken into use from the qualitative side. According to Monczka the following qualitative service factors shown in table 2 could be used for more wider performance measurement: (Monczka, 2005, p.269–270)

Table 2: Qualitative Service Factors (Monczka, 2005, p.270)

<i><b>Factor</b></i>	<i><b>Description</b></i>
Problem Resolution Ability	Supplier's attentiveness to problem resolution
Technical Ability	Supplier's manufacturing ability compared with other industry suppliers
Ongoing Process Reporting	Supplier's ongoing reporting of existing problems or recognizing and communicating a potential problem
Corrective Actions Response	Supplier's solutions and timely response to requests for corrective actions, including a supplier's response to engineering change request
Supplier Cost-reduction Ideas	Supplier's willingness to help find ways to reduce purchase cost

Supplier New-Product Support	Supplier's ability to help reduce new-product development cycle time or to help with product design
Buyer/Seller Compatibility	Subjective rating concerning how well a buying firm and a supplier work together

There are also many other researchers who have also tried to identify the best ways to identify the ways to perform the performance measurement. John Coyle has for example divided the supplier performance measurement into 4 different categories which are based on time, quality, cost and other/supporting functions. In the table 3 below are shown details of this deviation. (Coyle, 2003, p.490)

Table 3: 4 different categories of performance measurement according to Coyle et al. (Coyle, 2003, p490)

Way of measurement	Detailed description
Time	<ul style="list-style-type: none"> <li>-On-time delivery/receipt</li> <li>-Order cycle time</li> <li>-Order cycle time variability</li> <li>-Response time</li> <li>-Forecasting/planning cycle time</li> </ul>
Quality	<ul style="list-style-type: none"> <li>-Overall customer satisfaction</li> <li>-Processing accuracy</li> <li>-Perfect order fulfilment</li> <li>-Forecast accuracy</li> <li>-Planning accuracy</li> <li>-Schedule adherence</li> </ul>

Cost	<ul style="list-style-type: none"> <li>-Finished goods inventory turn</li> <li>-Days sales outstanding</li> <li>-Cost to serve</li> <li>-Cash-to-cash cycle time</li> <li>-Total delivered cost</li> <li>-All other costs</li> <li>-Cost of excess capacity</li> <li>-Cost of capacity shortfall</li> </ul>
Other/supporting	<ul style="list-style-type: none"> <li>-Approval exceptions to standard</li> <li>-Availability of information</li> </ul>

Coyle describes that there are at least 10 different factors which should be taken to account when thinking about the different ways to measure the performance of supply chain or supplier. These factors are shown in a table 4 below. The factors show that a good way to measure performance is to take a wide and efficient view of the subject and describe the results as easily as possible. (Coyle, 2003, p.486)

Table 4: 10 key factors for performance measurement (Coyle, 2003, p.486)

<b><i>A Good Measure</i></b>	<b><i>Description</i></b>
- is quantitative	The measure can be expressed as an objective value.
- is easy to understand	The measure conveys at a glance what it is measuring, and how it is derived.
- encourages appropriate behaviour	The measure is balanced to reward productive behaviour and discourage "game playing".
- is visible	The effects of the measure are readily apparent to all involved in the process being measured.

- is defined and mutually understood	The measure has been defined by and/or agreed to by all key process participants (internally and externally)
- encompasses both outputs and inputs	The measure integrates factors from all aspects of the process measured.
- measures only what is important	The measure focuses on a key performance indicator that is of real value to managing the process.
- is multidimensional	The measure is properly balanced between utilization, productivity, and performance, and shows the trade-offs.
- uses economies of effort	The benefits of the measure outweigh the costs of collection and analysis.
- facilitates trust	The measure validates the participation among the various parties.

### 3.2.2 Internal performance measurement

According to Bowersox the internal performance measurement consists of 5 different categories which are cost, customer service, productivity, asset management and quality. Below are assembled a short descriptions about each of these categories and also an example of the performance indicators related to them. (Bowersox, 1996, p.671)

1) Cost: This is maybe the most direct way to measure the performance as it reflects the cash spent to accomplish certain logistical objectives. The most common performance indicators related to to cost are:

- Total-cost analysis
- Cost per unit
- Cost as a percentage of sales
- Inbound freight
- Outbound freight
- Warehouse costs
- Administrative costs
- Order processing
- Direct labour
- Comparison of actual vs. budget
- Cost trend analysis
- Direct product profitability (Bowersox, 1996, p.671–672)

2) Customer Service: customer service has a very clear function and it is to satisfy the needs of the customer. This is not always easy, but it is one of the factors which needs to be taken to account when measuring the internal performance. The common performance measurement categories for customer service are:

- Fill rate
- Stock outs
- Shipping errors
- On-time delivery
- Back-orders
- Cycle time
- Customer feedback
- Sales force feedback
- Customer surveys

(Bowersox, 1996, p.672)

3) Productivity: Productivity is a way to measure the organizational performance and it is seen as the most critical performance measurement category. It consists of different types of relationships between input data and output data. Productivity can be measured with following measures:

- Units shipped per employee
- Units per labour dollar
- Orders per sales representative
- Comparison to historical documents
- Goal programs
- Productivity index

(Bowersox, 1996, p.672–673)

4) Asset management: asset measurement and management gives a company information about "the utilization of capital investments in facilities and equipment as well as working capital application to inventory to achieve logistics goals". The following categories can be used to measure the performance of asset management:

- Inventory turns
- Inventory carrying costs
- Inventory levels, number of days' supply
- Obsolete Inventory
- Return on net assets
- Return on investment

(Bowersox, 1996, p.673)

5) Quality: quality can be seen in this matter as an measurement of effectiveness to many different activities and therefore it measures many points at the same time. It is also a good indicator of the overall performance for the supplier. Quality can be measured with the following measures:

- Frequency of damage
- Dollar amount of damage
- Number of credit claims
- Number of customer returns
- Cost of returned goods

(Bowersox, 1996, p.674)

From quality point of view the best kind of quality for an order can be achieved by delivering so called "perfect order". The concept of perfect order can be understood so that it consists of four different factors and if the order fulfils all the four needs, it can be seen as "perfect". (Bowersox, 1996, p.674–675)

The 4 demands towards perfect order are:

- 1) Complete delivery of all items requested
- 2) Delivery to customer's request date with one-day tolerance
- 3) Complete and accurate documentation supporting the order, including packing slips, bills of lading, and invoices
- 4) Perfect condition

(Bowersox, 1996, p.674–675)

### 3.2.3 External performance measurement

In addition to the internal performance one can also measure the external performance of the company. Bowersox describes that this is done best by using 2 different performance indicators which are Customer Perception Measurement (CPM) and Best Practice Benchmarking (BPB). (Bowersox, 1996, p.675–676)

Customer perception measurement is achieved best by doing company- or industry-sponsored surveys and this way can be achieved a good view about a performance indication in general or for a specific order. Typically CPM includes measurements about availability, performance-cycle time, information

availability, problem resolution and product support. (Bowersox, 1996, p.676–677)

The Best practice benchmarking is used to compare firm's performance against other competitors or against the industry-leading performers. BPB tries to focus on measures, practices and processes which can be compared in each company. (Bowersox, 1996, p. 677–678)

### **3.3 Forecasting**

This chapter is describing the basics of forecasting. Forecasting has increased its importance during the years and are forming a valuable part of supply management. However there are also some issues involved in forecasting and all of this is described in this chapter.

#### **3.3.1 Forecasting in general**

One of the key elements of supply chain is the leadtime and it is maybe one of the most important part of logistics. It is also one of the first elements which is usually under the review, when the supplier and the customer try to determine the improvements in their supply chain workflow. These improvements can be done in many different ways and one of the most effective of them is called forecasting.

Forecasting can be understood to be a projection of patterns in past events into the future. In a reality this means that for example the customer tries to provide the supplier a forecast of its demand for a certain period of time (for example 12 months). After receiving the forecast, supplier will have the ability to anticipate the future demand and prepare themselves for it. Usually this means that the supplier can squeeze the leadtime and provide the goods or services faster than it would be possible if the order which was made would be made without any anticipation. (Baily, 2005, p.144)

### 3.3.2 Criticism towards the forecasting

Though forecasting is considered to be the basis of all planning and decision making (Lysons, 2006, p.330) there are also many issues with it. Maybe the biggest problem in forecasting is that the forecasts made for the future planning are generally all wrong. Baily has identified that the most typical points why the forecasts go wrong (Baily, 2005, p.144):

- 1) The perceived pattern is not continued into the future
  - 2) The past pattern has not been adequately understood
  - 3) Random fluctuations have prevented the pattern from being recognised
- (Baily, 2005, p.144)

Out of these points maybe the most common source of error related to the forecasts comes from the first point mentioned by Baily. People often think that when they see a certain pattern going on that it would go on like that also in the future. However this is not the case in a modern global world in which even some actions made far away on a different continent can have an effect on the business on the other side of the planet. Therefore in the forecasts it is essential also to search for certain kind of signs that might indicate that the previously seen pattern might change. (Baily, 2005, p.144).

The problem where the pattern is not adequately understood is something that is usually related to the persons making the forecasts. Observing the pattern in a right way is something that cannot be learned easily, but takes a lot of experience about the business and also mathematics. The third point where the fluctuations have been prevented from being recognised is also related to the experience and expertise of the persons making the forecast. So when making the forecast one should also look to the data received and study if it contains some patterns or if the pattern is cloaked by a series of random occurrences. (Baily, 2005, p.144)

If these points are well taken care of, the forecasting might be become much more useful for the company. However as it was earlier mentioned, the forecasts can be considered to be generally wrong which comes from a fact that a human tries to predict things which will occur in the future. Because of this it should be also noted that when looking at a forecast one should always take one of the following approaches towards forecast: Either there has to be found a better way to forecast the occurrences or the different flaws will be accepted and understood that forecasts can never represent the future occurrences 100 % correct. The appropriate way to respond to the latter approach is to reduce the reliance on the forecasts and keep them just as a tool which gives a good estimation of the future and nothing more.

### 3.3.3 Making a forecast

When the supplier and customer would like to create a forecast for themselves it comes also to a point to ask the usefulness of the forecast. Lysons has identified that there are six basic questions which can determine the need for the forecast. They are (Lysons, 2006, p.330):

- 1) What is the purpose of the forecast?
- 2) What is the time horizon?
- 3) What forecasting technique(s) is/are most appropriate?
- 4) On what data must the forecast be based and how shall it be analysed?
- 5) In what form shall the completed forecast be presented?
- 6) How accurate is the forecast?

(Lysons, 2006, p.330)

Out of these questions the first three are essential for the forecast to be even possible. If the business in which the supplier and the customer are involved is demanding a forecast for example to improve the leadtime significantly it should be alright to proceed with the forecast. On the other hand if the both parties notice that there is no actual need for the forecast and that it doesn't provide any kind of

improvement in the overall performance of the supply chain for both parties, it is easy to say that forecasting can be left out. The time horizon for which the forecast is used is also vital information as is the right technique to forecast the demand. The forecasting techniques will be introduced below.

#### 3.3.4 Forecasting techniques

Is there a right way to make a correct forecast? Or which are the ways to do a forecast? Forecasting techniques can be divided into two separate groups which are the qualitative approach and quantitative approach.

Qualitative information can be understood to be "soft" information which includes different kind of opinions, rumours and information based on some discussion. Qualitative approach on the other hand can be described to be "hard" information. This means that qualitative information should be based more on facts and include more numerical information which can be later used in mathematical forecasting techniques. It cannot be said that one of these is better than the other and a good forecast should include a wide range of quantitative information which is then corrected with a help of quantitative information. (Lysons, 2005, p.331)

Example qualitative techniques for forecasting can be for example expert systems, test marketing and delphi technique. These methods are all a soft way to do a forecast and are based quite a lot on the human knowledge or intuition about "what is going to happen". Test marketing is also an interesting way to make a forecast as it actually shows what kind of people are buying the products and why. (Lysons, 2003, p.332)

Quantitative approaches of forecasting events are quite often based on time series and that using information about the past, one can predict the consumption of the future. Maybe the most common quantitative way to forecast is use some kind of an average between some period of time and forecast the future with it. In addition to this, persons doing the forecast can include also a more specific data to

the forecast as fore example information about future trends, seasonal influence, cyclical movement or random error. (Lysons, 2005, p.332)

A more complex ways of doing some quantitative forecasting can be done by using the method of moving averages or exponentially weighted average method. The moving average method is based on acquiring a data for example for next six months. Then the data can be used so that one period will have a value of average or mean of 5 months. The next period will again have the value of average or mean, but this time the timeline is moved forward and the first value of acquired data is dropped out and a new data is introduced (in this case the sixth month). (Lysons, 2005, p.332)

The moving averages method has some weak points such as high need of raw calculations and that the data is weighted equally. Because of these issues a better mathematical way to make a forecast would be to use a exponentially weighted average method. It is based on a exponential series formula which is used in a following form as shown in formula 1(Lysons, 2005, p.332):

$$a + a(1-a) + a(1-a)^2 + a(1-a)^3 \dots = 1$$

Formula 1: Exponentially weighted average (Lysons, 2005, p.333–334)

In this formula 1,  $a$  is a constant with a value between 0 and 1. Usually  $a$  is determined to be between 0.1 and 0.2 which means that the forecast will be slower to react on different changes, but also makes it more stable unlike high values of  $a$ , such as 0.5. (Lysons, 2005, p.333–334)

The bullwhip effect is also commonly known effect inside supply chains. It is described best as to be the uncertainty which is flowing up-and-downstream inside supply chain and creates excessive inventory quantities, poor customer service, cash flow issues, stock outs, high material costs and transportation costs. (Lysons, 2005, p.334–335)

To oppose the bullwhip effect, firm should try to ensure the transparency and information sharing within the supply chain. Also forecasts shouldn't be taken so seriously, but there should be also some direct demand data which can be used instead of uncertain forecast which creates often problems to the manufacturing. (Lysons, 2005, p.334–335)

## **4 ANALYTICAL HIERARCHY PROCESS**

This chapter will introduce the main method which is going to be used in the supplier evaluation, the analytical hierarchy process. This chapter will show what it is, how it is used and what kind of issues it has.

### **4.1 Introduction**

This chapter will be describing one of the most famous decision-making tools used in economics, the analytical hierarchy process (AHP). The objective of this chapter is to familiarize the analytical hierarchy process for the reader and describe how it works.

The AHP model was created by Thomas Saaty who had worked earlier in his career at several research projects for the Arms Control and Disarmament Agency at the U.S. Department of State and also at Wharton School. During his research projects he had discovered that people had often many issues when it came down to make certain decision or to prioritize some points of their work. This motivated Saaty to create a new tool so that they would be able to make more complex decisions a lot easier. (Forman, 2008, p.4–5.)

Maybe the best things about the analytical hierarchy process is that it takes an approach towards the decision making from the rational and intuitive point of view and gives the ability to select the best solution from the various alternatives. According to Saaty, the reason why this kind of hierarchy is applied is because “it is possible to judge the importance of the elements in a given level with a respect to some or all of the elements in the adjacent level above”. The AHP model structures the decisions problem in a hierarchy model which consists of three different layers are shown in a figure 6 below: (Saaty, 2000, p.3)

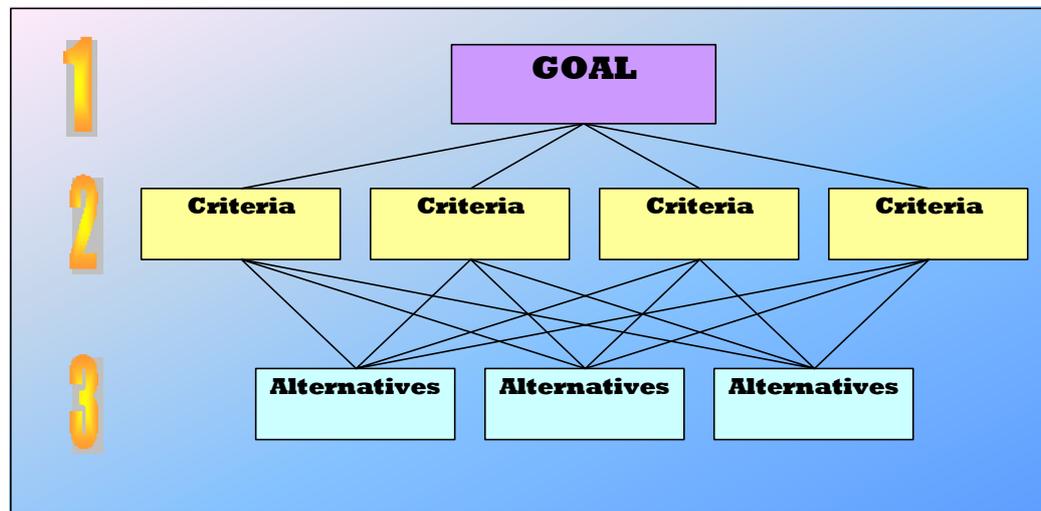


Figure 6: The three layers in AHP model (Saaty, 2000, p.3)

- 1) At the top of the hierarchy is located the goal of the decision.
- 2) The second hierarchy consists of the different criteria which are used to evaluate the alternatives
- 3) The third hierarchy consists of the different alternatives which require comparison

#### 4.2 Primary functions of analytical hierarchy process

AHP is methodology which has many different kind of applications. The main causes for the popularity of AHP model are the three primary functions it has. They are structuring complexity, measurement and synthesis.

The structuring complexity of AHP model is based on an idea that complex problems should be presented in such a way that even people without formal training could understand it. The simplicity of AHP comes up from the “hierarchical structuring of complexity into homogeneous clusters of factors”. The hierarchical point of view taken to AHP gives it an ability to be understood quickly by the human mind and therefore AHP can also be seen a friendly format of displaying complex situation for the human mind. (Forman, 2008, p5–6)

Earliest decision making models differed from AHP model in the way things were measured. For example MAUT – process (Multiattribute utility theory) is an example of a model which uses interval measurement instead of higher scale measurements such as ratio scale which AHP utilises. The reasons for "using the ratio scale in hierarchically structured methodologies is because the priorities (same as weights) of the elements at any level of the hierarchy are determined by multiplying the priorities of the elements in that level by the priorities of the parent element". (Forman, 2008, p.6)

Maybe the most notable function which differs AHP from many other analytical processes is its ability “to measure and synthesize the multitude of factors in hierarchy”. This is very important as there are many different tools and processes which can be used to create analyses, but there are few which can be used for producing any kind of synthesis out of these analyses. (Forman, 2008, s. 6)

### **4.3 Priorities in AHP**

The creator of analytical hierarchy process, Thomas L. Saaty, has stated that there are four different priorities which should be noted when performing an analysis based on analytical hierarchy process. According to Saaty the four different priorities of AHP are:

- 1) Define the problem and determine the kind of knowledge sought.
- 2) Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).

- 3) Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
- 4) Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.  
(Saaty, 2008, p.85)

Saaty has provided good basic rules on how to proceed with the priorities in the analytical hierarchy process. The process itself is including quite a lot of calculations and in some cases iteration rounds are needed. By accomplishing the themes suggested by Saaty the overcome should be a set of priorities for the AHP-table.

#### **4.4 The fundamental Scale**

Analytical hierarchy process utilises so called fundamental scale (show in the table 5 below). The fundamental scale differs from many other scales because it doesn't measure how many times one is larger than the other, but it tries to help to show how much of a fraction the one is larger than the other. So the fundamental table should be read in a way which would reflect the slight differences between the two objects (Saaty, 2000, p5–6).

Table 5: the fundamental scale. (Saaty, 2000, p.6; Rissanen, 2003, p.7; Ganesan, 2007, p.6; Salo, 2004, p.3; Saaty, 2008, p.86)

<b>Intensity of importance</b>	<b>Definition</b>	<b>Explanation</b>
<i>1</i>	<i>Equal importance</i>	<i>Two activities contribute equally to the objective</i>
<i>2</i>	<i>Weak</i>	
<i>3</i>	<i>Moderate importance</i>	<i>Experience and judgment slightly favor one activity over another</i>
<i>4</i>	<i>Moderate plus</i>	
<i>5</i>	<i>Strong importance</i>	<i>Experience and judgement strongly favor one activity over another</i>
<i>6</i>	<i>Strong plus</i>	
<i>7</i>	<i>Very strong or demonstrated importance</i>	<i>An activity is favored very strongly over another; its dominance demonstrated in practice</i>
<i>8</i>	<i>Very, very strong</i>	
<i>9</i>	<i>Extreme important</i>	<i>The evidence favoring one activity over another is of the highest possible order of affirmation</i>

In the fundamental scale showed in the table 5 can be seen three different columns. The most common way to display the intensity of importance of certain factor compared to another is to make a scale of 9 different steps. As said before, this scale shouldn't be viewed in a way that how many times is one larger than the other (1 vs. 2), but rather to think how large a fraction is one out of the other (1.1 vs. 1.3).

As fundamental scale is describing the small differences of importance's between two objectives it is very hard to determine a strict line between two intensity of importance. So according to Thomas Saaty, to get a bit more distinction between the importance's it is widely agreed to leave out the 2nd, 4th, 6th and 8th intensity of importance out and use only the uneven levels (bolded in the table 5). This way the distinction between two factors can be done more specifically and easily than just by guessing the distinction of 0.1 in one way or other. (Saaty, 2000, p.6)

#### **4.5 Describing a problem with Analytical Hierarchy Process**

As described earlier, AHP model is based on hierarchy model which can be used to divide a larger problem into smaller contexts and then defining their weights. . To build up a successful AHP result one should take to account the following steps which describe the AHP as a whole.

The first step in building the analytical hierarchy process is determining the problem and selecting the objective. The determination of the issue is a very important factor in the AHP as it can be seen as the goal of the whole process and every calculation made during the process is a step to achieve the goal. When thinking about the hierarchical model, the goal is set to be the top layer which has various of different layers below it (please see figure 6 for more information). (Haas, 2005, p.10; Ganesan, 2007, p.3; Salo, 2004, p.2)

After the goal has been set it is time to move on to the next level of AHP model. The next level should now be then determination of the criteria used to solve the top hierarchical layer, the goal (see chapter 4.1). There are many different ways to select the criteria for AHP (see chapter 4.3) and it is good to remember that it is allowed to use both quantitative and qualitative methods. (Haas, 2005, p.10; Ganesan, 2007, p.3; Salo, 2004, p.2–3)

The third layer of AHP model will consist of different alternative picked up by the measurer. The alternatives have also a large role in the process as one of them should be the answer to the question set in the first layer. So it should be then noted that AHP doesn't take to account how good one alternative actually is, but it rather compares quite similar alternatives whit each other. (Haas, 2005, p10; Ganesan, 2007, p.3–4; Salo, 2004, p.2–3)

After the goal has been determined, criteria have been determined and different alternatives have been selected it is time to arrange all those factors in one hierarchical tree. After that AHP continues with determining the relative rankings of the different alternatives. At this point it is good to be aware that AHP does allow one to compare the different qualitative and quantitative information with each other. This is achieved by using the pairwise comparison by which it is possible to compare how much more important one factor is over the other. The scale used in pairwise comparison is the fundamental scale which is described in the earlier chapter 4.4. A good example of what kind of pairwise comparison can be made with AHP can be found in the table 6 below (Haas, 2005, p.10; Ganesan, 2007, p.3–4; Salo, 2004, p.3–4)

Table 6: An example of pairwise comparison table (Saaty, 2008, p.86)

*Which drink is consumed more in the USA?*

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*An example of examination using judgements*

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<i>Drink consumption in US</i>	<i>Coffee</i>	<i>Wine</i>	<i>Tea</i>	<i>Beer</i>	<i>Sodas</i>	<i>Milk</i>	<i>Water</i>
Coffee	1	9	5	2	1	1	1/2
Wine	1/9	1	1/3	1/9	1/9	1/9	1/9
Tea	1/5	2	1	1/3	1/4	1/3	1/9
Beer	1/2	9	3	1	1/2	1	1/3
Soda	1	9	4	2	1	2	1/2
Milk	1	9	3	1	1/2	1	1/3
Water	2	9	9	3	2	3	1

When the pairwise comparison has been made one should have the matrix as shown above in table 6. The next step in analytical hierarchy process is to turn the matrix of pairwise comparisons into a real ranking of priorities. According to the designer of the analytical hierarchy process, Thomas L. Saaty, this is best achieved by using the so called eigenvector. (Haas, 2005, p.10; Ganesan, 2007, p.12; Saaty, 2008, p.86–77)

The eigenvector is achieved by doing some mathematical operations to the matrix of pairwise comparisons. The process starts squaring the achieved pairwise matrix with itself resulting into a new matrix. After the new matrix has been achieved, one should calculate the sum of each vertical rows in the matrix. When this has been done, the sum of the each vertical row will be calculated and this gives the ability to normalize the achieved matrix. The normalization is then used to calculate the weight and provide a real ranking of priorities. This method is then supposed to be continued with a new iteration round until the previous and the achieved normalized values are exactly the same. However when the decimal difference is getting smaller (many decimals) the meaning of the iteration also gets smaller as the results are already accurate enough. (Haas, 2005, p.10; Ganesan, 2007, p.12; Saaty, 2008, p.86–77)

After one has achieved calculating the eigenvectors for the priorities, the same process should then be applied to the alternatives picked earlier and calculate eigenvectors and normalized values for each alternative in terms of each criteria. This requires some matrix calculations, but also shows the versatility of AHP model which is also able to handle very large problems with including some quantitative information in determining the ranking within the alternatives. (Rissanen, 2003, p.11)

The last step in determining the best solution for achieving the goal is to perform a matrix calculation between a matrix which includes weights for each alternative in terms of criterias and a matrix which includes all the weights for the criteria. When these two matrixes are added up, the final weights are received which then determine the final results to this analytical hierarchy process.

Table 7: Example table by Saaty which shows the weights for criteria and alternatives (Saaty, 2008, p.89)

Criteria	Flexibility 0.036			Future opportunity 0.122			Security 0.262	Reputation 0.075	Salary 0.506	Overall Priority
Subcriteria	Location 0.091	Time 0.218	Work 0.691	Entrepreneurial 0.105	Salary increases 0.637	Top level position 0.258				
Global weights (criteria $\times$ subcriteria)							0.262	0.075	0.506	
Domestic Company	0.003	0.008	0.025	0.013	0.078	0.032	0.225	0.064	0.124	0.193
Internat'l Company	0.295	0.084	0.062	0.090	0.555	0.591	0.054	0.101	0.547	0.333
College	0.496	0.055	0.115	0.061	0.258	0.274	0.095	0.247	0.289	0.214
State University	0.131	0.285	0.249	0.239	0.124	0.083	0.626	0.588	0.039	0.262

The example table 7 made by Saaty illustrates what kind of table one should be dealing with when the final matrixes are to be calculated and the weights of the subcriterias and all other aspects are know. (Saaty, 2008, p.89)

#### **4.6 AHP criticism**

Although analytical hierarchy process is a very good tool for many situations where one have to find a solution to a problem using some analytical methods, there are also some criticism claimed against AHP model.

Maybe the most commonly used criticism against analytical hierarchy process goes down to the usage of pairwise comparisons and inability to handle any kind of uncertainty. As described by Chan this issue derives mainly because "its inability to adequately handle the inherent uncertainty and imprecision associated with the mapping of the decision-maker's perception to exact numbers". This means that AHP would require that decision maker would be certain about the nature of the qualitative criteria. In some cases this is very difficult because the AHP model expects that decision maker would be able to describe the qualitative criteria in a quantitative form for example using the fundamental scale (1-9). Although the qualitative criteria could be transferred to a qualitative number, AHP doesn't take to account the uncertainty the decision maker feels when assigning the quantitative number to it so there is always some kind of uncertainty present in the AHP model. To resolve this problem there has also been developed a different kind of variations of AHP model such a as fuzzy extended analytical hierarchy process (FEAHP) – model (Chan, 2007, p.418; Chan, 2008, p.3830–3831)

#### **4.7 AHP and supplier selection/development**

Analytical hierarchy process is used for many different purposes and one very common point of use for it is measuring the suppliers during the supplier selection and development. This chapter will introduce few of them and shows quite a good overview about different criteria which are used in the supplier selection and development in the modern science.

Chan and Kumar have investigated in their researches the global supplier development using analytical hierarchy process. In their research they have identified 5 criteria which affect most to the supplier selection (the original table can be seen in appendix 1 and appendix 2). These main criteria are (Chan, 2007, p.420):

- Cost (Product price, freight cost, tariff and customs duties)
- Quality (Rejection rate of the product, Increased lead time, Quality assessment, remedy for quality problems)
- Service performance (Delivery schedule, technical and R&D support, response to changes, ease of communication)
- Supplier's profile (Financial status, customer base, performance history, production facility and capacity)
- Risk factor (Geographical location, political stability, economy, terrorism)

(Chan, 2007, p.420)

These main criteria also include several several different attributes which describe the subcriterias for each main criteria. These subcriterias are mentioned in the table above inside parentheses. (Chan, 2007, p.420 – 423)

Sevkli has described in his research a problem related to supplier selection and tries to determine the best ways for supplier selection using AHP model for it (the original table can be seen in appendix 3). The criteria which Sevkli describes for supplier selection are (Sevkli, 2008, p.129):

- Performance assessment (Shipment, delivery, cost)
- Human resources (Number of employees, organizational structure, training, number of technical staff)
- Quality system assessment (Management commitment, inspection and control, quality planning, quality assurance)
- Manufacturing (Production capacity, maintenance, lead-time, up to date, storage, development)

- Business criteria (Reputation, location, price, patent, technical capability)
  - Information technology (RFID, EDI, Internet)
- (Sevкли, 2008, p.129)

Ching-Chow Yang and Bai-Sheng Chen have described the supplier selection process by using the quantitative and qualitative criteria which are applied to AHP model (the original table can be seen in appendix 4). The criteria which they have used are:

- Qualitative
  - Quality
  - Finance
  - Customer service
  - Production capacity
  - Design & technical capability
  - IT systems
- Quantitative
  - Turnover
  - Cost
  - Delivery
  - Distance

(Yang, 2006, p.931)

Ghodsypour and O'Brien have made a research report in which they also describe what kind of AHP criteria could be used in supplier selection (the original table can be seen in appendix 5). According to them the supplier selection criteria can be divided three categories which are (Ghodsypour, 1998, p.205):

- Cost
- Quality
  - Defects
  - Process capability

- Service
  - On-time delivery
  - Ease of communication
  - Response to changes
  - Process flexibility (Ghodsypour,1998, p.205)

As a conclusion from the supplier selection and development using analytical hierarchy process can said that all of these previously shown cases follow the same rules and apply basically the same kind of criteria: cost, quality and service capability. The examples shown earlier are a good overview of the used criteria in current researches and can help built up the AHP model for a new case. What is also noticeable from all of these examples is that though the basic principle is the same, there are also some differences between models which also shows that the criteria are also a case specific and researchers don't have a common view of which are the "right" criteria for supplier selection.

## **5 CASE: EADS SECURE NETWORKS OY**

In the fifth chapter the main concentration will be in the practical part of the Master's thesis. This chapter will give a good view of EADS Secure Networks Oy, analyze its purchasing processes and apply the analytical hierarchy process in practise.

### **5.1 Company introduction**

This chapter will be providing background information about the EADS Secure Networks Oy which has been the company this thesis has been applied to. The chapter will also describe some basic information about the TETRA-network solutions which are one of the key products EADS Secure Networks is providing.

#### **5.1.1 Overview of the company**

EADS Secure Networks is a global manufacturer of different secured networks using technologies such as TETRA, TETRAPOL and P25. (EADS, 2009a) The companies main products include different core network which takes care of main switching and management tasks, different basestation models, dispatching stations, different applications and network management systems. In Finland EADS Secure Networks Oy employs more than 300 people in Helsinki and Jyväskylä.

EADS Secure Networks Oy is also a part of global EADS group (European Aeronautic Defence and Space Company N.V.) which is the global leader in aerospace, defence and related services. EADS group has a very large product portfolio which includes aircraft manufacturer Airbus and the world's largest helicopter supplier Eurocopter. EADS is also involved in space programmes such as Ariane and Galileo, and is a major partner for Eurofighter programme and missile provider MBDA. EADS employs globally about 116 000 people at more

than 70 production sites and in 2007 it created a revenue of 39, 1 billion euro. (EADS, 2009b)

Because EADS Secure Networks is a part of such a large company and includes various of different product portfolios the thesis has focused the research on EADS Secure Networks Oy TETRA-technologies. The same suppliers can be also involved in providing equipment to other technologies or divisions as well, but the suppliers performances on that sector will not be investigated.

### 5.1.2 Overview of TETRA – standard

TETRA (Terrestrial Trunked Radio) - is a standard which has been developed by ETSI (European Telecommunications Standards Institute). TETRA network utilises digital trunked radio standards and is designed to meet the high requirements set by various users of Professional Mobile Radio (PMR). (Tetra Association, 2009a)

As described by Tetra Association, TETRA – networks are designed in such manner that independent manufacturers can develop infrastructure and radio terminal products which can be fully compatible with each other. The possibility to use products of different producers in the same TETRA network has also spread the user field of the standard. Currently TETRA- networks and users can be found from the following user groups (Tetra Association, 2009a):

- Public safety
- Transportation
- Utilities
- Government
- Military
- PAMR (Public Access Mobile Network)
- Commercial & Industry
- Oil & Gas (Tetra Association, 2009a)

### 5.1.3 EADS Secure Networks mission critical products

EADS Secure Networks Oy has a wide selection of different mission critical solutions for its customers using TETRA. The product portfolio can be seen to consist of two different product lines: terminals and infrastructure. The terminal products which are offered by EADS Secure Networks are also divided in many different subcategories based on the end usage (handheld terminals or mobile terminals) and the frequency of the end-user network. From picture 1 can be seen one example of EADS Secure Networks offered TETRA PMR terminals. It is also good to note that as EADS Secure Networks is offering its customers mission critical solutions, it also means that each manufactured terminal is made specifically for the end-customers network and it cannot be used by any other party due to the security reasons. So in this matter the production differs quite heavily from manufacturing of basic GSM-phones as made for example by Nokia or Samsung.



Picture 1: EADS THR880i and TMR880i radio terminals for TETRA Network (EADS, 2009c, 2009f)

The second product line which EADS Secure Networks offers to its customer is infrastructure. The main products in this product line are base stations and switches (shown in picture 2) which are the key components in data transmission

for the terminals in pre-determined region. Other products which are offered are different kind of dispatching configurations (shown in picture 3) and also applications which can control a whole nationwide TETRA network. Infrastructure product line also includes quite a lot of hardware which has to be designed specifically for customer due to the security reasons. This again brings some own challenges for the supply chain and purchasing as all customer orders are specific and require customer specific hardware and software to be installed inside the products.



Picture 2: A picture of TETRA switch offered by EADS Secure Networks (EADS, 2009d)



Picture 3: A picture of TETRA dispatching station provided by EADS Secure Networks (EADS, 2009e)

## 5.2 Purchasing and suppliers

Purchasing is one of key functions in a modern telecommunication-organization and therefore it is important to take first a look inside the purchasing process which is used at EADS Secure Networks. This chapter will also show the background for the whole work so that it is easier to understand the issues and benefits of supplier network investigated by AHP model.

### 5.2.1 Overview of purchasing process

As described earlier in the theory section of the thesis, the purchasing process is basically very similar in each company, but usually also includes some kind of "tweaks" so that it would be applied better for each organization.

In figure 7 can be seen the supply chain process which is used at EADS Secure Networks. This supply chain process is of course describing some basic process flow which is used at EADS Secure Networks and is not showing a detailed step-by-step-process which is also described for company's internal use. This process is also describing more about daily operational purchasing case in which the supplier is already known and the transactions with them are constant. Therefore there is no need to "search" a supplier each time a purchasing operation is need to be made as it is described in a process by Lysons (figure 2) in theory section. However when there are some more special needs from the end customer (special accessories or software) the supply chain process is usually transferred into a process which is reminding quite much the described by Lysons, so that there will be a search of supplier between steps 4 and 5.

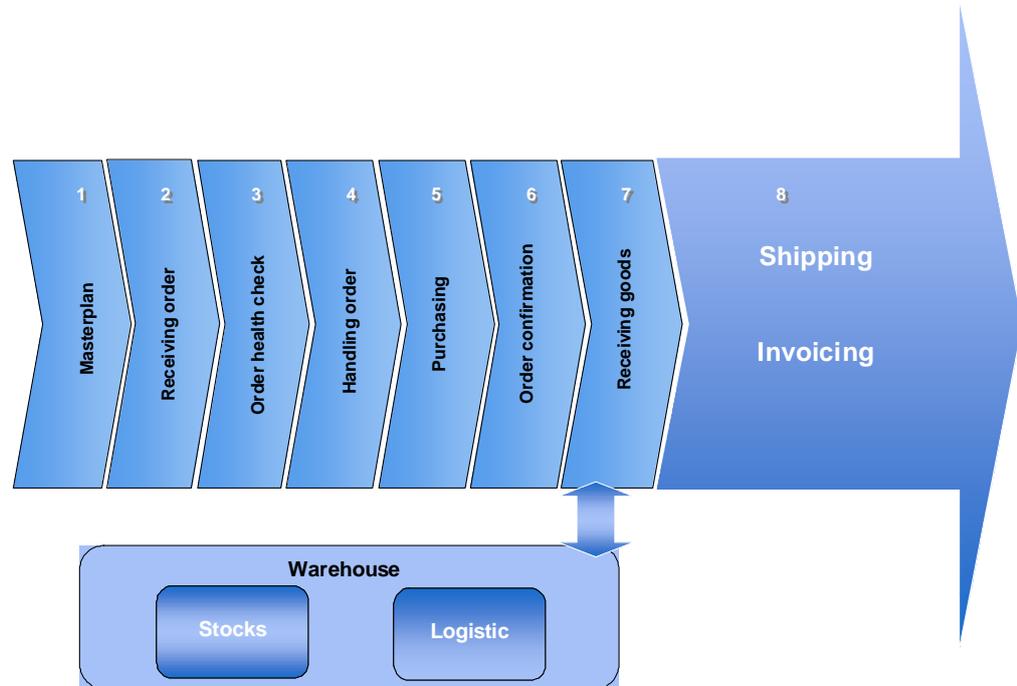


Figure 7. EADS Secure Networks Oy supply chain process (Heikkinen, 2008)

The supply chain process which is described in figure 7 can be seen to consist of 8 different steps. The points in which supplier is usually needed are 1, 5, 6 and 7 which are described in more detail below.

**Masterplan:** The first point (number 1 in figure 7), which is the masterplan, is a vital tool of communication between EADS Secure Networks and its suppliers. It is used to show up a supplier the forecasted orders which EADS Secure Networks will have. This way company can give supplier a view of upcoming orders and by doing this it can shorten the leadtime from order intake to end customer significantly. It also provides a way for the suppliers to adjust their capacity and order enough material according to the needs of EADS Secure Networks. Different forecasts are considered as very important data as TETRA equipment require special security measures to be taken before the delivery and therefore basic hardware cannot be used as such for every customer, but needs to have a customer specific security protocols. The forecast will be handled in a more detailed way in chapter 5.2.2.

**Purchasing:** The purchasing procedure (step number 5 in figure 7) itself is very simple and straight forward for the majority of products and components. For the purchasing procedure to be successful the purchaser uses SAP ordering interface to create a purchase order. While making the purchase order it is also important to know if the order made by end customer is forecasted or not as it effects on the total order leadtime due to higher leadtimes used in some special TETRA materials. In order to secure customer deliveries each of the key suppliers keeps weekly updates between itself and EADS Secure Networks. This way in case of some material or delivery issues the supplier and EADS Secure Networks can have an agreement on how to get the production and deliveries on track and minimise the delivery delays.

Inside EADS Secure Networks there are also two different ways to make the purchaser orders. One way to proceed with it is to make sales order based purchase order. This means that the goods ordered from the supplier are already assinged to a specific order and to a specific customer. The second way to proceed with the purchaser order is to make so called stock orders. The stock orders are used for materials which can be configured later on easily against a customer order. The reason for making some stock orders might come from agreements between EADS Secure Networks and its customers, where the customer would like to have its goods to be delivered in a shorter leadtime than normally would be agreed. Also by doing some stock orders EADS Secure Networks has also the ability to ensure that it has enough material for its customer even though the supplier might have some material difficulties. However it is not recommended to do too much of the stock orders as it might result in too high stocks. It might also result in a situation where EADS Secure Networks would have much of old material at hand which might not be usable anymore for example due to some new specifications or version changes.

**Order confirmation:** Order confirmation (step number 6 in figure 7) is required to be delivered by supplier in an agreed timeframe. It can be seen as suppliers commitment to deliver the ordered products within certain amount of time. The date of goods delivery provided by the supplier is used later in EADS Secure Networks order confirmation for the end customer deliveries. So in cases when the supplier has some delivery issues and has to reconfirm order many times it all reflects also on the whole delivery chain until the final customer (EADS Secure Networks customer is not always the final end customer).

**Receiving goods:** When (step number 7 in figure 7) goods have been sent from supplier to EADS Secure Networks a goods reception has to be performed. This is done in SAP and physically in warehouses. After all goods for the customer order has been received and configured, then the customer delivery can be made from EADS Secure Networks warehouse. There are also orders which are made for stock, so that leadtimes for customer orders can be shorten. It is still good to note that configurations taken from stock cannot be used as such, but they require some customer specific software installations and security protocols to be applied.

The purchasing process used at EADS Secure Networks can be seen to follow quite closely the same basics as the theory of the purchasing and purchasing processes. The only real differences which can be found between the theory and the practical implementation is that EADS Secure Networks is adding to the purchasing process more weight to the forecasting (masterplan) and adding to the process a step called health check. The health check is a step which is applied to each of the orders received at EADS Secure Networks and its basic idea is that every order which is sent to EADS Secure Networks has to be fully checked before it is put in system as the final sales order. This step is very important as the customers do not always know the correct set of configuration they should order, due to the various of different security and technical related matters related to PMR-products. Therefore each orders is passed on to health check and if some changes should be made to the configuration ordered, the request for order modification is sent to the customer. Otherwise the order is carried out to the SAP system and will show up in the supplier end as a new purchase order.

### 5.2.2 Forecasting challenges inside EADS Secure Networks

One of the challenges facing the supply chain is the need of getting right kind of forecasting so that suppliers can gather a right kind of amount of raw material for their production. As Lysons has described, forecasting should be the basis of all decision making, but again this is not always possible because forecasting cannot always produce specific and precise information for the purchasing and supply chain purposes. (Fjällberg, 2009, interview, appendix 12)

The precise forecasting is taken seriously inside EADS Secure Networks and it is one of the tools which is used for managing the suppliers. As it has been commented before, TETRA products always require some customer specific hardware and software to be used. The main purpose of the forecasting at EADS Secure Networks is to provide some visibility to its suppliers and therefore prepare the suppliers with the correct capacity and material flow. It is important to design the forecasts so that they are more balanced and would not cause a huge bullwhip effect to the supplier network. Although the visibility might be the biggest reason for forecasting the second point for creating them is because suppliers require them. (Fjällberg, 2009, interview, appendix 12)

The most typical way to make the forecast is to make it a rolling 13 months forecast so that it would show to the suppliers the demand expectations of the future and also provide some more detailed information about the orders coming in few months time. The accuracy of the forecast is quite an important matter as suppliers might also want to bind EADS Secure Networks to commit itself to a certain material quantity which in the worst case, if the forecast does not come true, would be bought by EADS Secure Networks from the supplier. This kind of behaviour certainly lowers the risks on the supplier side, but it creates also heavy pressure for EADS Secure Networks to accomplish its forecasts in a correct way and as accurate as possible to avoid any financial losses. (Fjällberg, 2009, interview, appendix 12)

The forecasting techniques might be varying from company to company. At EADS Secure Networks there are some customized tools used for it which shows the quantities of products predicted by sales and the projects. This way the estimated numbers can be then forwarded to the supply chain which then calculates their own estimations about the material needs. However this is not always easy as the data provided at the beginning is quite soft and the hard data can be made only after many various calculations. (Fjällberg, 2009, interview, appendix 12)

The forecasting methods and techniques do provide quite good forecasts to EADS Secure Networks suppliers. However it really doesn't matter how advance and quantitative tools there are in use when the input given to these tools is most of the times qualitative and sometimes on a very soft basis. Therefore it should be also important for the suppliers to understand that as the theory of forecasting already suggested that the forecasts cannot be given as exact figures, but they are just good estimates even at the best. Therefore suppliers should be also monitoring EADS Secure Networks forecasts and trying to monitor the true accuracy of the forecasts provided to them to get the material flow more efficient.

### 5.2.3 Challenges with suppliers

Each company which has outsourced some production has encountered issues with its suppliers. At EADS Secure Networks this is no different and there are some main issues which can be noticed and reviewed in general. These issues are one of the points of review done by analytical hierarchy process later on.

**Leadtime:** Maybe one of the most common issue with a supplier is the leadtime issue. For some reason the supplier cannot perform at expected level and the leadtime of the product manufactured can increase. This often affects on the customer deliveries made and therefore an issue encountered by supplier's supplier can have a great impact on the final customer delivery.

The solution for a better leadtime can be often found in the better forecasting. There are many situations where customer orders are delayed because of bad forecasting and therefore the quantity and the delivery schedule might come as a surprise to EADS Secure Networks and the supplier. In addition to the bad forecasting done by the project, sales and end customer towards supply chain the leadtime issue can also come up in a situation where customer is ordering some products with a significantly shorter leadtime than what is agreed upon in the contract.

To ensure the on-time customer deliveries EADS Secure Networks uses some KPI's to measure the suppliers leadtime performance. The main KPI's used are CRD (delivery against customer request date) and OPD (delivery against original promise date). These figures are giving a good indication of customer delivery performance and also show how well can supplier match up EADS Secure Networks requests to handle orders. Below in figure 8 can be seen an extraction of actual CRD figure of the supplier. In this figure it is clearly seen that in the first months of the year the supplier hasn't been able to match customer request (in this table customer is EADS Secure Networks) date and therefore has performed badly, but improved its situation in the second quarter. However the reason for a poor CRD performance cannot always be put on suppliers shoulders as the requested date from the end customer plays a key role in this figure. For example an order from the end customer which is made under the leadtime agreed by EADS Secure Networks and the customer has a negative impact on suppliers CRD performance if it cannot be matched.

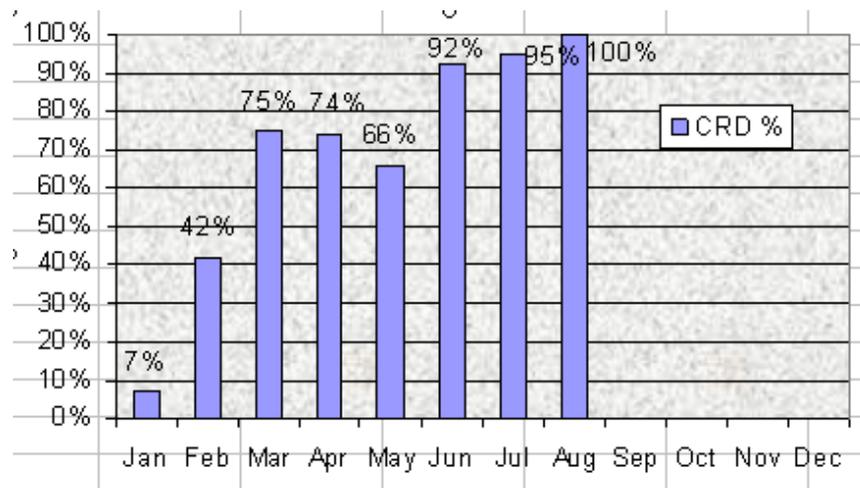


Figure 8. Supplier CRD performance (Fjällberg, 2008)

In the figure 9, the supplier performance is measured in the same timeline, but this time OPD-figures are used. This figure shows that supplier has been able to match its own confirmation dates much better than the CRD-dates. This again doesn't provide a full figure of the supplier's performance, but gives indication that after the first quarter of the year supplier has been able to deliver goods as promised and there haven't been any larger material issues which might have had an effect on the January figures.

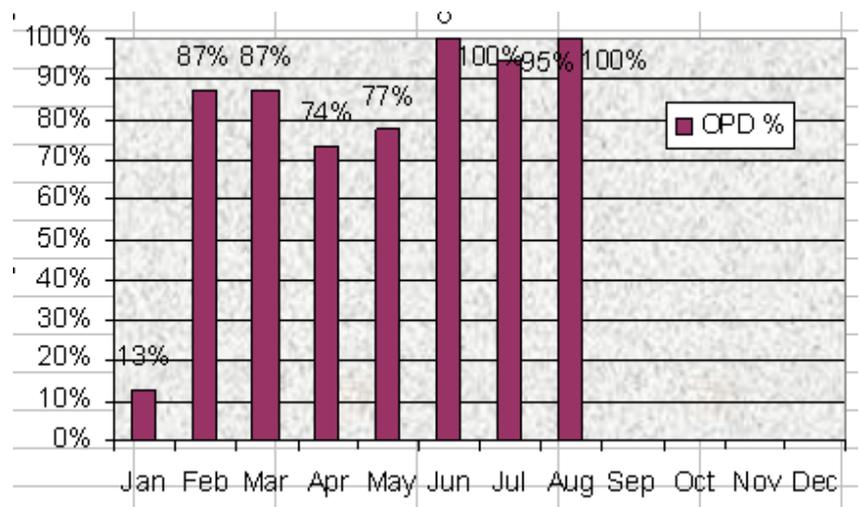


Figure 9: Suppliers OPD performance (Fjällberg, 2008)

**Quality:** Quality of the products can be measured in many different ways. The overall quality can be reviewed for example by auditing suppliers and requiring some standard quality certificates from them. This way EADS Secure Networks can ensure the quality of its products, but of course certificates cannot be always encountered as proof of quality, just as indicator of it.

One of the oldest way to describe the quality is to say that "quality is just what the customer wants it to be (Baily, 2005, p.108)". However this is not the case in a modern industry as now the quality is though to be something which exceeds customers expectations. To exceed customer quality EADS Secure Networks has to also closely monitor its suppliers in order to gain products which offer the quality that TETRA-customers expect to receive.

The first point where quality is measured is of course during the first testing of the product. After the product has reached the specifications defined by the product line it is taken to manufacturing. During manufacturing the products always face some faults and therefore it is always possible that some products which have failures end up to the end customers. The supplier quality is also therefore measured by the amount of faulty units delivered to the end customer by EADS Secure Networks.

The first way to measure the supplier quality is to follow up how many units are so called DOA (Dead On Arrival) or DQA (Defect in Quality on Arrival). These types of faults can be usually found in a cases where customer receives products and while setting it up the unit or product for some reason does not work as it should despite the quality assurance made on factory. Usually the DOA and DQA cases are reported only after the products have been taken to use (might take even years) and for EADS Secure Networks this is tricky as suppliers might not accept the DOA or DQA after a long period of time, but would consider it to be more of a product which is in need of repair. The amount DOA and DQA products are closely followed at EADS Secure Networks and require customer reclamation in order to proceed with replacing the faulty unit to a new one. The customer

reclamations then results in reclamation towards the supplier who then has to take an action to replace the faulty unit (if the customer reclamation is done correctly and the unit is indeed DOA or DQA). EADS Secure Networks also requires that supplier investigates each reclamation carefully and provides a corrective action report to it which includes the reasons of production of the faulty unit. It also should describe what kind of corrective actions the supplier has taken in order to avoid these kinds of reclamations in the future. The corrective action report is also a way for EADS Secure Networks R&D to receive information about faults in the products and offer some corrections to them.

The second type of quality measurement is done with the repair side of the products. TETRA products offered to the customers are build to last quite heavy usage from the customer side, but still there are times when for example during a police mission the radio receives some severe damages. Often the damages can be repaired at different EADS Secure Networks repair centres and the radio will be returned to the customer. If the product has received severe damages then there might also be a need to swap the units to a new one. EADS Secure Networks closely monitors the amount of units which are sent out to its repair centres and always investigates the failures behind each repairs for example to see if the fault has been done by the supplier during manufacturing stage.

One part of the quality which is also valued inside EADS Secure Networks is that the supplier is able to provide a good level of process for information security. A lot of products which EADS Secure Networks provides to the Tetra network are having different levels of encryption. This again means that EADS Secure Networks and the suppliers need to be sure that the encrypted data is moved from a place to another in a safe matter. This again calls from a supplier side ability to respond to the information security and provide a good quality processes to do it. For example some of the suppliers might need to have a specific encryption area where the encryption to the products would be made only by security checked persons under surveillance to avoid any kind of risk which might be related to Tetra products and national security.

**Communication:** Communication which is handled between supplier and client is essential part of daily work. If the communication is handled poorly it might affect seriously the relationships between client and the supplier.

EADS Secure Networks tries to keep the supplier communication active so that both EADS Secure Networks and the supplier are aware of the issues and try both to solve the issues encountered. The essential part of communication between the suppliers are different weekly, monthly and quarterly meetings which give information about supplier performance and daily operations. They also provide a good way to discuss with suppliers about the currently situation and provide a good way to start reacting to solve the issue encountered even before it actually impacts to the customer deliveries. These meetings can also be considered as a part of strategic work between the parties as there can be discussed also about wider improvements in the products which give cost benefit not only to EADS Secure Networks, but also the supplier. The goal of the communication is usually to be quite transparent so that both parties can trust each other better.

However the transparency doesn't always work with the suppliers as at some points the suppliers might have a feeling that they can solve the issues easily themselves before the problems will have an impact on EADS Secure Networks deliveries, but are not always successful with it. This might encountered in a situations in which EADS Secure Networks deliveries are quite suddenly delayed without further notification and if there are some urgent orders with penalty threat behind them, the actions needed are quite urgent and require quite a lot of effort from all the parties. So, if the transparency would be better at some points it might have a smaller impact on both parties than the actions mentioned earlier. Other issues which might come from the poor communication are missing or incorrect packing lists, double deliveries, deliveries without notification etc.

### **5.3 Applying AHP within EADS Secure Networks**

Analytical hierarchy process is a new way to measure the supplier's performance inside EADS Secure Networks. It can give a new way of looking at the suppliers as its main idea is to compare supplier's performance with each other. This way the results of analytical hierarchy process should be a table which shows the strong and weak suppliers. Equally as important to measuring the supplier's performance is also to analyze the factors behind the results and this is done in chapter 6.

### **5.4 Determining goal for AHP**

The objective of the research made by analytical hierarchy process is to study how the different suppliers compare to each other inside EADS Secure Networks. The goal for the analytical hierarchy process calculations is to determine which supplier has overall the best performance against the other suppliers. After the results are achieved it is also important to analyze the data to receive also understanding why the other suppliers have weaker scores than the others and what kind of improvements can be made to improve the weak points the suppliers.

### **5.5 Determining criteria for AHP**

As shown in the theory section there are quite many ways to analyze suppliers using analytical hierarchy process. In this thesis there is going to be five main criteria and some subcriteria which are all shown below in figure 10.

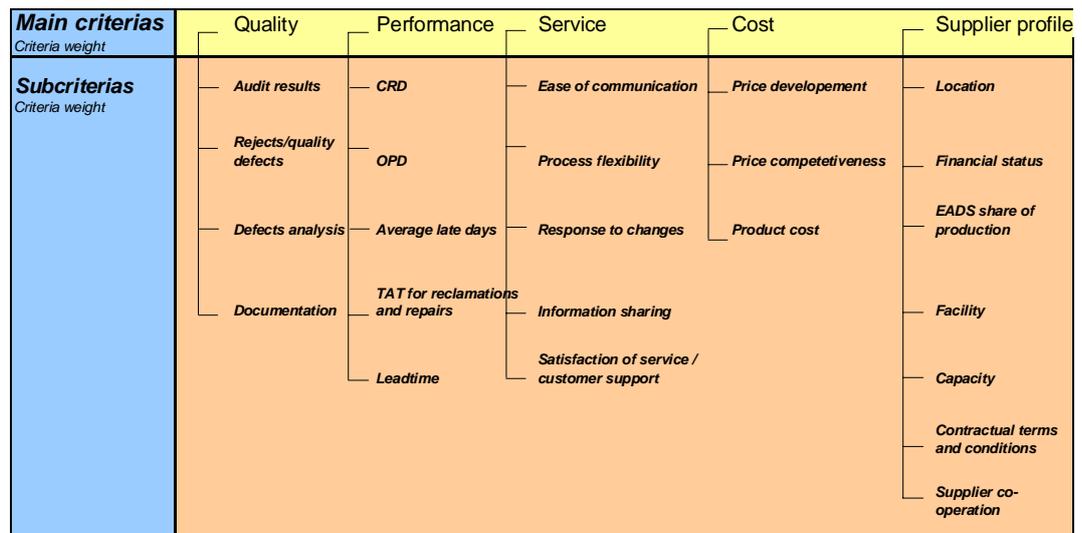


Figure 10. All the main- and subcriterias used in the thesis

The main scope of this thesis is to study the suppliers in a wider way than usual. This means that the study will take into account also many aspects from the qualitative side of the supplier by examining the suppliers with people who are in a daily contact or are key persons towards the supplier.

The goal of this study is to give a picture about the best supplier EADS Secure Networks has at the moment. For an efficient examination of the supplier by AHP process the supplier will be evaluated with five main criteria which are:

- Quality
- Performance
- Service
- Cost
- Supplier profile

The following criteria were chosen because they describe the suppliers from different aspects and give information about them in quantitative and qualitative form. The choice of these criteria was done by reviewing the criteria used in literature and combining from them a balanced criteria which also have the data input available for them inside EADS Secure Networks.

The performance and cost are representing more of the quantitative side of the criteria and for each of these criteria there is also data available which can be used to determine the differences between the suppliers. Quality, service and supplier profile are on the other hand showing for of qualitative information about the supplier and although there are some information in quantitative form, most of the information for these criteria will be gathered up from interviews made to operational purchasing and procurement team inside EADS Secure Networks. For a deeper analysis it was also decided that each of these main criteria should be divided clearly into subcriteria to show the reader what do they consist of and also for more deeper analysis on the main criteria. In the description of the subcriteria was used quite a lot of background from theory part, but also some practical information from EADS Secure Networks persons involved in procurement and supply chain management.

Below are described the five main criteria selected for the accomplishment of the analytical hierarchy process and also their subcriteria. The total weights of each criteria can be found in the chapter 5.7 where all the calculations made for AHP are reviewed.

### 5.5.1 Quality

Quality section has been selected as one of the five main criteria in the AHP process and it describes the overall quality of the selected suppliers. Quality is also one of the main criteria which should have a bit more weight when determining the AHP results as it is having a great impact on the quality of EADS Secure Networks products. Without a good quality products company, such as EADS Secure Networks which deliverers products for users with high demands, cannot compete in the security markets.

The main quality criteria has been divided into four subcriterias which are audit result of the supplier, rejects/quality defects the supplier has, defect analysis and documentation.

The audit results of the supplier consists of many audit-related measurements (review of quality of the supplier at the spot, reviewing the ISO-certifications achieved, etc) and has been conducted by several auditors which come from EADS Secure Networks procurement department or quality management. All of the suppliers auditions to the selected suppliers have been done on a regular basis and the data received from the is corresponding to the current state of the supplier.

The rejects/quality defects which supplier encounters measures the ratio of no rejects versus total deliveries. This ratio also gives a good overview of the product quality for the supplier and therefore it is weighted as an important factor inside quality criteria.

Defects analysis is an important tool when a defected product is noticed and the supplier should be responsible in delivering the defect analysis for it according the agreement in the contract. The defect analysis which are provided by the supplier to EADS Secure Networks are also measured by the content quality and the duration of the analysis. If the defect analysis is made in a proper way according the agreement and inside the agreed timeframe it would result in a better grade for the supplier.

The documentation itself has also been selected as one of the subcriterias for the overall supplier quality. A good documentation shows that the supplier is indeed professional and can actually meet the demands required by EADS Secure Networks. For a supplier to achieve a good grade in the documentation section they should be able to provide a good quality documents in agreed timeframe.

### 5.5.2 Performance

One of the most common metering points when reviewing the supplier is to measure the total performance the supplier delivers to its customers. It is important to have a supplier which can provide the products in agreed timeframe and of course the better the performance the supplier has, the greater the impact it has in the whole supply chain network. The weight of the performance was also decided to be high as the performance is also a point which will show quite easily also to the final customer and therefore effects on customer relationships. However it is good to note that performance cannot also be the only important factor when choosing the supplier and the key focus should be in finding a well balance between all the factors.

The performance measurement of the supplier has been divided into five different subcriteria which are CRD, OPD, ALD, TAT for reclamations and repairs, and the leadtime.

The abbreviation CRD stands for customer request date and it measures how well can the supplier match the request delivery date requested by EADS Secure Networks. So that the supplier would have a chance for a good performance in matching the CRD there is always made an agreement about the minimum leadtime for each supplier. This would mean that even in the urgent cases EADS cannot demand to receive the products for themselves in a shorter leadtime than what has been agreed, but supplier can of course provide the products if it is possible. Also it is good to note that there are also some tolerances agreed about what is considered a late delivery. A good CRD figure also shows that supplier can deliver the products when it has been requested, but also not too early because that would result in increased stock value for EADS Secure Networks. However it can also be agreed between EADS Secure Networks and the supplier that the original promised date can be changed so that it wouldn't have a negative impact on the delivery (for example in a situation where items should be received much

earlier than anticipated or the order has been postponed by certain time). These figures are calculated for each supplier on a monthly basis.

The abbreviation OPD stands for original promised date and it describes the date when the supplier has agreed to deliver the products to EADS Secure Networks. Although the suppliers can also reconfirm the delivery dates for their deliveries the usual way has been that OPD figures are calculated from the first confirmation date. The OPD figure is a good way to measure the delivery performance of the supplier and also see how well can the supplier plan their own production so that they are able to meet their own promises. These figures are calculated for each supplier on a monthly basis.

ALD (average late days) is describing the average number of days the supplier had their products late. It is good to note that the figure is not taking to account the total amount of days it took supplier to deliver the products or nor does it take to account the cases where the supplier did meet the leadtime requirement. This tool is able to let EADS Secure Networks see that how long in average will it take the supplier to deliver the products when the delivery is late. This tool also does not take to account that how many of lines were there actually late which might of course lead to a result where the supplier has only one item late, but the result would be poorer than the result with a supplier which has many lines late, but who would be able to deliver the products faster in average than the other supplier. These figures are calculated for each supplier on a monthly basis.

TAT (turn around time) is an abbreviation for turn around time and the criteria TAT for reclamations and repairs calculates how long will it take for the supplier to repair or replace the faulty unit and send it back to EADS Secure Networks. The turn around time for each supplier has been calculated for each supplier separately for the purposes of this thesis.

The leadtime is the last subcriteria for supplier performance. It is one of the most common measurements in performance measurement of the supplier and it shows how long will it take for the supplier to deliver the goods. The starting point of the leadtime is the purchase order date from EADS Secure Networks to the supplier and the leadtime will end when the goods have been received in EADS Secure Networks warehouse. The leadtime for each supplier was measured from the data received from the SAP.

### 5.5.3 Service

One of the aspects in this thesis was also to measure the service level EADS Secure Networks receives daily from their suppliers. This kind of service measuring is usually something that cannot be done in quantitative way, but rather in qualitative way. For this thesis there were chosen a series of subcriteria which would describe best the service level received and they were: ease of communication, process flexibility, response to changes, information sharing and satisfaction of service/customer support. To first four criteria there were also conducted a series of interviews where both the persons from operational purchasing and procurement had an opportunity to express their feelings about the different criteria (please see appendix 11 for the questioner). For the last criteria the results from internal quality report was used to give the grade and compare the suppliers.

The ease of communication was asked during the interview from EADS persons involved in daily business with the suppliers. In this section the questions were relating to the daily issues which were encountered with the suppliers. It also showed how well can EADS Secure Networks and the supplier relationships be handled on a personal level. The questions related to the interviews can be viewed from the appendix 11

The process flexibility concentrated on a topics that would reveal how flexible processes do the suppliers have in practise. The process flexibility was asked from many viewpoints (manufacturing, improvement, proactiveness, etc) to give an overview of the topic.

Response to changes is a criteria which can measure quite good the capability which supplier has when they encounter some sudden changes. These changes can come up from some sudden changes in demand (positive or negative demand change), but also from also some EADS Secure Networks or their own internal needs. The results received from interview shows how well EADS Secure Networks personnel felt about the suppliers in this section.

Information sharing is important when two or more companies try to establish a good and trustworthy relationship between each other. Information sharing level was asked with series of questions from the persons interviewed and the results were then used in supplier comparison. It can be said that the more open the relationship there is between all the parties, the better the results the suppliers achieved in this section.

Satisfaction of service/customer support was measured by different criteria (for example on call support, repair time, easy administration follow up for maintenance warranty). In this section the supplier's proactiveness/reactivates in solving the customer issues brought the better results to them.

#### 5.5.4 Cost

The cost is one of the main criteria which has been evaluated to be a very important factor when measuring the suppliers total performance in the analytical hierarchy process. This is because the cost section is the one which can bring quite a lot of savings to the company on a yearly basis if it is handled properly. In the cost section there were used three subcriterias which gave an overall view about how well can the supplier handle their part in achieving the yearly savings

in products, but also to show how well do they compare on a global market against their competitors on a price matter. The subcriteria used for determining the score for the best cost were standard price versus purchasing price variance, price competitiveness and product cost.

The standard price versus purchasing price variance is a way to measure how well the EADS Secure Networks and the supplier can negotiate the cost reductions on a yearly basis. Each product is usually evaluated in the beginning of the year with a certain value which is then frozen for the whole year and called the standard price. Standard price can be then used to evaluate for example the total costs which come from the purchasing to a certain supplier on a yearly basis. Also for organization which has a lot of project-based working it is important to get an estimation what kind of costs will there be for a certain project for purchasing the goods. The purchasing price however is something that can change many times in one year during some cost reduction solutions, design changes or configuration changes. When calculating the standard price versus purchasing price variance can be achieved a value which shows what kind cost savings can be done for example in one or more years versus the agreement. Also it is showing how well can all the parties work also on the procurement field and achieve these better results. The better results doesn't also mean that the cost changes would be made only by EADS Secure Networks, but the cost reduction should also be done proactively by the supplier for example by selecting and comparing different 2nd tier suppliers. From calculation point of view if the purchasing price is found to be lower than the standard price it would result in a negative figure which means that company has been successful in achieving a cost reduction which again leads to a better result. When calculating the values there were used some of the key figures from the most common products ordered from each supplier.

The price competitiveness is the second cost subcriteria and it is designed to measure how well does the supplier actually compare in terms of offered price versus market price or to the willingness of price reduction compared to the other companies working on the same field as the evaluated supplier.

The last subcriteria from the cost side is the product cost. The value calculated in this section shows the overall price development of the products supplier offers to EADS Secure Networks. The more the cost reduction to the products can be achieved, the better the results are.

#### 5.5.5 Supplier profile

The main criteria of supplier profile is going to give an analysis of the supplier from both internal and external perceptiveness. The supplier profile is designed to show some data about supplier which are not that often compared in any way and don't have that much significance in supplier evaluation, but do provide some interesting specific information about what kind of supplier EADS Secure Networks actually has in its use. It also gives quite good overview of the supplier and includes subcriteria such as location, financial status, EADS share of production, facility, capacity, Contractual terms and conditions, and supplier co-operation.

The location is the first subcriteria measured for supplier profile and this meter includes some information where the supplier is located and what kind of risk there is that supplier will move to another country. In the evaluation process it has been taken to account the current benefits of the location country and what kind of issues the possible transfer to another country will have in terms of transportation, transportation cost and export control. Also the risks related to security and encryption matters have been taken to account when evaluating supplier's current country and the risks involved if the supplier would move another country.

The financial status of the supplier shows how good the situation the supplier has financially. If the financial situation is not good, it might have a negative input also for supplier's delivery and service capabilities towards EADS Secure

Networks. In measuring the financial status of the supplier there were used some financial information about the supplier (quick ratio and return on investment)

The subcriteria which shows the EADS Secure Networks share of production is very interesting figure as it shows how significant customer EADS Secure Networks actually is for the supplier. When the share is also known it can also give a an advantage in negotiations as the customer might be too important for the supplier to loose. However the comparison is not done in way that the bigger the share EADS Secure Networks has of the supplier the better, but it has also taken to account that too large share of production might also negative for EADS Secure Networks and therefore an optimum share of production would be about 30 %.

The facility subcriteria is describing how good the facility is which is used by the supplier. The advantages and disadvantages have been found out from the interviews conducted with operational purchasing and procurement persons (please see appendix 11).

The capacity of each supplier given to EADS Secure Networks can vary a lot and therefore the capacity EADS Secure Networks is using and might need in the future is reviewed for each supplier. If the supplier has a good capacity for its purposes and can increase it without difficulties in the future, it would result in a better grade.

Contractual terms and conditions are evaluated for each supplier by the responsible procurement person and it shows how well does the supplier actually comply in practise with the agreement made. The lower the number of compliances and exceptions there is the better the grade supplier receives.

Supplier co-operation is measured by the suppliers corresponding procurement persons. This subcriteria measures the satisfaction of supplier co-operation between the supplier and EADS Secure Networks. It takes to account the dialogue capability, partnership willingness and reliability to commitments.

## 5.6 Determining alternatives for AHP

The AHP analysis will be performed to five different suppliers which will be shown as suppliers A, B, C, D and E. Each of these suppliers are responsible of delivering products to EADS Secure Networks and can be categorized as key suppliers. It is good to note that all of these suppliers do not represent the same kind of manufacturing field or product field, but are focused on a specific product portfolios with a specialized manufacturing techniques. Some of the suppliers might have the ability to manufacture the items by themselves while others rely quite heavily on other suppliers and act only as a reseller. Therefore at some points it is very hard to compare the suppliers with each others as they are quite different by their nature.

## 5.7 Calculations made for AHP criteria

This chapter will describe the calculations which are made according the analytical hierarchy process. The first step in this analytical hierarchy process was the description of the five main criteria for the supplier evaluation. In the figure 11 can be seen how the analytical hierarchy process is building up from the main goal, all of the main criterias and all of the suppliers acting as alternatives.

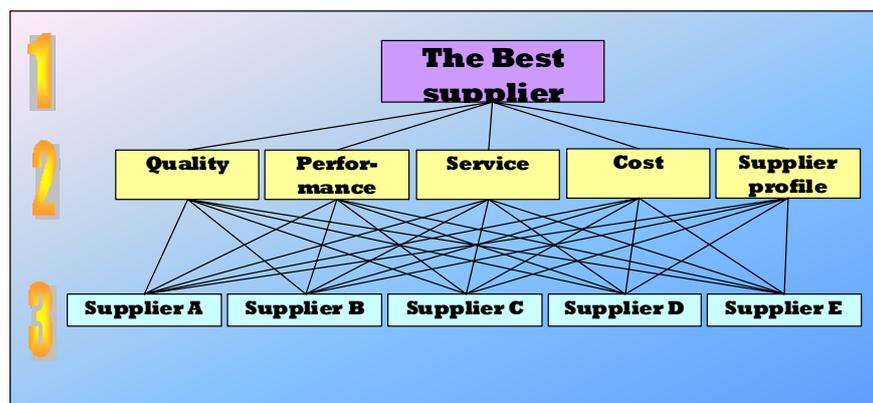


Figure 11. The three layers of AHP process.

In table 8 below can be seen how the matrix is conducted for all of these main criteria. In deciding the relations between the criteria the fundamental scale was used. As it can be seen from this table there are some criterias which are determined to be more important than the others.

Table 8: Table shows how each of the criteria is pairwised with each other.

	Quality	Performance	Service	Cost	Supplier profile
Quality	1/1	1/1	3/1	1/1	5/1
Performance	1/1	1/1	3/1	1/1	5/1
Service	1/3	1/3	1/1	1/3	3/1
Cost	1/1	1/1	3/1	1/1	5/1
Supplier profile	1/5	1/5	1/3	1/5	1/1

After the matrix of the main criteria were conducted, the next step would be the multiplying the matrix with itself after which it would be easy to calculate the normalization value which would be used as weight of each criteria in the analytical hierarchy process. In the table 9 below can be seen the first iteration for the main criteria.

Table 9: Table shows the result of multiplying the matrix shown in table 8 with it self. It also shows the eigenvector and normalized value received from the calculations.

	Quality	Performance	Service	Cost	Supplier profile	Eigenvector	Normalized value
Quality	5,00000000	5,00000000	13,66666667	5,00000000	29,00000000	57,66666667	0,28130081
Performance	5,00000000	5,00000000	13,66666667	5,00000000	29,00000000	57,66666667	0,28130081
Service	1,93333333	1,93333333	5,00000000	1,93333333	11,00000000	21,80000000	0,10634146
Cost	5,00000000	5,00000000	13,66666667	5,00000000	29,00000000	57,66666667	0,28130081
Supplier profile	0,91111111	0,91111111	2,46666667	0,91111111	5,00000000	10,20000000	0,04975610

As the first iteration of the matrix is not always accurate enough, each of the matrix calculated in this thesis had two iterations of the original matrix to be sure that the normalized value would be indeed calculated accurately. Table 10 shows the second iteration of the original matrix (or the same result is achieved by multiplying the matrix above once with itself).

Table 10: The second iteration round from the original matrix shown in table 8. The table shows the eigenvector and the normalized vectors used to calculate the weights for each of the main criteria.

	Quality	Performance	Service	Cost	Supplier profile	Eigenvector	Normalized value
Quality	127,84444	127,844444	344,8666667	127,844444	730,3333333	1458,73333	0,28083552
Performance	127,84444	127,844444	344,8666667	127,844444	730,3333333	1458,73333	0,28083552
Service	48,688889	48,6888889	131,4	48,6888889	278,2	555,666667	0,106977015
Cost	127,84444	127,844444	344,8666667	127,844444	730,3333333	1458,73333	0,28083552
Supplier profile	22,991111	22,9911111	62,02222222	22,9911111	131,4	262,395556	0,050516425

When comparing the results of the table 9 and table 10 it can be seen that the normalized values are differing from each other only on the later decimals. This means that the normalized vector achieved by the second iteration round is specific enough and all the next iterations would be changing the vector only on the last decimals which do not have a significance from the final result point of view.

The next step which is performed in the analytical hierarchy process is to decide the subcriterias weights for each of the main criteria. During the AHP process each of the subcriterias was evaluated in a pairwise comparison form according to the importance's which were seen inside EADS Secure Networks. The evaluation part resulted in a table 11 which can be seen below. Table 11 shows the evaluation done with the help of fundamental scale. The matrixes formed from each of these subcriterias were then calculated as final weights according to the same calculation methods described earlier for the main criteria.

Table 11: Matrixes which were used to calculate the subcriterias normalization values for each of the subcriterias to each supplier.

Quality	Audit result	Rejects/Quality defects	Defect analysis	Documentation	
Audit result	1/1	1/9	1/5	1/3	
Rejects/Quality defects	9/1	1/1	5/1	7/1	
Defect analysis	5/1	1/5	1/1	5/1	
Documentation	3/1	1/7	1/5	1/1	
Performance	CRD	OPD	ALD	TAT time	leadtime
CRD	1/1	3/1	1/1	3/1	3/1
OPD	1/3	1/1	1/1	1/1	1/1
ALD	1/1	1/1	1/1	1/1	3/1
TAT	1/3	1/1	1/1	1/1	1/1
leadtime	1/3	1/1	1/3	1/1	1/1
Service	Ease of communication	Process flex.	Response to changes	Information sharing	Satisfaction of Service / Customer Support
Ease of communication	1/1	1/1	3/1	1/1	1/1
Process flex.	1/1	1/1	3/1	1/1	1/1
Response to changes	1/3	1/3	1/1	1/3	1/5
Information sharing	1/1	1/1	3/1	1/1	1/1
Satisfaction of Service / Customer Support	1/1	1/1	5/1	1/1	1/1
Cost	Std vs ppv	Product cost	Price competitiveness		
Std vs ppv	1/1	1/1	1/1		
Product cost	1/1	1/1	1/1		
Price competitiveness	1/1	1/1	1/1		
Supplier profile	Location	Financial status	EADS share of production	Facility	Capacity
Location	1/1	1/1	1/3	1/3	1/3
Financial status	1/1	1/1	1/3	1/3	1/3
EADS share of production	3/1	3/1	1/1	1/1	1/1
Facility	3/1	3/1	1/1	1/1	1/1
Capacity	3/1	3/1	1/1	1/1	1/1
Contractual Terms and conditions	5/1	5/1	3/1	1/1	1/1
Supplier cooperation	3/1	3/1	3/1	3/1	3/1

Below can be seen table 12 which shows the overall situation about each of the criteria and shows the weights of each of the main criteria and subcriteria. This table is basically summarizing all the data which have been received from two multiplying iterations performed to table 11.

Table 12: From this table it can be seen how each of the main and subcriteria are weighted.

<b>Main criterias</b> <i>Criteria weight</i>	Quality 0,28083552	Performance 0,28083552	Service 0,106977015	Cost 0,28083552	Supplier profile 0,050516425
<b>Subcriteria</b> <i>Criteria weight</i>	<b>Audit results</b> 0,044227753	<b>CRD</b> 0,350882253	<b>Ease of communication</b> 0,226021571	<b>Price development</b> 0,3333333333	<b>Location</b> 0,050859338
	<b>Rejects/quality defects</b> 0,643689783	<b>OPD</b> 0,147426654	<b>Process flexibility</b> 0,226021571	<b>Price competitiveness</b> 0,3333333333	<b>Financial status</b> 0,050859338
	<b>Defects analysis</b> 0,229748996	<b>Average late days</b> 0,237303689	<b>Response to changes</b> 0,068632724	<b>Product cost</b> 0,3333333333	<b>EADS share of production</b> 0,119234623
	<b>Documentation</b> 0,082333468	<b>TAT for reclamations and repairs</b> 0,147426654	<b>Information sharing</b> 0,226021571		<b>Facility</b> 0,139793473
		<b>Leadtime</b> 0,116960751	<b>Satisfaction of service / customer support</b> 0,253302565		<b>Capacity</b> 0,139793473
					<b>Contractual terms and conditions</b> 0,225404185
					<b>Supplier co-operation</b> 0,27405557

In table 12 it can be seen that analytical hierarchy process has given quality, performance and cost factors the same weight (28 % each) which means that they all have the same relevant importance when analyzing the suppliers. The service has achieved of 10 % importance of the main criteria and the supplier profile is categorized as least important main factor with total of 5 % significance. After all of the weights are clear for each of the main and subcriteria it is time to carry on the analytical process with the information about the suppliers.

## **5.8 Analyzing suppliers achievements by each main criteria**

This chapter is concentrating in showing the results which are achieved by analytical hierarchy process. Each chapter will describe the results of the main criteria and show the suppliers ranking by the weights they have achieved.

### **5.8.1 Best supplier by quality criteria**

Suppliers quality in this supplier evaluation is conducting from 4 different subcriteria which are audit result, rejects/quality defects, defects analysis and documentation. The matrix which was used to calculate two iteration rounds to the matrix shown in table 13 below can be found from appendix 6. In the table 13 can be seen 2 separate matrixes which are then multiplied together to receive the final results for the supplier with best quality. The left sided matrix in table 13 shows the results which each of the supplier has received in the four sub-categories. This matrix is then multiplied with another matrix which includes all the weights for subcriteria.

Table 13: The table shows on the left side each of the weighted normalized results achieved by the second iteration round from the original matrix regarding the quality which is shown in appendix 6. On the right side are the weighted normalized results for each subcriteria.

SUPPLIER	Audit result	Rejects/Quality defects	Defects analysis	Documentation	CRITERIA	
A	0,076923077	0,090909091	0,129018632	0,164511537	0,0442278	Audit result
B	0,230769231	0,090909091	0,055090712	0,062666716	0,6436898	Rejects/Quality defects
C	0,230769231	0,272727273	0,343436011	0,443798674	X 0,229749	Defects analysis
D	0,230769231	0,272727273	0,343436011	0,164511537	0,0823335	Documentation
E	0,230769231	0,272727273	0,129018632	0,164511537		

As a result of the multiplying the 2 matrixes, shown in table 13 above, is a new table 14. This table 14 then shows the final results which is received for the quality matrix. In this table is shown a ranking about which supplier is the best the quality category. According to the information seen from the table 14 the supplier C has the best quality out of all of the suppliers and supplier B the worst. When viewing the results it can also be seen that suppliers C and D are quite close to each other, followed by the supplier E a little bit behind. The supplier A and B are according to the quality analysis are clearly behind the other suppliers.

Table 14: The table shows the final weighted results for each of the suppliers in quality section. On the right is displayed the results by rank.

Supplier	Weight	Rank
A	0,105106	4
B	0,08654	5
C	0,301202	1
D	0,278207	2
E	0,228945	3

### 5.8.2 Best supplier by performance criteria

In the performance part there are 5 criteria (CRD, OPD, ALD, TAT and leadtime) which are used to measure the performance of the supplier. The matrix which was used to calculate two iteration rounds to the matrix shown in table 15 below can be found from appendix 7. The first matrix describes the performance of the

supplier in each of the five categories and the second matrix is showing the weight for each of the criteria.

Table 15: The table shows on the left side each of the weighted normalized results achieved by the second iteration round from the original matrix regarding the performance which is shown in appendix 7. On the right side are the weighted normalized results for each of subcriteria.

SUPPLIER	CRD	OPD	ALD	TAT	Leadtime	CRITERIA
A	0,150230848	0,255154899	0,112257647	0,234749039	0,320209251	0,350882253 <b>CRD</b>
B	0,636672438	0,487594312	0,028932246	0,309942433	0,503630631	0,147426654 <b>OPD</b>
C	0,026918314	0,022713038	0,291727131	0,234749039	0,037872307	X 0,237303689 <b>ALD</b>
D	0,126032506	0,057859347	0,214598568	0,026083227	0,069143906	0,147426654 <b>TAT</b>
E	0,060145893	0,176678404	0,352484408	0,194476264	0,069143906	0,116960751 <b>Leadtime</b>

When these 2 matrixes shown in table 15 above are then multiplied with each other a new matrix is made which is shown in table 16. Table 16 is now showing that for the best performing supplier out of all is supplier B and the worst supplier is D. When the results are viewed more closely it can be again seen that the group of 5 suppliers is dividing into 2 separate sections. The supplier B is showing that it can perform clearly the best out of all suppliers. In the second category are the rest of the suppliers which are fairly close to each other and of course in terms of performance it is important that all of the suppliers could improve the level of their performance to the level of supplier B.

Table 16: The table shows the final weighted results for each of the suppliers in performance section. On the right is displayed the results by rank.

Supplier	Weight	Rank
A	0,189029253	2
B	0,406745945	1
C	0,121059424	4
D	0,115610095	5
E	0,167555193	3

### 5.8.3 Best supplier by service criteria

From service point of view there are total of 5 criteria (ease of communication, process flexibility, response to changes, information sharing, satisfaction of service/customer support) which are then forming up the service received from the supplier. The matrix which was used to calculate the two iteration rounds to the matrix shown in table 17 below can be found from appendix 9. In the table 17 shown below, the left matrix is showing up the information about the performance of each supplier in the 5 criteria and the right matrix is showing all the criteria.

Table 17: The table shows on the left side each of the weighted normalized results achieved by the second iteration round from the original matrix regarding the service which is shown in appendix 9. On the right side are the weighted normalized results for each subcriteria.

SUPPLIER	Ease of communication	Process flexibility	Response to changes	Information sharing	Satisfaction of Service / Customer Support	CRITERIA	
A	0,466458122	0,299815084	0,32028067	0,367874969	0,343436011	0,226021571	Ease of communication
B	0,193920824	0,208289488	0,113064352	0,367874969	0,055090712	0,226021571	Process flexibility
C	0,072850115	0,028964269	0,033189848	0,081598535	0,129018632	X 0,068632724	Response to changes
D	0,193920824	0,379830622	0,420400778	0,101052993	0,343436011	0,226021571	Information sharing
E	0,072850115	0,083100536	0,113064352	0,081598535	0,129018632	0,253302565	Satisfaction of Service / Customer Support

After the two matrixes are multiplied with each other, a new matrix is then received and it can be seen in the table 18 below. According the information in table 18 the best supplier in terms of service is supplier A and the worst is supplier C. The table also shows that that the differences between the service level is big and the difference between the best supplier and the worst 2 suppliers is clear.

Table 18: The table shows the final weighted results for each of the suppliers in service section. On the right is displayed the results by rank.

Supplier	Weight	Rank
A	0,365317631	1
B	0,195770877	3
C	0,076414173	5
D	0,268367385	2
E	0,094132188	4

#### 5.8.4 Best supplier by cost criteria

From cost point of view there were total of 3 criteria which were used to measure the suppliers performance (price development, price competitiveness and price competitiveness). The matrix which was used to calculate the two iteration rounds to the matrix shown in table 19 below can be found from appendix 8. In the table 19 on the left matrix can be seen the scores which suppliers have achieved in each of the criteria and on the right matrix can be seen the weight of each of the criteria.

Table 19: The table shows on the left side each of the weighted normalized results achieved by the second iteration round from the original matrix regarding the cost which is shown in appendix 8. On the right side are the weighted normalized results for each subcriteria.

SUPPLIER	Price development (standard price vs purchasing price variance)	Product cost	Price competitiveness	CRITERIA	
				Price development (standard price vs purchasing price variance)	Product cost
A	0,272727273	0,137692677	0,447315881	0,33333333	X 0,33333333
B	0,272727273	0,033526781	0,170608743	0,33333333	
C	0,090909091	0,282297712	0,170608743	X 0,33333333	
D	0,272727273	0,183972203	0,170608743		
E	0,090909091	0,362510627	0,040857889		

After both of the matrixes have been multiplied with each other, a new matrix is received and it is seen in table 20. From table 20 can be seen that the supplier A is performing the best on the cost side and the supplier B is the worst one. However when taking a closer look at the weight-values shown in the table it can be seen that between the suppliers B,C,D and E there is not much of an difference here and suppliers are quite close with each other, except for the supplier A who clearly outperforms all the rest.

Table 20. The table shows the final weighted results for each of the suppliers in cost section. On the right is displayed the results by rank.

Supplier	Weight	Rank
A	0,285911944	1
B	0,158954266	5
C	0,181271849	3
D	0,20910274	2
E	0,164759202	4

#### 5.8.5 Best supplier by supplier profile criteria

In terms of supplier profile there were total of 7 different criteria (location, financial status, EADS share of production, facility, capacity, contractual terms and conditions, and supplier co-operation) which were used to measure the total performance of the suppliers. The matrix which was used to calculate the two iteration rounds to the matrix shown in table 21 below can be found from appendix 10. In the table 21 can be seen the results for each of the suppliers for each of the criteria. The matrix seen on the left is multiplied with the matrix seen on the right for the total result in supplier performance.

Table 21. The table shows on the left side each of the weighted normalized results achieved by the second iteration round from the original matrix regarding the supplier profile which is shown in appendix 10. On the right side are the weighted normalized results for each subcriteria.

SUPPLIER	Location	Financial status	EADS Share of production	Facility	Capacity	Contractual Terms and conditions	Supplier co-operation	CRITERIA
A	0,26258393	0,24662737	0,11111111	0,14133797	0,16451154	0,11593386	0,28083552	0,05085934 Location
B	0,11499386	0,03994321	0,11111111	0,33586462	0,44379867	0,28681623	0,05051642	0,05085934 Financial status
C	0,13845317	0,11747743	0,11111111	0,33586462	0,06266672	0,03886377	0,28083552	0,11923462 EADS Share of production
D	0,22138511	0,53270273	0,33333333	0,14133797	0,16451154	0,2715699	0,28083552 X	0,13979347 Facility
E	0,26258393	0,06324926	0,33333333	0,04559482	0,16451154	0,28681623	0,10697701	0,13979347 Capacity
								Contractual Terms and conditions 0,22540419
								Supplier co-operation 0,27405557

In the table 22 shown below are the total results for supplier profile. The best supplier in supplier profile was the supplier D and the worst was supplier C. When the table is reviewed a bit closer it can be noted that the gap between the best and the worst supplier was not that big. Also supplier A,B,C and E all have achieved in very close scores which again shows that each of these suppliers are having very close performance to each other in this category.

Table 22. The table shows the final weighted results for each of the suppliers in supplier profile section. On the right is displayed the results by rank

Supplier	Weight	Rank
A	0,184998722	3
B	0,208614015	2
C	0,167701428	5
D	0,259030577	1
E	0,179655259	4

### 5.8.6 Best supplier according analytical hierarchy process

After all of the main criteria have been reviewed separately for the suppliers it is to move on to the final results made with the analytical hierarchy process in this supplier evaluation. In table 23 can be seen a matrix which now has all the information about suppliers performance in each of the 5 main criteria (quality, performance, service, cost and supplier profile) and the values included in it can be found in the concluding tables (green tables) of each of the previous chapters 5.8.1-5.8.5. Now the left matrix is finally multiplied with the right matrix which includes the weights of each main criteria and as a result is achieved the final table 24.

Table 23: This table shows all the values achieved from the final results from each of the subcriteria to each of the supplier. On the right side can be seen the weight of each of the main criteria.

SUPPLIER	Quality	Performance	Service	Cost	Supplier profile	CRITERIA	
A	0,105106057	0,189029253	0,365317631	0,285911944	0,184998722	0,28083552	Quality
B	0,086540309	0,406745945	0,195770877	0,158954266	0,208614015	0,28083552	Performance
C	0,301201636	0,121059424	0,076414173	0,181271849	0,167701428	X 0,106977015	Service
D	0,278207088	0,115610095	0,268367385	0,20910274	0,259030577	0,28083552	Cost
E	0,22894491	0,167555193	0,094132188	0,164759202	0,179655259	0,050516425	Supplier profile

In the table 24 can be seen that according to the all matrixes calculated earlier the race for the best supplier is actually a very close run, which has brought itself to a tie! The suppliers A, B and D actually perform with the same result! The difference between the top 3 suppliers is actually only 0,0035 and this variance is seen only after precise calculations with 9 decimals starting from the first matrixes. This kind of close competition was really not foreseen in the beginning of AHP. The fourth best supplier out of all was supplier number C and the supplier E was left as the last. However when looking at the bigger figure, all of the suppliers did perform very well and the difference between the best and the last supplier was only 0,03 which is little over 15 % of difference.

Table 24: The final weights for all of the suppliers according to the AHP process.

Supplier	Weight	Rank
A	0,21	1
B	0,21	1
C	0,19	4
D	0,21	1
E	0,18	5

The table 24 can be now seen as an official table of results regarding the supplier evaluation made in this thesis. The table shows that all of the suppliers did perform very identically in the end, but it was also interesting to see that all of the suppliers also had their strengths and weaknesses in the end and the final results were achieved also in a bit different ways. The next chapter will provide more information about the suppliers positioning in each of the main criterias and also some suggestions how their performance can be improved.

Although the analytical hierarchy process did show quite interesting results in the end, it would be still also interesting to see how the suppliers performed by their ranking in overall. The table 25 shown below describes the suppliers ranking according to analytical hierarchy process and by the ranking results each of the supplier received during the AHP calculations.

Table 25. The results for each supplier by different methods

Method	Supplier	AHP result	Average rank	Average rank (weighted)	Median
Supplier positioning	A	1	2,2	2,0	2
	B	1	3,2	2,6	3
	C	4	3,6	2,5	4
	D	1	2,4	2,3	2
	E	5	3,6	2,9	4

The table 25 offers some interesting information about the suppliers positioning with different calculation methods. According AHP model the suppliers A,B and D achieved the same results. If the suppliers positions are viewed by average ranks we can notice that supplier A has achieved the best results out of the five suppliers and it is closely followed by supplier D. The supplier C seems to have achieved a bit worse ranking results than A and D which would suggest that

supplier B has few very strong points which can lift its total performance in AHP process, but the bad ranking results in few other criteria leave it a bit behind the supplier A and D. According the average rank supplier C and E are having a tie in the lowest rankings, but when the criterias are weighted, the supplier C actually has the third best result. The median results in the table verify the different calculations that supplier A and D have a bit better overall performance than supplier B and the supplier C and D are left out as the last ones. The reason why there are some differences in the supplier field between the AHP results and ranking results are because the difference between two suppliers in AHP model can be quite big or small. The ranking however doesn't show how big or small the difference between the two suppliers is, but rather shows who was the best supplier and who was the worst worst supplier in each category.

Even though in this AHP process the calculations made showed that the suppliers are having quite equal total results it is good to remember that the results are a combination of weights set to the main criterias. In the beginning of this process it was valued that performance, quality and cost are the three most important factors because each of these criterias also have a large role on how the customers see EADS Secure Networks as their supplier in terms of product quality, delivery performance and product cost. The service and supplier profile were not valued as high as the three criterias mentioned earlier. But if the criterias would be weighted in a different way the results would be certainly a bit different and it might result in a bit different end results. For example adding more weight to the service criteria might give a bit better end result for supplier A. However the effect on the final order by changing the criterias wouldn't probably be big because the top three suppliers were better than suppliers C and E, but small differences might be achieved between the top 3 supplier.

## 6 DISCOVERIES MADE ABOUT SUPPLIERS AND EADS SECURE NETWORKS

This chapter is going to take a look on the results achieved in supplier evaluation performed by AHP. It is also going to provide some comments about EADS Secure Networks and what kind of improvements could be considered in the future for the company.

### 6.1 What AHP showed about suppliers?

In chapter 5.8 was reviewed the results received by the analytical hierarchy process, but what did those results actually show about the suppliers? And how can those results be interpreted?

First if we take a look at the table 24 shown in chapter 4.8.6 it can be seen that all of the suppliers have achieved, according to the analytical hierarchy process, a very similar final results. Although according to this table there were not much of difference in the final results of the supplier, there were quite many differences when suppliers were reviewed separately by each of main criteria. Table 26 below is showing how each of the suppliers ranked in each of the main criteria. These results were very interesting as they showed that each of the main criteria had a bit different supplier ranking. The results of this table are also reviewed in the chapters 6.1.1 – 6.1.5.

Table 26: Suppliers ranking by each of the main criteria.

Main criteria	QUALITY			PERFORMANCE			SERVICE			COST			SUPPLIER PROFILE		
	Supplier	Weighted result	Rank	Supplier	Weighted result	Rank	Supplier	Weighted result	Rank	Supplier	Weighted result	Rank	Supplier	Weighted result	Rank
Suppliers position	C	0,3012	1	B	0,4067	1	A	0,3653	1	A	0,2859	1	D	0,2590	1
	D	0,2782	2	A	0,1890	2	D	0,2684	2	D	0,2091	2	B	0,2086	2
	E	0,2289	3	E	0,1676	3	B	0,1958	3	C	0,1813	3	A	0,1850	3
	A	0,1051	4	C	0,1211	4	E	0,0941	4	E	0,1648	4	E	0,1797	4
	B	0,0865	5	D	0,1156	5	C	0,0764	5	B	0,1590	5	C	0,1677	5

The fact that by the final verdict all suppliers are quite close with each other in total performance can be also seen as a good sign at EADS Secure Networks. This is because if the overall performance of the suppliers is quite the same, it also shows that EADS Secure Networks has been able to get there suppliers work good and with the same kind of overall performance. So there is no single supplier which can cause a dramatic effect on the overall performance of EADS Secure Networks as well. However it is also good to note that when results showed that all the suppliers were close to each other in overall performance, the process did not tell that each of the suppliers had a very good performance overall, but that all the suppliers were close to each others performance.

#### 6.1.1 Strong and weak points for supplier A

The supplier A performed very well in the service and cost related measurements. During the interviews it was also noticed that people from operational purchasing and procurement were overall very happy with the service provided by the supplier A and this is of course very good that the relationship between the two parties are on this level. On the cost side the supplier A also provided very well performance and showed that it can compete on this very demanding market and provide also solutions which are cost effective, although the product costs for the supplier could be lowered a bit to provide even better performance in this segment. On the delivery side, the supplier A did provide quite good results by ranking up as second, but the overall performance could have been also better in this segment. In the performance segment it would important if supplier A would try to improve the CRD and OPD figures for EADS Secure Networks, because by improving the numbers in that section it could improve quite easily the overall performance to a better level and really try to compete with supplier B which is on a very good level at the moment.

When looking at the weaker points of the supplier A it is interesting to see that it wasn't left out last in any of the main criteria. The worst score it did receive was from the quality criteria in which it was ranked as fourth. In this segment it was behind the top 3 suppliers and for the supplier A this is indeed a point of improvement for the future. The results can be improved by reducing the amount of rejects/quality defects versus total deliveries which was reviewed to be on quite high level during the last audition. Also supplier A does have also clear improvements on the defect analysis-stage and for example the reclamations made to the supplier A are taking very long time to be analyzed at the moment. The only way to improve this is to push harder the supplier A to really improve the situation and describe their processes better so that the reclamation handling time would not be long because of bad processes.

#### 6.1.2 Strong and weak points for supplier B

When looking at supplier B we can see that it has the best performance main criteria result out of all of them and this is the really strong part of the supplier B. In the performance it can really out perform the rest of the suppliers, but it does have also a weak point in it and it is the ratio for average late days. This means that supplier B has quite long average late days compared to the other suppliers which is of course a point of improvement for the rest of the suppliers. Supplier B has also quite good results from the supplier profile and service level it provides. A good result in these sectors are showing that supplier B is seen from EADS Secure Networks point of view as a supplier which is able to provide good level of service to the company and the personnel of supplier B is really helpful although the contact persons towards EADS Secure Networks had changed quite often which had caused some extra work for the operational side of the supplier management.

When looking at the weaker points of supplier B we can notice that it was ranked as the worst supplier in both quality and cost segments. For supplier B the bad results in these two segments also meant that it suffered in the final AHP grades because it means that supplier B performed badly in two out of three most important criteria. Especially in quality the supplier B does have a great room of improvement as it was clearly behind the top 3 suppliers in that segment. Supplier B seems to have some difficulties to get good quality products on the product line as the ratio of rejects/quality defects versus total deliveries was only on average level and could be improved further on. The state of quality can be also seen reflecting on the EADS Secure Networks deliveries where the supplier B does have quite a lot of reclamations about defected products. Also defect analysis and documentation could be done in a better way as for example the current quality plan can be seen to be on a very general level without any specifications.

On the cost side the supplier B did rank as last and the main reason for this was actually that it performed badly against other suppliers in the product cost category. Many of the suppliers were able to reduce the prices of their products, but supplier B had actually some price increasings and this was seen as a bad sign. By improving its performance better on the product cost side and by achieving some cost reductions the performance of supplier B can be improved and this would also have an effect on the total ranking of supplier B in a positive way. It will be also interesting to see how supplier B can achieve some cost savings also by it own as its current financial situation is not looking good and there might be some organizational changes coming with it and it would be good for EADS Secure Networks also to prepare for them.

### 6.1.3 Strong and weak points for supplier C

According to the analytical hierarchy process the supplier C ranks itself as fourth although the gap is rather small to the top 3. When viewing the results of supplier C it can be seen that it has the best result in quality. Quality is very important for each supplier and for the supplier C it is clear that quality of the products and processes is something that the supplier has been putting effort on.

When looking at the weaker parts of the supplier C we can see that it is performing the worst in the service and supplier profile. What is really worrying is that supplier C has a very bad result in the service and it seems that it is really not that willing to work with the EADS Secure Networks. Many of the comments from interviews suggest that the relationship is not that good with supplier C and it is really hard to communicate with them. Of course this is very bad because the communication methods is also something that the companies are building their relationships also in the business of tomorrow so the level of communication is something to be expected to be improved by supplier C in the future. It is recommended for EADS Secure Networks that it would discuss in a strong way about the situation of current service level received with the supplier C and try to get some kind of solution to improve the situation as if the difficulties do go on with the supplier C it might have a great impact on the whole EADS Secure Networks delivery capability.

In supplier profile the supplier C did perform bad and it again verifies that it really has some issues in the level of service towards EADS Secure Networks. Especially weak part was the part where supplier should follow the contractual terms and conditions which again brings to the communicational issues described earlier. When looking on the performance table we can also notice that the performance of supplier C is the second weakest. The ALD and TAT seemed to be on a good level, but CRD, OPD and leadtimes are the worst of them all. This shows that supplier C does have great issues with its production as it cant really deliver anything on time.

After all of these comments it is strongly suggested that with supplier C would be created some improvement plan for performance and communication improvement so that it would not have such a negative effect on EADS Secure Networks daily business. If it seems that the supplier C is not recognizing the needs for it, it should be also considered to change the supplier to some other party who is able to respond to the customers needs in a more friendly and business-oriented way.

#### 6.1.4 Strong and weak points for supplier D

The supplier D is actually a very interesting supplier to examine as it can be seen that it has the best supplier profile and is achieving the second best result in cost, quality and service, but is failing quite badly on the performance side. As a verdict it can be said that supplier D actually delivered a good quality products with a good price, offers a good level of service and has a nice profile, but for some reason is not delivering their products in a good period of time.

When taking a look at the performance segment which is the weakest link for the supplier D it can be noticed that most of the problems for it come from bad OPD, TAT and leadtime figures. The TAT values seem to be on a quite bad level and this is a result of bad reclamation handling done by the supplier D. However due to the organizational changes there has been some improvement seen in the TAT performance of the supplier D. The key point in this is actually the willingness to serve EADS Secure Networks better and it seems that supplier D is moving to a right direction on this field, although the overall figures are not improved enough. The problems which supplier D has with OPD and leadtime figures is that it tries to promise a little too much to EADS Secure Networks and gets hits if it fails to do it. Therefore it shouldn't try to promise too fast delivery times if it is not able to fulfill them, but would rather confirm them for a bit ahead and then reconfirm it if they actually can deliver faster.

It is important that the supplier D would start to perform better for all of these figures in the future because it really does have the capabilities for a better result, but just doesn't have the will to show it. If the performance of supplier D could be pushed more closer to the result of supplier B it would be clear that the supplier D would be the best supplier of them all.

#### 6.1.5 Strong and weak points for supplier E

According to the supplier evaluation by analytical hierarchy process the supplier E had overall worst performance out of the five suppliers. Although the differences weren't that big, the supplier E was showing a poorer average performance than the top 3 suppliers. The best results supplier E received from quality and performance, although it was having average results from all of them. Also it can be questioned if the supplier E actually received the second best result in the OPD-field or not as it tries to confirm everything for as far away as possible and the starts to reconfirm many times the same order to achieve a good result. This kind of behavior sure brings good results, but it really doesn't make the performance of supplier E good. The good point for supplier E was that it was actually doing quite steady results as it ranked in each category as third or fourth, so harmonization is the key point for supplier E.

Overall the supplier E should also have some kind of improvement plan for it so that it could increase its total performance to a new level. In the improvement plan the points to improve would be at least defect analysis, CRD, leadtime, the whole service level, pricing of the products of supplier E, the facility of the supplier and the co-operation willingness of the supplier towards EADS Secure Networks. If even half of these points would be improved it would certainly show up as suppliers improved performance and also harmonizing the total performance of EADS Secure Networks suppliers.

## **6.2 Improvements made in EADS Secure Networks**

Although in this thesis the key point was the supplier evaluation by the AHP process it is also good to note that the supplier performance is not totally depending on the performance of the supplier, but the performance might be affected also by the customer demands.

On the quality side it is clear that the products production quality is depending on the quality which supplier is providing, but the quality can be also improved by the customer. In terms of quality it would be important also for the customer to start to demand a better kind of quality for the products and services supplier provides. If the supplier does not receive any kind of feedback on its products it is also hard for them to start really improving them. Also in case of EADS Secure Networks the quality improvements are also depending from it too, because it is also owning the rights for the products which supplier only produce. So to improve the quality, the R&D people from both companies should start to discuss more widely about the issues and co-operate in a better way than what is done at the moment.

On the supplier performance side EADS Secure Networks has also a great responsibility towards supplier, so that they would be able to provide a good performance figures to EADS Secure Networks. One of the issues which supplier might have is that it receives an order which doesn't not have a sufficient order leadtime as has been agreed. If the supplier wouldn't then be able to match EADS Secure Networks request date it would mean that the supplier has failed although the order still might be delivered well before the minimum order leadtime. This kind of problem is not caused only by EADS Secure Networks, but it can also be led to the end customer, who is for some reason ordering from EADS Secure Networks the order in insufficient order leadtime. This kind of behaviour should be carefully analyzed and it should be also made clear to the customer that if the order is not received in correct form with all the order details and sufficient leadtime it should not be accepted. This way the harm done further in the supplier

network can be minimized, because the actual problem is not the suppliers weak performance, but the customers too high demands. Also the knowledge about the character of the Professional Mobile Radio products is not totally clear to the customers. Each customer always has its items produced against an order because EADS Secure Networks has to always configure the products to a correct frequency, language package and security level. This can be done only after receiving the order with full details.

The other problem which is also relating to the performance of the supplier is the lack of information about the material amount to be ordered by EADS Secure Networks from the supplier. EADS Secure Networks inform each of the suppliers on a monthly basis the forecasts about the products it is going to be ordering. This way the supplier can always be preparing itself for the orders and acquire the material in advance. However on the supplier side it is also clear that they cannot store a huge amount of material in their warehouses so that the leadtime to the final customer could be reduced by some amount of time, as this kind of behaviour would result in huge stocks. Therefore the importance of the forecasts is very big and it is also something that should be made carefully each time. The problem with the forecasts that EADS Secure Networks provides is that they are only forecasts and do not represent the final figures which suppliers receives (for example the numbers forecasted can be postponed to the next months figures). The problem of inaccurate forecasts can be seen to come from three points: the market of security products, the inaccuracy provided by sales and the inaccuracy provided by the customer. The market of high security products which EADS Secure Networks deliverers are usually a type of market where the demand might be changing quite rapidly because the project might be cancelled or postponed. Also in some cases the orders might be actually larger than expected or with different configuration than expected. These kind of changes affect greatly the forecasts and can cause situation where the forecast accuracy four months beforehand and two months beforehand might be actually changing with tenths of percents. Also the demand two months beforehand and the actual orders have the same kind of changes.

So in order to improve the situation it should be made clear to the customers the order leadtime they should follow when placing the orders. The customers do actually play a very important role in their own leadtimes and if they fail to provide the information forward it is very hard to compensate the mistake further on. Also sales team should be more accurate with the figures they are providing to the supply chain so that warehouses would not have too much of products waiting for customer orders. Therefore the suggestion also is that the importance of the correct forecasts would be made clear to each player because inaccuracy can create huge difficulties not only to EADS Secure Networks, but with bullwhip effect to many of its suppliers, 2nd tier suppliers and so on. Also EADS Secure Networks could also start to monitor its forecasted figures compared against the ordered amounts. This could provide some valuable results about the company's own behavior and also give an ability to optimize the forecasted figures to a more realistic level. The measurement of forecast accuracy could be therefore added as one of the KPI's to be measured inside supply chain. Although it is good to note that even the best kind of corrective actions afterwards cannot save the forecast if the raw data is very far away from the actual figures.

In the supplier communication part it was noticed also that the communication between EADS Secure Networks and the supplier works best when it is honest, open-minded and co-operational. This is not the case with all of the suppliers at the moment and it would be also interesting to examine that why certain suppliers do not behave in the ways mentioned earlier. Is it because of personal relationships or maybe the lack of interest in the business with EADS Secure Networks? Whatever are the reasons it should be made also clear that if the open attitude is expected from the supplier, the same kind of attitude should be also used by the customer. The communication should be the same in both directions to avoid the issues.

When examining the costs, the importance of procurement and R&D people really comes in. The suppliers cannot always do the cost savings by themselves as the product specifications might not be theirs to decide or change. This means that procurement and R&D should always take an important role to negotiate with the suppliers about possible savings because in one end there is the person who can approve/reject the changes and in the other end there are persons who can only comment the way the improvements might be made from production point of view. This kind of co-operation would surely benefit the both. For some suppliers this kind approach has been taken, but some it could still be better.

Overall it can be said that the task to improve the suppliers performance in any of the categories mentioned in this thesis should be done in co-operation between EADS Secure Networks and the supplier. This way the actual improvements could be done in a better understanding with each other and the improvements needed would be commented from the both sides.

Also it was seen during the process that there was a clear need to measure different aspects of the suppliers with many different methods. The supplier evaluation is also something that should be given a larger role when developing the suppliers overall performance. It is also very interesting to measure suppliers with different methods and compare the results with some other study, but the important thing is that the measures which are performed should be balanced between different quantitative and qualitative factors. This way also some tacit knowledge which is not showing in any of the performance reports is also given a chance to be evaluated and noticed as it shows sides from suppliers which cannot always be measured in the traditional quantitative ways.

## **7 SUMMARY**

This thesis is covering the research done on supplier evaluation using analytical hierarchy process inside EADS Secure Networks Oy. The objective of the thesis is to provide some view of how the supplier evaluation can be done using analytical hierarchy process. In the practical form the main objectives were also to analyze the results about the best and worst supplier EADS Secure Networks Oy has and also provide some development ideas for the future benchmarks.

The main problem in the thesis is the need to know the best supplier which EADS Secure Networks has and try to give information on how the supplier performance could be increased for each of the suppliers. For making the supplier evaluation there are many different methods to choose from and for this thesis analytical hierarchy process was chosen. This was done because it would be interesting to see how quantitative and qualitative information handle with each other and for making an analysis where the suppliers are compared against each other.

The thesis starts by describing the basic principles of purchasing. Purchasing has evolved quite heavily during the last decades and is now involving many different tasks from basic purchases to supplier management and acquisition assistance. The basic purchases and purchasing efficiency are the most common objectives the purchasing has, but nowadays also the supplier relationship management, organizational goals and strategy thinking are bringing many new aspects to the traditional purchasing. The purchasing processes have also evolved during the years from the basic processes to a large whole which includes many subprocesses and e-documents.

The next chapter of the thesis goes down more deeply inside the supplier evaluation side by examining the quality and performance factors on the supplier field. The quality of the supplier can be understood in many different ways because quality has different kind of natures. Also determining what exactly is

quality is not that easy as it depends on the nature of the quality. For performance measurement there are many types of criterias which can be used for measuring suppliers performance. The most typical of them include time, costs and quality, but also services can be used for supplier performance evaluation. One key factor in a good supplier performance is the forecasts delivered by the customer to the supplier. Forecasts enable better planning for the supplier and can decrease the leadtime of the product significantly. However bad forecasts can also have a negative effects and create too large or too little stocks for all of the suppliers in the whole supply chain and therefore it is important that forecasting is done as effectively as possible, although forecasting should be always considered as a good estimation and nothing more.

After describing all of the background information about supplier management, purchasing and supplier evaluation methods the thesis will move on in describing the measuring method used in this thesis which is analytical hierarchy process. The analytical hierarchy process starts by determining the goal which should be achieved in the end of the process. After it is determined, there should be selected some evaluation criterias. The criterias can also include various subcriterias and this way the evaluation can be done on a very wide level. After criterias have been determined the last point is to describe the alternatives which are used for AHP process. When all of these points are described with pairwise comparisons, the calculation process can begin. AHP process is carried out by calculating eigenvector for each of the supplier which is then normalized to achieve the weight for each measurement. When the weights are calculated it is easy to carry out the process and determine which of the alternatives is the best in achieving the goal.

The next chapter of the thesis is concentrating on the case company EADS Secure Networks Oy which is one of the key hardware and software providers on the market for TETRA-solutions. The chapter also shows some of the ways the purchasing process is build at EADS Secure Networks after which it starts to describe the analytical hierarchy process in a real situation. One of the most time consuming matters of the thesis has been the constructions of the matrixes to each

of the main criteria, subcriteria and suppliers performances per criteria. It required much information about the supplier so that the pairwise comparison matrixes could be made. Also getting all of the formulas was not easy, but it provided quite good and important information about the suppliers. After the AHP model was carried out for EADS Secure Networks the results were a bit surprising as three suppliers ended in a tie. When examining the details of the AHP process it was noticed that the suppliers ended up in their results in different ways. Overall the best suppliers according to AHP were suppliers A, B and D which were followed by suppliers C and E.

The last chapter is concentrating in analyzing the results achieved in the last chapter. Supplier A had strong points in the service, cost and performance part, but the quality of this supplier was on a bit lower level. Supplier B had the overall best performance out of all which helped it to achieve good overall result by AHP. The problematic parts for supplier B were the quality and cost segments. Supplier C provided good results in the quality section, but had very low results on the service and performance levels. It was noticed that the supplier C was not really wanting to provide good service for EADS Secure Networks and the position of this supplier should be reviewed carefully before there are any further commitments towards this supplier. The supplier D achieved very good results on the cost, quality, service and supplier profile parts, but did fail a bit on the performance side. Part of the problem of supplier D:s performance is that it was too nice in the measurements and could start to improve its statistics simply by viewing how the data is calculated (for example confirmations). Supplier E was left out as the last one by AHP model and this was really no surprise as the supplier E had only received average results throughout the process. Supplier E should also try to improve its statistics in a bit better directions so that it won't have a negative impact on EADS Secure Networks business. When viewing on the EADS Secure Networks activity towards suppliers it was noticed that some of the current performance issues might be relating to inaccurate forecasting towards suppliers. Forecasting should be reviewed more carefully inside EADS Secure Networks and it should be also noted to the people who are making the forecasts

to include a bit more accurate data. Customers should also have more responsibility about the orders they place so that the leadtimes for the orders are set according to the agreement between EADS Secure Networks and the customer. The company should be also having more supplier performance evaluations by different criterias so that qualitative and quantitative information could be recorded and analyzed by different performance measurement tools also in the future.

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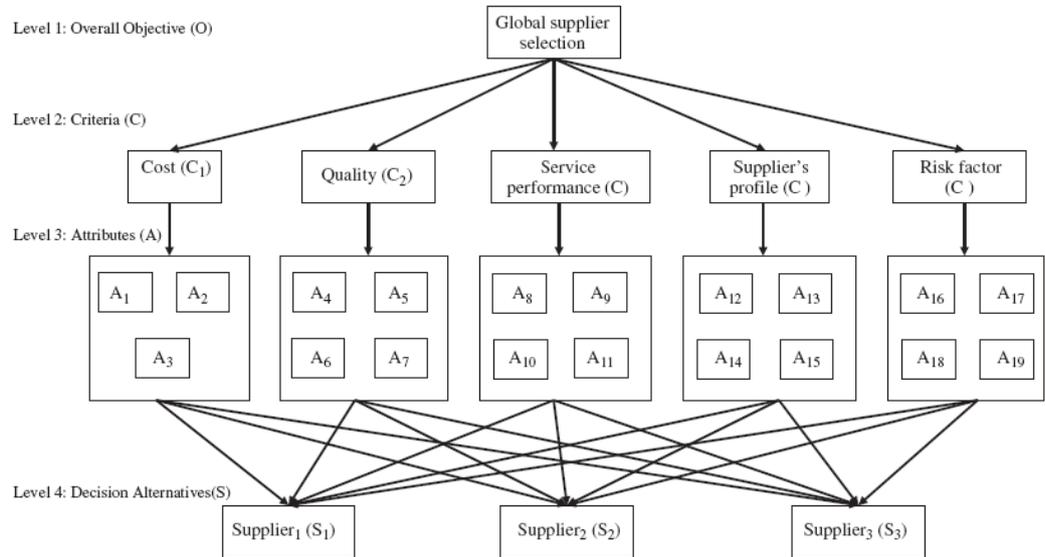
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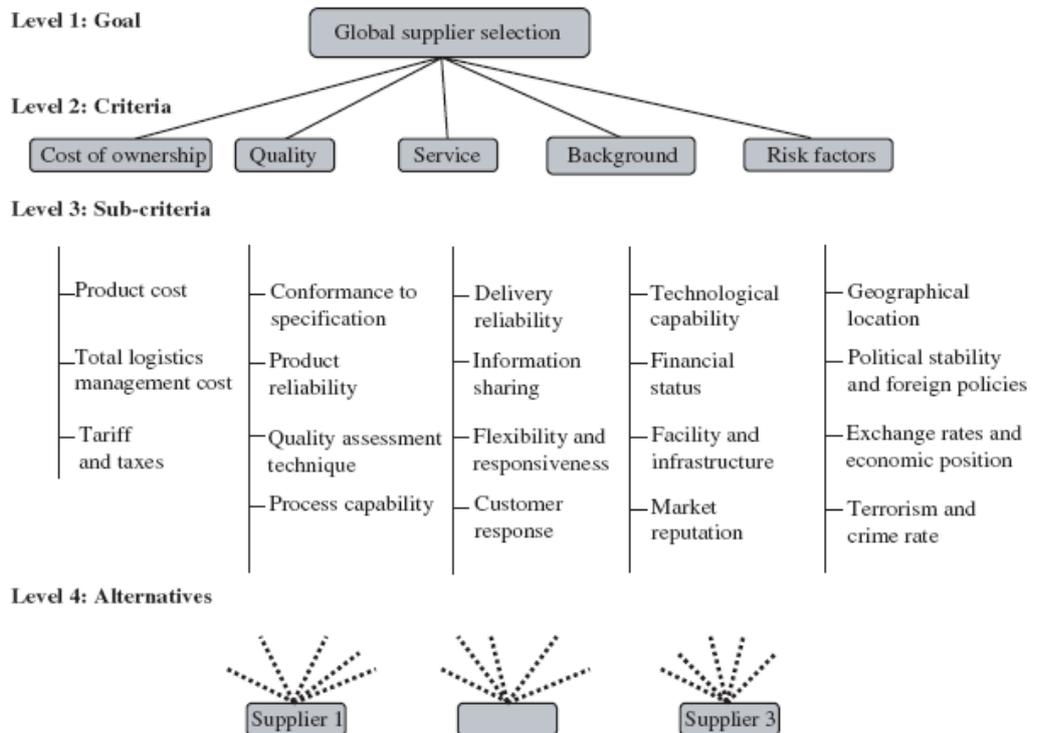
## INTERVIEWS

Fjällberg, Tommy	Tetra Supply & Demand Specialist	29.01.2009
Hakkarainen, Marko	NPI Manager	14.01.2009
Heteaho, Sami	Senior Sourcing Manager	21.01.2009
Jämsä, Ilona	Operational Purchaser	19.12.2008
Kananen, Hannele	Operational Purchaser	05.01.2009
Laitinen, Petri	Sourcing Manager	09.01.2009
Liimatainen, Virva	Sourcing Manager	08.01.2009
Vrieling, Mark	Operational Purchaser	07.01.2009

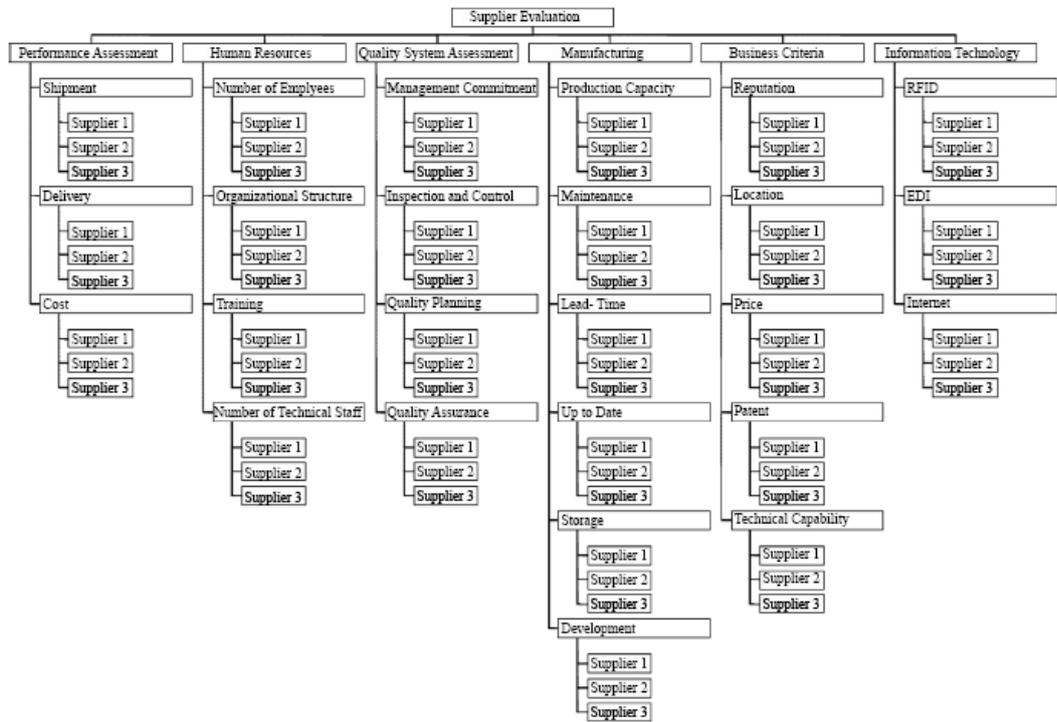
**APPENDICIES**



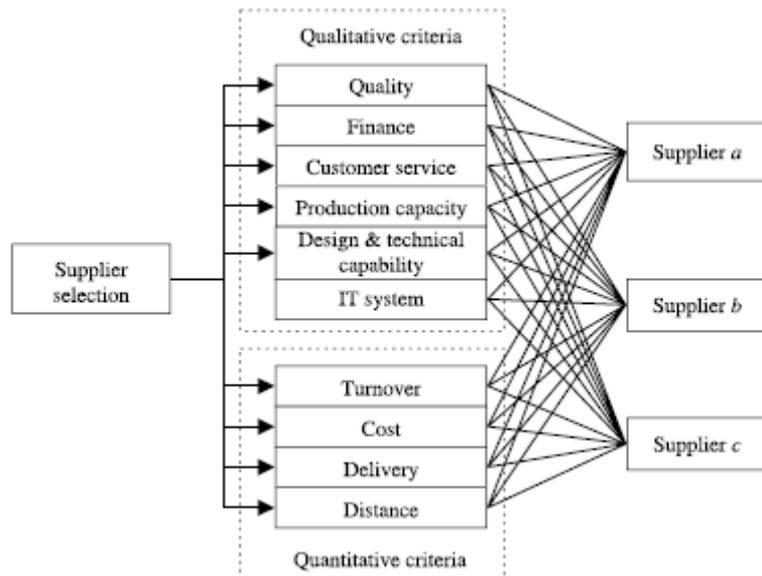
Appendix 1: Hierarchy for the global supplier selection (Chan, 2007, p.420)



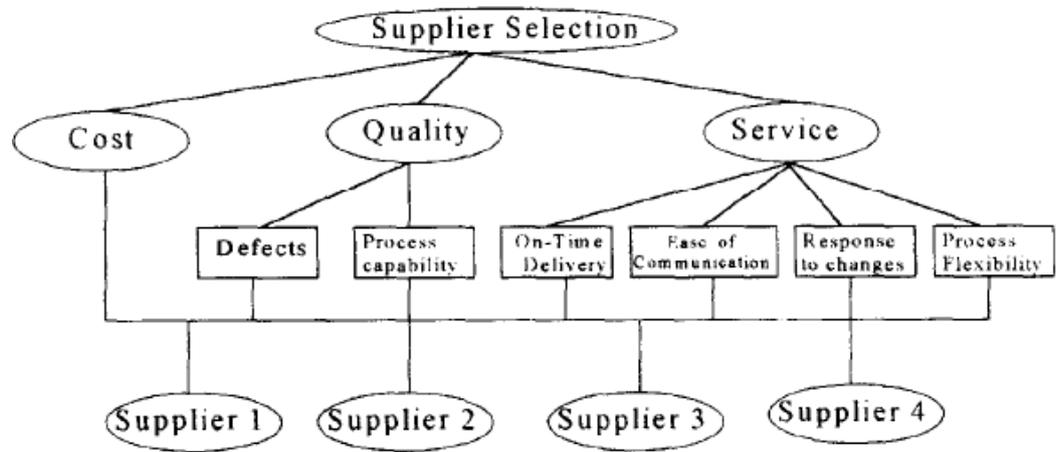
Appendix 2: Hierarchy for the global supplier selection (Chan, 2008, p.3834)



Appendix 3: Structure of supplier selection problem (Sevкли, 2008, p.129)



Appendix 4: Qualitative and quantitative criteria used in the supplier selection process (Yang, 2006, p. 931)



Appendix 5: Ghodsypour, 1998, p.205

<b>Audit result</b>	A	B	C	D	E
A	1/1	1/3	1/3	1/3	1/3
B	3/1	1/1	1/1	1/1	1/1
C	3/1	1/1	1/1	1/1	1/1
D	3/1	1/1	1/1	1/1	1/1
E	3/1	1/1	1/1	1/1	1/1
<b>Rejects/Quality defects</b>	A	B	C	D	E
A	1/1	1/1	1/3	1/3	1/3
B	1/1	1/1	1/3	1/3	1/3
C	3/1	3/1	1/1	1/1	1/1
D	3/1	3/1	1/1	1/1	1/1
E	3/1	3/1	1/1	1/1	1/1
<b>Defects analysis</b>	A	B	C	D	E
A	1/1	3/1	1/3	1/3	1/1
B	1/3	1/1	1/5	1/5	1/3
C	3/1	5/1	1/1	1/1	3/1
D	3/1	5/1	1/1	1/1	3/1
E	1/1	3/1	1/3	1/3	1/1
<b>Documentation</b>	A	B	C	D	E
A	1/1	3/1	1/3	1/1	1/1
B	1/3	1/1	1/5	1/3	1/3
C	3/1	5/1	1/1	3/1	3/1
D	1/1	3/1	1/3	1/1	1/1
E	1/1	3/1	1/3	1/1	1/1

Appendix 6: Matrixes which were used to calculate the quality normalization values for each of the subcriterias to each supplier.

CRD	A	B	C	D	E
A	1/1	1/7	7	1/1	5/1
B	7	1/1	9	9/1	9/1
C	1/7	1/9	1	1/7	1/5
D	1/1	1/9	7	1/1	3/1
E	1/5	1/9	5	1/3	1/1
OPD	A	B	C	D	E
A	1/1	1/1	9	7	1
B	1/1	1/1	9	7	9
C	1/9	1/9	1	1/7	1/9
D	1/7	1/7	7	1/1	1/7
E	1/1	1/9	9	7	1
Average late days	A	B	C	D	E
A	1/1	7	1/3	1/3	1/3
B	1/7	1	1/7	1/7	1/9
C	3	7	1	1/1	1/1
D	3	7	1	1/1	1/3
E	3	9	1	3	1/1
TAT for reclamations and repairs	A	B	C	D	E
A	1/1	1/1	1/1	9	1/1
B	1/1	1/1	1/1	9	3
C	1/1	1/1	1/1	9	1/1
D	1/9	1/9	1/9	1	1/9
E	1/1	1/3	1/1	9	1/1
Leadtime	A	B	C	D	E
A	1/1	1/3	7	7	7
B	3	1/1	7	7	7
C	1/7	1/7	1	1/3	1/3
D	1/7	1/7	3	1/1	1/1
E	1/7	1/7	3	1/1	1/1

Appendix 7: Matrixes which were used to calculate the performance normalization values for each of the subcriterias to each supplier.

Price developement (standard price vs purchasing price variance)	A	B	C	D	E
A	1/1	1/1	3/1	1/1	3/1
B	1/1	1/1	3/1	1/1	3/1
C	1/3	1/3	1/1	1/3	1/1
D	1/1	1/1	3/1	1/1	3/1
E	1/3	1/3	1/1	1/3	1/1

Product cost	A	B	C	D	E
A	1/1	5/1	1/3	1/1	1/3
B	1/5	1/1	1/7	1/7	1/7
C	3/1	7/1	1/1	1/1	1/1
D	1/1	7/1	1/1	1/1	1/3
E	3/1	7/1	1/1	3/1	1/1

Price competetiveness	A	B	C	D	E
A	1/1	3/1	3/1	3/1	7/1
B	1/3	1/1	1/1	1/1	5/1
C	1/3	1/1	1/1	1/1	5/1
D	1/3	1/1	1/1	1/1	5/1
E	1/7	1/5	1/5	1/5	1/1

Appendix 8: Matrixes which were used to calculate the cost normalization values for each of the subcriterias to each supplier.

Ease of communication	A	B	C	D	E
A	1/1	3/1	5/1	3/1	5/1
B	1/3	1/1	3/1	1/1	3/1
C	1/5	1/3	1/1	1/3	1/1
D	1/3	1/1	3/1	1/1	3/1
E	1/5	1/3	1/1	1/3	1/1
Process flexibility	A	B	C	D	E
A	1/1	1/1	9/1	1/1	5/1
B	1/1	1/1	7/1	1/3	3/1
C	1/9	1/7	1/1	1/9	1/5
D	1/1	3/1	9/1	1/1	5/1
E	1/5	1/3	5/1	1/5	1/1
Response to changes	A	B	C	D	E
A	1/1	3/1	7/1	1/1	3/1
B	1/3	1/1	5/1	1/5	1/1
C	1/7	1/5	1/1	1/9	1/5
D	1/1	5/1	9/1	1/1	5/1
E	1/3	1/1	5/1	1/5	1/1
Information sharing	A	B	C	D	E
A	1/1	1/1	5/1	3/1	5/1
B	1/1	1/1	5/1	3/1	5/1
C	1/5	1/5	1/1	1/1	1/1
D	1/3	1/3	1/1	1/1	1/1
E	1/5	1/5	1/1	1/1	1/1
Satisfaction of Service / Customer Support	A	B	C	D	E
A	1/1	5/1	3/1	1/1	3/1
B	1/5	1/1	1/3	1/5	1/3
C	1/3	3/1	1/1	1/3	1/1
D	1/1	5/1	3/1	1/1	3/1
E	1/3	3/1	1/1	1/3	1/1

Appendix 9: Matrixes which were used to calculate the service normalization values for each of the subcriterias to each supplier.

Location	A	B	C	D	E	
	A	1/1	3/1	5/1	1/1	1/1
	B	1/3	1/1	3/1	1/3	1/3
	C	1/5	1/3	1/1	3/1	1/5
	D	1/1	3/1	3/1	1/1	1/1
	E	1/1	3/1	5/1	1/1	1/1
Financial status	A	B	C	D	E	
	A	1/1	5/1	3/1	1/3	5/1
	B	1/5	1/1	1/3	1/9	1/3
	C	1/3	3/1	1/1	1/5	3/1
	D	3/1	9/1	5/1	1/1	9/1
	E	1/5	3/1	1/3	1/9	1/1
EADS Share of production	A	B	C	D	E	
	A	1/1	1/1	1/1	1/3	1/3
	B	1/1	1/1	1/1	1/3	1/3
	C	1/1	1/1	1/1	1/3	1/3
	D	3/1	3/1	3/1	1/1	1/1
	E	3/1	3/1	3/1	1/1	1/1
Facility	A	B	C	D	E	
	A	1/1	1/3	1/3	1/1	5/1
	B	3/1	1/1	1/1	3/1	5/1
	C	3/1	1/1	1/1	3/1	5/1
	D	1/1	1/3	1/3	1/1	5/1
	E	1/5	1/5	1/5	1/5	1/1
Capacity	A	B	C	D	E	
	A	1/1	1/3	3/1	1/1	1/1
	B	3/1	1/1	5/1	3/1	3/1
	C	1/3	1/5	1/1	1/3	1/3
	D	1/1	1/3	3/1	1/1	1/1
	E	1/1	1/3	3/1	1/1	1/1
Contractual Terms and conditions	A	B	C	D	E	
	A	1/1	1/3	5/1	1/3	1/3
	B	3/1	1/1	7/1	1/1	1/1
	C	1/5	1/7	1/1	1/5	1/7
	D	3/1	1/1	5/1	1/1	1/1
	E	3/1	1/1	7/1	1/1	1/1
Supplier cooperation	A	B	C	D	E	
	A	1/1	5/1	1/1	1/1	3/1
	B	1/5	1/1	1/5	1/5	1/3
	C	1/1	5/1	1/1	1/1	3/1
	D	1/1	5/1	1/1	1/1	3/1
	E	1/3	3/1	1/3	1/3	1/1

Appendix 10: Matrixes which were used to calculate the service normalization values for each of the subcriterias to each supplier.

Appendix 11: Interview form used for making interview to operational purchasing and procurement persons involved with each of the suppliers reviewed.

***Ease of communication:***

How easy do you think it is to get in contact with your supplier?

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How good are is the level of communication between you and your counter part?

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Are there any communicational issues with your supplier?

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What kind of grade would you give to the supplier about the communication level between them and EADS? (GRADE)

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***Process flexibility:***

When your supplier has been requested to change some process, how difficult was it in practise?

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Has your supplier been proactive in changing some bad processes?

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How flexible processes do you think your supplier has? (GRADE)

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***Response to changes:***

Do you think your supplier is able to respond to rapid changes?

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Do you think your supplier will go through some organizational changes in near future?

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How would you grade your supplier about the response to changes? (GRADE)

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***Information sharing:***

Do you think your supplier shares enough information?

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What kind of issues do you usually encounter because lack of communication?

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How could supplier improve their level of communication?

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How would you grade information sharing level of your supplier? (GRADE)

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***Facility & capacity:***

How modern the facility of your supplier is?

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Is it efficient?

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Do you think it has enough capacity for EADS needs?

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Do you think EADS should use the capacity supplier provides in a better way?

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How would you grade the status of facility & capacity of your supplier?  
(GRADE)

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Grading:

- 1 = Poor
- 2 = Unsatisfying
- 3 = Satisfying
- 4 = Good
- 5 = Excellent

Appendix 12: Questions used in interview about the forecasting (Fjällberg, 2009)

- 1) What is the purpose of the forecast?
- 2) What is the time horizon?
- 3) What forecasting technique(s) is/are most appropriate?
- 4) On what data must the forecast be based and how shall it be analysed?
- 5) In what form shall the completed forecast be presented?
- 6) How accurate is the forecast?