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Operational Excellence in Supply Chain Management

- Using a Holistic View and Key Performance Indicators -

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Acknowledgements

During our last course within the master program of mechanical engineer we came in contact with Ericsson Mobile Platforms (EMP) where we expressed our wishes to write our master thesis. The opportunity to work with an international company and within the area of procurement was well aligned with our wishes and our academic background. The purpose of this study is secure operational excellence at the department of procurement and supply at EMP. The study was conducted during the autumn of 2008 and equals 30 hp.

We want to take the opportunity to thank our supervisor Peter Unelind, Julia Moore and everybody at the department of Procurement and Supply who have supporting us through this study. We also want thank our supervisor, Everth Larsson, at the department of Industrial Management and Logistics at the faculty of engineering, Lund University. To everyone else who have been interviewed and supporting us along the way, thank you.

Lund, February 2009

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Abstract

Background Ericsson Mobile Platforms delivers platform technology to mobile handset developers. Because of the short product life cycle on mobile phones, EMP's delivery performance and supply reliability is crucial. In order for EMP to keep control of the supply process, performance measurements have been established. Prior to 2007 only the supply performance of ASICs[1] (Application Specific Integrated Circuits) were monitored by EMP. This was due to the strategic importance of these components, both from an economical and a platform functionality perspective. The measurement system used today, which also includes PCBs (Printed Circuit Boards) have been used since the beginning of 2008. The objective to start measuring on the EMP internal performance and their suppliers' performances has been to increase the control of the supply process and to be able to proactively work with improvements and changes in the supply set-up.

Purpose The purpose is to achieve and/or create a foundation for future improvement regarding efficiency and effectiveness in the flow of goods and information and the way of work within the procurement process. This will be done through securing operational excellence in supply chain management through use of KPIs, way of working and information flow.

Method The authors need to look at the department from a broad perspective, a holistic view, which makes the systems approach most suitable for the study. To be able to quickly build up a broad foundation of understanding and information, a qualitative approach consisting of interviews with key people and observations will be conducted. Because knowledge within the research area to some extent does exist, the study method will be a combination of explanative and normative. The authors want to seek deeper knowledge within specific areas to be able to present suggestions of improvements.

Conclusions The transparency within the Procurement and Supply's department (from now abbreviated P&S) was not satisfactory and there was found a few information gaps within the internal process. These gaps are identified and suggestions how to increase the information transparency are presented. To eliminate the gaps, new measurements and redefinitions of the existing measurement are suggested. The authors have developed the, already existing, documenting system for analysing failures in the KPIs. The analysis, called root cause analysis, is important for the continuous improvement work of the process and the measurements. Recommendations of what to include in the new supporting system to secure transparency and to simplify the work in the root cause analysis have also been done. An investigation of how the suppliers perceive the P&S work and what they think is important in the working relation between them and EMP has been made to support the establishment of new measurements. Criterion have been set up on when and how new suppliers shall be measured on their performance.

Key words Operational excellence, process control, performance measurement.

[1] Application Specific Integrated Circuit (ASIC) is the name for an integrated circuit (IC) design with a specific functionality.

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1 Introduction

In the introduction the background of the master thesis will be described. Reasoning about question formulation, purpose, focus, delimitation and target group will be presented.

1.1 Background

Ericsson Mobile Platforms delivers platform technology to mobile handset developers. Because of the short product life cycle on mobile phones, EMP's delivery performance and supply reliability is crucial in order to retain and attract new customers. In order for EMP to keep control of the supply process, performance measurements have been established. Prior to 2007 only the supply performance of ASICs[2] (Application Specific Integrated Circuits) were monitored by EMP. This was due to the strategic importance of these components, both from an economical and a platform functionality perspective. The measurement system used today, which also includes PCBs (Printed Circuit Boards) have been used since the beginning of 2008.

The objective to start measuring was to increase the control of the supply process and to be able to proactively work with improvements and changes. One of Ericsson's watchwords during the last year has been "Operational Excellence", which corresponds well with Procurement and Supply's ongoing work with performance measurements. In order to increase the effectiveness and efficiency within the department correct measurements and indicators need to be in place. Increased control and visibility of the process and its outcome increases the possibility to carry out improvements based on sound knowledge that will have a positive effect on the process and the performance.

Important is that the established measurements are well aligned with the Procurement and Supply's and the overall objective of the company. EMP's overall mission is "To be the leading mobile platform supplier, with complete and optimized solutions in all segments, making our customer truly successful"[3] and if we look at the Procurement and Supply's mission it is "To focus on efficient, responsive and reliable match of supply and demand and doing this through, an optimal flow of information, goods and cash"[4].

1.2 Problem Discussion

The master thesis will investigate the accuracy of the established performance measurements according to the missions stated above. As said earlier, the past year is the first full year using the today's measurements. EMP therefore sees it as important to evaluate whether the measurement system has the right focus, if all important steps of the process as a whole are measured and the right information is gathered.

[2] Application Specific Integrated Circuit (ASIC) is the name for an integrated circuit (IC) design with a specific functionality.
[3] Ericsson internal information (2008-09-30)
[4] Ericsson internal information (2008-10-01)

1.3 Question Formulation

Based on the information regarding EMP's performance measurement system presented above, three questions were formulated:

- *Having the departments mission in mind, is there any potential gaps that today's measurements system are not taking into consideration?*

- *From a process control perspective, is the performance measurement system measuring all important activities throughout the process as well as the process as a whole?*

- *Is the system taking both customer and supplier important factors into consideration?*

To conclude; *How can the department of Procurement and Supply secure Operational Excellence by using KPIs and process control to ensure that their mission is achieved in an effective and efficient way?*

1.4 Purpose

The purpose of this study is to achieve and/or create a foundation for future improvement regarding efficiency and effectiveness in the flow of goods and information and the way of work within the procurement process. Listed below are the two main areas of focus throughout the master thesis.

- Secure Operational Excellence in Supply Chain Management through use of KPIs, "way of working" and information flow.

- Establish a foundation for improved process control to secure that the organisation/department works both effectively and efficiently.

1.5 Focus and Delimitation

When an external customer is discussed throughout the master thesis, the customer of small volume prototype phones, phone boards for laboratory testing[5] and ASIC prototypes (called PAS, short for Prototype ASIC Supply) are intended. Internal customers are known as in-house/outsourced manufacturing, R&D and reference design. The main focus of the master thesis is the internal procurement process and its performance measurement system. Because of the characteristic of EMP's work and business model (for further readings see the following chapter) the procurement department is only ordering for small scale prototype production and external demand in prototype phase.

As mentioned before, a holistic approach is intended. During the first interviews with the customer project manager, David Håkansson, the authors were informed that contacting customers and asking them to answer a survey will be very hard. Therefore the external customer side of the holistic approach will be disregarded. This is further explained in the empirical chapter.

In the next chapter the authors describes an organisational change that is about to happen, a joint venture with ST-NXP Wireless. At the time when the master thesis is conducted the information on how this will affect the department Procurement and Supply is still unknown, therefore the joint venture is not further discussed throughout the study.

The focus of the thesis will be more of operational nature than strategic. Identification of gaps in the measurements system is sought for in order to make sure all the important steps within the process are measured and that the measures are aligned with the mission statement.

1.6 Target Group

The primary target group of this master thesis is the department of Procurement and Supply at Ericsson Mobile Platforms who has formulated the assignment together with the authors.

Except for EMP the study shall also be of interest to the Faculty of Engineering and the department of Industrial Management and Logistics, people with a certain interest of the area and younger students within the same area of focus.

1.7 Disposition

The master thesis' disposition is shown below in figure 1-1. In the *Introduction* the question formulations will be discussed and the purpose of the thesis declared. After that a brief *Presentation of Ericsson,* EMP and the department where the study is done will follow and after this the *Methodology* and the thesis' approach will be discussed.

The *Theory* chapter will give the reader background knowledge and information needed in order to easily follow the authors' thoughts throughout the study.

Empirical findings will be discussed and presented in this chapter.

In the *Analysis* chapter, the previously presented theory will be used as baseline in order to discuss the empirical findings and to confirm the conclusions that will be drawn. Improvements and changes will be presented in this chapter based the analysed empirical findings.

The last chapter of the thesis will briefly describe the findings and *Conclusions* that have been made and presented in the analysis. *Recommendations* for further investigations and improvements will be presented.

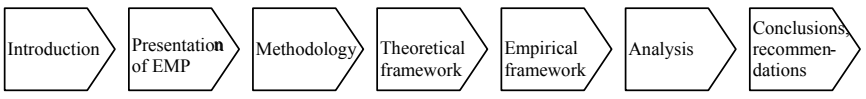

Figure 1-1, The disposition of the thesis.

2 Presentation of Ericsson Mobile Platforms

This chapter will give the reader a brief introduction to the company and the organisation where the study is carried out.

2.1 Ericsson

Ericsson was founded in 1876 by Lars Magnus Ericsson when he saw the potential to improve and develop the technical quality of the phone communication. Today Ericsson is a world-leading provider of telecommunications equipment and related services to mobile and fixed network operators globally. Ericsson is one of few companies that offer end-to-end solutions for all major mobile communication standards.

As shown in figure 2-1, Ericsson is organised in three different business units (Networks, Global Services and Multimedia). Mobile platforms, henceforth EMP, is a part of the Multimedia business unit. The multimedia business unit includes; service layer products (applications and end-user services), revenue management systems, enterprise solutions and mobile platforms.

When Ericsson and Sony formed a joint venture, in October 2001[6], the development unit for mobile phones, Ericsson Mobile Communications, was split into two parts, the mobile phone development and the platform development. The mobile phone development was Ericsson's contribution to the 50/50 joint venture and the platform development became the foundation for what today is named Ericsson Mobile Platforms.[7]

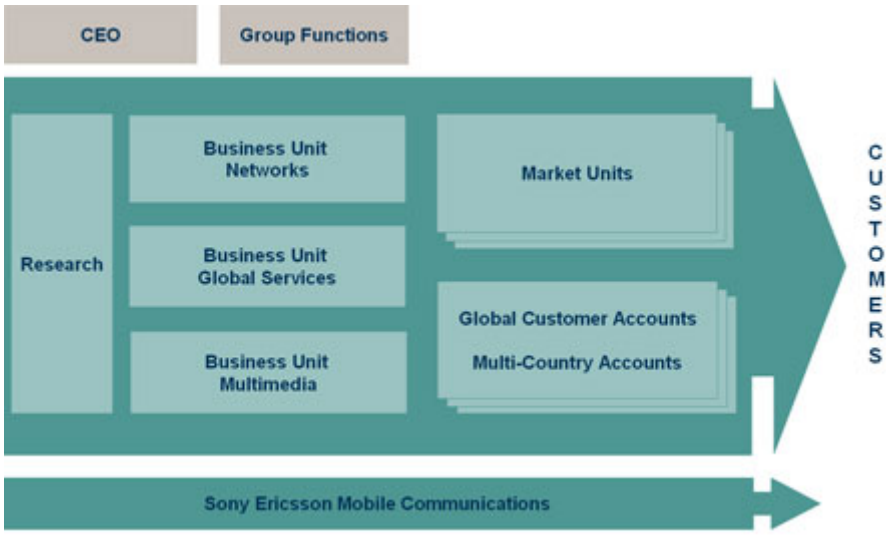

Figure 2-1, Ericsson organisation

[6] <www.sonyericsson.com>, 2008-10-02

[7] Kornby Michael , 2005. "The EMP Story". Ericsson Review, No.1

2.2 Ericsson Mobile Platforms

In January 1st, 2007, EMP became a unit within Business Unit Multimedia in Ericsson. The mission of EMP is: "To be the leading platform supplier, with complete and optimised solutions in all technology segments, driving the market to make our customers successful".[8]

2.2.1 Joint venture (EMP and ST-NXP Wireless)

In August 20, 2008 Ericsson announced that Ericsson Mobile Platforms and ST-NXP Wireless will merge into a joint venture. Together the two companies will create a strong player in the semiconductor and platform industry for mobile applications. Their main customer will be companies such as Nokia, Samsung, SonyEricsson, LG and Sharp. The new company will employ approximately 8000 people and have its head quarter in Geneva, Switzerland. At the point of writing the new company is not in place as a legal entity and has yet not been named.

The two companies carry complementary technology, EMP with its platform technology and ST with semiconductor solutions. Together they will offer a one-stop-shop solution for its customers, providing everything needed for the mobile handsets manufacturer. Driving factors behind the joint venture are the customers' demand for a single supplier that offers a complete solution, taking full responsibility for the offer and the increasing competition on the market. The growth in scale, responsibility and offering will increase the new company's competitive advantage and make it a satisfactory competitor to the today's market leader, Qualcomm. The new company will be a so called "fables semiconductor company", which means that the silicon technology and manufacturing capabilities will be outsourced to foundries, assembly and test suppliers. Still, a complete offer will be proposed to the customers.

2.2.2 Products and customers

EMP's product portfolio consists of mobile terminal technology within GSM/GPRS[9], EDGE[10] and WCDMA[11] standards. Some part of the technology that EMP provides is sourced from external suppliers. This will decrease with the extended technology portfolio and ownership of its value chain within the joint venture.

EMP's complete offer is based on a comprehensive intellectual property portfolio consisting of; integrated circuit design, platform software, complete design of reference phones, test software and support services. This all together creates a platform system that is tested and proved to work in most of the major networks throughout the world.

2.2.3 Organisational structure

Appendix 1 shows the organisational structure of EMP, which is functionally organised and structured with its own administrative functions. The Sourcing and Supply function is located right below the vice president of EMP. Sourcing and Supply is divided into three separate functions; Procurement and Supply, Hardware Strategic Sourcing and Software Strategic Sourcing. The study will be conducted within the Procurement and Supply department that is responsible for the supply of material to reference design builds and distribution of sample

[8] <www.ericsson.com>, 2008-09-08
[9] Global System for Mobile communication/General Packet Radio System
[10] Enhanced Data rates for Global Enhancement
[11] Wideband Code-Division Multiple Access

ASICs (Project Procurement).[12] Procurement and Supply is also responsible for procurement of indirect material and services (IM&S) and projects regarding the supply chain (Supply project).

EMP's business model makes EMP's supply involved only in the early maturity phase of a component. EMP, together with a supplier, jointly develops the specific ASIC components.

[12] Peter Unelind, 2008-10-05

3 Methodology

The methodology chapter describes the approach the study uses to achieve the purpose stated in the first chapter.

3.1 Research Approach

The three methodological approaches used in business research are the analytical, the systems and the actors approach, which will be further described within this section.

3.1.1 The analytical approach

The analytical approach is based on classic analytical philosophy and claims that the reality has a summative character. By breaking down big problems into smaller problems and solving each of them separately, the answer to the bigger problem is the sum of all the answers to the smaller problems according to the analytical approach. Knowledge acquired through the analytical approach is considered to be independent of the observer and being based on a formal logic that disregards from the subjective experience.[13]

The analytical approach needs an existing theory, towards a hypothesis is verified or falsified. The verified or falsified hypotheses then constitute parts of the objective reality accordingly. The result of studies using this approach should be presentable in cause-effect relations, logical models and/or representative cases with generalisable characteristic to be possible prerequisite in future research.[14]

3.1.2 The systems approach

If we compare the systems approach with the analytical approach we see that the systems approach does not have a summative character, instead it has a holistic view meaning that the sum of the parts differ from the whole. Systems approach does not only put value into each different part but also in the relation between the parts, which can lead to positive or negative synergies.[15]

Knowledge that is acquired through the systems approach is considered to be dependent on systems or classes of systems. This approach explains parts as through the characteristics of the whole and without some of the parts the risk of affecting the whole picture is considered severe.[16]

3.1.3 The actors approach

The actors approach is based on that concept within the social reality are ambiguous and constantly reinterpreted. The human beings are seen as the generating actors who create the reality at the same time as reality create them. Because of these assumptions the reality that is described by a specific researcher is dependent on its experiences and actings.[17]

[13] Arbnor and Bjerke (1994) *Företagsekonomisk metodlära,* p. 49-64
[14] Ibid p. 49-64
[15] Ibid p. 49-70
[16] Ibid p. 49-70
[17] Ibid p. 49-79

What makes the actors approach so much different from the analytical and systems approach is that it claims that the core of knowledge comes from understanding/meaning for the subject. In this way ambiguity is therefore both desired and needed to create knowledge.[18]

The result from a study done with the actors approach leads to growing knowledge of those processes that socially constructs the reality. The results are presented in different forms of descriptive language, ideal-typified language and emancipatory interactive action out in the field.[19]

3.1.4 Hermeneutic and Positivism

A person's view on knowledge, called epistemology, is strongly connected to its view upon the world. The two different extremities in the epistemology are called hermeneutic and positivism. The connection between hermeneutic/positivism and the research approaches is shown in figure 3-1.[20]

Those who claim that there are no fundamental differences between social and natural science are called positivists or explanatics. The positivists claim that the classical method has proven their value in analysing the classical natural science is applicable to social science with minor modifications. Explanaticists say that explanatory logics are identical in natural and social science. Knowledge is acquired through verification or falsification of hypothesis and lead to objective results, independent of the observer.[21]

Those whose opinions stand in the opposite to the explanatics are called hermeneutics. They claim that models for natural science are not applicable and unsuitable for social science domains, even if modified. Within the hermeneutics, knowledge does not need to come from hypotheses tests, instead knowledge can be acquired by creating understandings. The hermeneutics also strives for objectivity in his research but more in form of cause.[22]

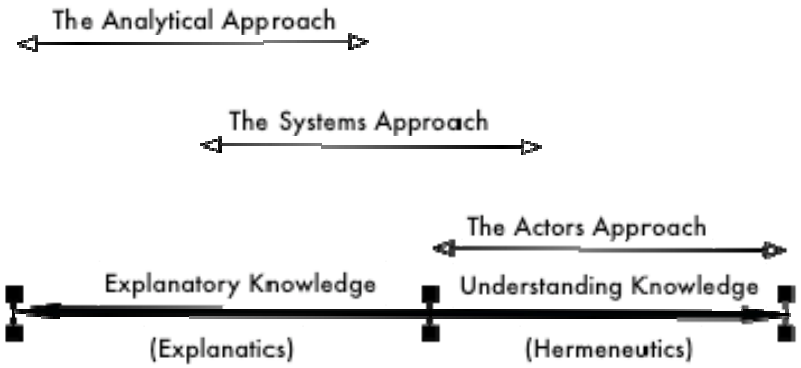

Figure 3-1, Model describing the boundaries between explanatics and hermeneutics and its connection to the different research approaches.[23]

[18] Arbnor and Bjerke (1994) *Företagsekonomisk metodlära,* p. 49-79
[19] Ibid p. 49-79
[20] Wallén Göran (1996) *Vetenskapsteori och forskningsmetodik*, p. 33-34
[21] Arbnor and Bjerke (1994) *Företagsekonomisk metodlära,* p. 44-48
[22] Ibid p. 44-48
[23] Ibid p. 44-48

3.1.5 Explorative, Descriptive, Explanative and Normative studies

The amount of existing knowledge within a research area can be of importance when choosing study method. The four most common methods are presented below.[24]

Explorative studies are often preferred when there is little existing knowledge within the area and the objective is to find fundamental understandings and formulate hypothesis. Descriptive studies are used when basic knowledge exists within the research area and the study's objective is to describe, but not explain, relations. Descriptive studies answer questions like: How many? When? Where? How often? Explanative studies are used when deeper knowledge and understandings are sought and when the writer both wants to describe and explain. The explanative study tries to describe causal relations among different concepts and answer the question, why? Normative studies are used when there exists apprehension within the research area and the objective is to give guidance and suggest improvement.[25]

3.1.6 The approach of the master thesis

The purpose of this master thesis is to investigate the performance measurement systems and potential areas that are not measured sufficiently today. We will therefore need to look at both internal and external, from a department point of view, processes to see what do affect the process. We need to look at the department from a broad perspective, a holistic view, which therefore makes the systems approach most suitable for the study.

Because knowledge within the research area do exists, to some extent, the study method will be a combination of explanative and normative. The authors both want to seek deeper knowledge within specific areas and, in the end, be able to present suggestions of improvement.

3.2 Research Methods

3.2.1 Inductive, Deductive and Abductive method

These methods depend on the researcher's approach and relation to the levels of abstraction where theory (general) and empirics (concrete) are the two endpoints. Inductive means that you analyse the reality (empirics) from where patterns that can be resumed in models and theory are searched. The inductive model lets you study a subject, without looking at the existing theory, and then formulate theory based on these empirical findings. When using the deductive method the researcher starts its study in a theoretical framework, which it uses to draw prediction about the empirics. The objective is then to verify these predictions with collected facts and data. If the researcher changes the level of abstraction, between induction and deduction, throughout the research the method is called abduction. Figure 3-2 shows the relations and the levels of abstraction between the above described research methods.[26]

[24] Björklund and Paulsson (2003) *Seminarieboken*, p. 58
[25] Ibid p. 58
[26] Ibid p. 62

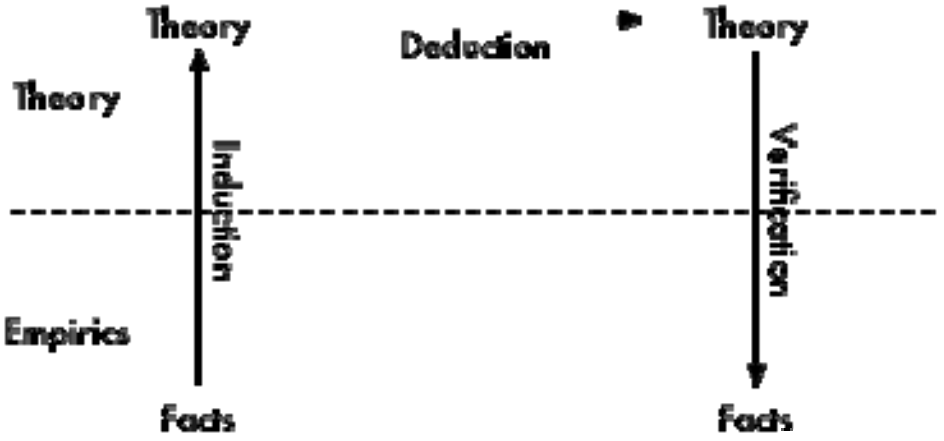

Figure 3-2, Illustration of inductive and deductive approach. [27]

3.2.2 Methods used in the master thesis

The master thesis have some specific cases outlined in the beginning of the work and along the way the authors will try find to new cases to take in consideration. The method of use in the study will therefore be of abductive characteristic. The cases that are stated from the beginning will be analysed from a deductive perspective where we will start looking at applicable theory to see if the today's way of working is correct. The cases that we find interesting and relevant for the study will be adopted in the study. These cases are founded on empirical findings and so for the inductive method is used.

3.3 Qualitative and Quantitative Approach

Qualitative and quantitative approach refers to in which way collected information can be evaluated.[28]

Quantitative studies cover information that can be measured and evaluated numerically.[29] The result is often presented as structures or trends in collected data that may lead to verification or falsification of the hypotheses formulated in the beginning of the study. This method is appropriate to use when the purpose is to draw high-level conclusions on a broad set of research units.[30]

Qualitative methods are used when the objective of the study is to create deeper knowledge within a specific area, a situation or an occurrence.[31] Compared to the quantitative approach, the possibility of generalizing is inferior. The use of non-structured and unsystematic observations is common in the qualitative method.[32]

3.3.1 Approach used in the master thesis

In the study the authors want to investigate operational performance and the supply process at the department and key things that may affect it. To be able to quickly build up a broad foundation of understanding and information a qualitative approach consisting of interviews

[27] Björklund and Paulsson (2003) *Seminarieboken*, p. 63
[28] Ibid p. 63
[29] Ibid p. 63
[30] Holme I. M., K. Solvang B., (1997), Forskningsmetodik – Om kvalitativa och kvantitativa metoder, p.76-78
[31] Björklund and Paulsson (2003) *Seminarieboken*, p. 63.
[32] Holme I. M., K. Solvang B., (1997), Forskningsmetodik – Om kvalitativa och kvantitativa metoder, p.76-78

with key persons and observations will be carried out. In parallel with the interviews, literature and document studies will be conducted to applicable theories for the study. After a certain level of understanding, knowledge and information is gained, calculations will be performed to be able to evaluate and investigate the acquired information. The authors will therefore use a combination of qualitative and quantitative approach.

3.4 Data and data collection

3.4.1 Primary and Secondary data

Data that is collected for a study can be of two different types: primary or secondary. Primary data are collected through interviews, experiments and observations specifically designed for the study[33]. Because of the data collection method is designed for the specific purpose the outcome of the interviews, observations or surveys can also show underlying values/reactions from the interviewees or respondents.[34]

Secondary data is printed data not specific for the study such as written literature, lectures and web-based sources. An advantage with existing printed data is that it can broaden the knowledge base within the research area but at the same time not give good enough in-depth knowledge within the area of the study. By knowing this, it is very important to have in mind and be critical towards data and its reliability and applicability in the study.[35]

3.4.2 Data used in the master thesis

Because of the choice of research method that is discussed in the previous sections, our study will stand on both primary and secondary data. Primary data will be used in form of interviews, empirical observations and surveys. Secondary data; literature, articles and previous done research's, are used to build up a theoretical foundation for the study.

3.4.3 Interviews

In business research, interviews are a common technique for gathering information and also often used in studies based on the systematic approach.[36]

Interviews can be carried out in many different ways for example, in personal either as group sessions or with one single person at the time, via e-mail, over the phone and also as a questionnaire. The structure of the interview varies, depending of its purpose. It can be structured with predefined questions, which are gone through in a predicted order. If no questions are predefined the method is called unstructured and this is more of a discussion where questions come up along the interview. A combination of the two methods is called semi-structured; some questions are predefined in order to start a discussion. In general, interviews are time consuming and the answers can sometimes be hard to interpret.[37]

[33] Arbnor and Bjerke (1994) *Företagsekonomisk metodlära,* p. 224
[34] Björklund and Paulsson (2003) Seminarieboken, Lund, Studentlitteratur. p. 68
[35] Ibid p. 67
[36] Arbnor and Bjerke (1994) *Företagsekonomisk metodlära,*,p. 242-243
[37] Björklund and Paulsson (2003) *Seminarieboken*, Lund, Studentlitteratur

3.4.4 Interview method used in the master thesis

As the authors are located on site at EMP at the department where the master thesis is done, face-to-face interviews are conducted. In most cases interview questions are prepared in beforehand in order to be efficient during the interview - semi-structured interviews. Due to the close cooperation with responsible employees at the Procurement and Supply department, discussion and unstructured interviews are conducted throughout the thesis. Because of the majority of the interviews are unstructured and more of a discussion with the employees, interviews are not recorded and attached in the thesis.

A survey will conducted with a certain group of suppliers to increase the knowledge of how EMP is perceived as a customer. This will be done using an anonymous web based survey function in order to save time for the authors and hopefully get more reliable answers.

3.5 Credibility

Validity, Reliability and Objectivity needs to be taken into consideration in order for us and other readers to evaluate whether the objective of the study is fulfilled or not.

3.5.1 Validity, Reliability and Objectivity

Validity, reliability and objectivity are three metrics that can show the study's credibility. Validity is describing to what extent you are measuring what you really want to measure. A high validity means the purpose of the measuring is fulfilled with a high level of sureness. The reliability indicates to what extent you will receive the same result if the study is repeated. Objectivity is whether different values affect the study, e.g. if the interviewed person's personal values are affecting his answers or if the researcher's values affects the study.[38]

Error! Reference source not found. shows what the above described concepts mean. The far left picture shows both low reliability and validity, the study does not measure what you want to measure and the reliability of the measuring are also low. The centre picture shows high reliability, repeatability, but low validity; you are not measure what first was supposed to measure. The far right picture shows high reliability and validity, right measurements and high repeatability.[39]

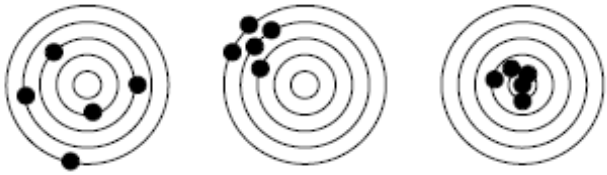

Figure 3-3, Schematic illustration of validity and reliability. [40]

3.5.2 Validity, Reliability and Objectivity in this study

During the master thesis' interviews, both authors have been attending and taking separate notes. Afterwards the authors have discussed the interview together to make sure that they have interpreted the answers in the same way, to some extent the answers are also confirmed

[38] Björklund and Paulsson (2003) *Seminarieboken*, Lund, Studentlitteratur. pp. 59-62
[39] Ibid pp. 59-62
[40] Ibid p. 60

with the interviewees. This is done in order to minimise the risk of confusion and keeping a high level of reliability on the research.

3.6 Case Study

Case studies as a research method explain, explore, or describe an area of interest. The case study is excellent for theory building, for providing detailed explanations of best practice and providing more understanding of the data gathered. The data can be empirical or modelled data as well as qualitative or quantitative. Empirical data is data gathered for the analysis through surveys or case studies and modelled data is by a model, manipulated data. The study can be conducted as a single case study or multiple case studies. [41]

3.7 Analysis models

3.7.1 Gap analysis[42]

The Gap analysis is a common term to identify, specify and execute the gap between the existing and wanted situation. The gap can be the difference between the company's existing competence and the competences needed to realise chosen strategy. The analysis use to include six tollgates.

1. Define area of analysis. For example; efficiency, competence performance etc.
2. Describe the existing situation
3. Describe wanted situation and targets
4. Analyse the gap between wanted and existing situation
5. Take decision of ways to fulfil the gaps
6. Follow up and if necessary change the way erasing the gaps.

A gap matrix can be used to identify what areas that is included in the analysis. In the matrix, y-axis includes the existing situation and the x-axis includes the wanted situation. The diagonal describes the way of how to come to the wanted situation.

3.7.2 Logical reasoning[43]

There are three kinds of logical reasoning: deduction, induction and abduction. An example with preconditions, rules and conclusions, where the rule and the precondition implies the conclusion, can be used to easily explain the difference between the three reasoning types:

Deduction. In this case you are using the rule and the precondition to make the conclusion. In mathematics this style of reasoning is used.

Induction. This method is learning the rule after numerous examples of the conclusion following the precondition. Scientists are often using this type of reasoning.

Abduction. In this type you are determining the preconditions. The style uses the conclusion and the rule to support that the precondition explains the conclusion. The method is often used for diagnosticians.

3.7.3 Analysis model used in this thesis

This master thesis analysis model uses a mix of gap analysis and logical reasoning. The logical reasoning style that is used is the deduction type. Deduction type is chosen because of

[41] Ellram (1996) *"The use of the case study method in logistics research"*
[42] Karlöf B and Helin Lövingsson F (2007) *Management från A till ö – Förklaringar till 150 begrepp och modeller*
[43] Menzies T (1996) *"Applications of abduction: knowledge-level modelling"*

the preconditions and rules are given, through the gap analysis and the conclusions are searched for. The analysis will conducted as case study of empirical data gathered at EMP.

4 Theoretical Framework

The theoretical framework gives the reader a fundamental review of theories that are the foundation for the report and its analysis.

4.1 Supply Chain Management, an Introduction

A supply chain can be described as the flow of material through all activities from production through delivery to final customer. The supply chain process coordinates and integrates all the activities from suppliers through manufactures and distributors to end customer. Together with product development and customer relations the supply chain builds up the three major processes within the organisation. The interaction and integration between these three flows together sets the prerequisite for the company's success.[44]

The key factor to make the supply chain successful is the managing of integration between all the activities both within and outside the organisational boundaries. In customer oriented business, the demands from the customer have a great impact on the range of services and products provided. This will also affect how the supply chain is designed, set up and measured.[45]

Porter introduces the value chain in his book Competitive Advantage in 1985, which can be seen as a foundation for what has evolved to what we today call the supply chain[46]. The value chain consists of five primary processes that add value to the output of the firm: inbound logistics, operations, outbound logistics, marketing and sales and service. A set of linked value chains are called value networks, which will be further discussed in the following part. The value chain does not focus on the process and the relations to the surroundings, only the closed internal system[47].

Value creation within the value system[48] is the perceived product- or service-value in the eye of the customer. The activities/processes that lay the foundation for value creation are called value adding activities. Examples of value adding activities can be a specific feature on the product, after sales services, customisation of the product and on-time deliveries.[49]

All the activities within the supply chain and their management can be gathered under the name Supply Chain Management (SCM). The object of SCM is to manage the integration of cross-functional and organisational operations with the objective to eliminate redundancy activities. By improving the SCM the process becomes more flexible, time and cash efficient towards the customer.[50]

[44] Skøtt-Larsen T, Schary P (2003) *Managing the Global Supply Chain,* Copenhagen, p 23
[45] Ibid pp. 24-26
[46] Ibid
[47] Ljungberg Anders, Larsson Everth (2001) *Processbaserad verksamhetsutveckling*,
[48] Skøtt-Larsen T, Schary P (2003) *Managing the Global Supply Chain,* Copenhagen, p. 49-50
[49] Porter, Michael E (1985) Competitive Advantage: Creating and Sustaining Superior Performance, p. 45-48
[50] Handfield, Robert B & Nichols, Ernest L (2002) *Supply Chain Redesign*, p. 32

4.2 Process Thinking within the Supply Chain

Taken the complexity and global interaction between companies' supply chains in consideration, today's supply chains can be described as value networks. A value network means the network of linked value chains required in order to produce the demanded product or service.[51] To be able to understand this complex network of processes, activities and organisations the supply chain can be analysed as a system with all its included processes.[52]
Because of the level of maturity within the area of logistics, the focus on process improvement is increasing. This is considered as a natural way of development because of the increasing complexity and globalisation of companies' supply chains, which increases the demand for an agile and flexible supply chain process.[53]

4.3 The Definition of a Process

A process can be described as: *"a number of linked activities that transforms input to create output"*[54]. A single activity can then be linked to other activities, both within and outside the organisation. These, not often, sequential linked activities together build up the process. On a higher level of abstraction a company can be described as the network, which all the processes are building up. To describe a process by using the first definition is therefore not expository enough; instead the definition below should be used.
"A process is a network of linked activities that are performed repeatedly and which uses information and resources to transform "object in" into "object out" in accordance with customer needs."[55]

This quote gives a more extensive description of the process. In contrast to the other definition this one describes the process as a network of linked activities, which means that it uses value networks instead of a single value chain to transform object in to object out. It also says that the process needs resources and information to transform object in to object out. Without sufficient and the right resources and information supplied to the process the transformation will not be sufficient. The definition also shows the objective of the process, to satisfy the initial customer need.[56]

The process way of looking into the organisation points at the importance of using a holistic view, to focus on all the activities between initiated need and satisfied need. How the boundaries of the process are drawn varies from case to case, depending on to what extent the company is working in a process oriented way or not. The boundaries may also change over time as the focus of process orientation increases and evolves within the organisation. In order to set the boundaries for the process it is important to look at resources and information. The suppliers are often forgotten when talking about the process, but this is just as important as listening to the customers' need when designing the process.[57]

[51] Johnson G, Scholes K, Whittington R (2005) *Exploring Corporate Strategy*, p. 140
[52] Skøtt-Larsen T, Schary P (2003) *Managing the Global Supply Chain,* Copenhagen, pp. 30-35
[53] Ljungberg Anders, Larsson Everth (2001) *Processbaserad verksamhetsutveckling*, p.55
[54] Ibid p. 44
[55] Mentzer, John T., Myers Matthew B., Stank Theodore P. (2007) *Handbook of global supply chain management*, p. 103
[56] Ljungberg Anders, Larsson Everth (2001) *Processbaserad verksamhetsutveckling*, pp. 42-46
[57] Ibid pp. 57-60

4.4 Identifying and Mapping a Process

A prerequisite for working with processes are the understanding, communication and daily use of the processes throughout the organisation. To be able to identify an organisation's processes the different levels of processes need to be understood:

- *Main processes*
- *Supporting processes*
- *Management processes*

Main processes are those processes that are used to describe the business' purpose on a high level of generalisation. By studying the main processes, an understandable overview of the business should be obtained.[58] Main processes have the object to fulfil the external customers need.[59] Two quotes are used to describe the main process: "*Processes that realises the business concept"*[60] and *"Processes that together build up a system which is the foundation for the business. If one process is removed the business fails"*[61]**.** The main processes are of great importance for the business and primarily create the value perceived by the customer. Examples of main processes that are common in most industries are, Supply products/services, develop products, sell products/services and to supply after-sales services. The number of main processes used to describe a business varies from only the two first above and up to ten, depending on the level of preciseness.[62]

Supporting processes should not be ascribed any value to itself, their main objective is to supply and support the main processes with resources.[63] The supporting processes therefore only have internal customers to supply with deliverables in form of resources or object in to the main processes, supporting processes are not vital for the business.[64] The categorisation of different processes is highly subjective but the impact on the organisations view upon the process may depend on the categorisation. A categorisation shall not be seen as something unchangeable, because of the changing nature of business over time and so also the processes.[65]

Management processes are those that lead, manage and coordinate the main- and supporting processes. Common tasks for management are to; secure, lead and communicate the path for the organisation to the rest of the organisation. It is also the management's task to create and enable the chosen path within the organisation.[66]

4.4.1 Categories and components within the process

Figure 4-1 shows the components of a process. To start the process an object in is needed, this can be in the form of a customer demand or a resource to a supporting process. Within the process there can be other activities or sub processes depending on the level of generalisation. A process or activity delivers a "deliverable" that triggers the next process or activity; this can also be in the form of a document. The object out is what the process deliver which is a

[58] Ljungberg Anders, Larsson Everth (2001) *Processbaserad verksamhetsutveckling*, p. 184
[59] Bergman Bo, Klefsjö Bengt (2001) *Kvalitet från behov till användning,* p. 472
[60] Ljungberg Anders, Larsson Everth (2001) *Processbaserad verksamhetsutveckling*, p. 82
[61] Ibid p. 83
[62] Ibid p. 85
[63] Ibid p. 185
[64] Bergman Bo, Klefsjö Bengt (2001) *Kvalitet från behov till användning,* p. 473
[65] Ljungberg Anders, Larsson Everth (2001) *Processbaserad verksamhetsutveckling*, pp. 185-186
[66] Ibid pp. 186-187

satisfied customer need for the main process. The relation of the different categories of processes is illustrated in figure 4.1.[67]

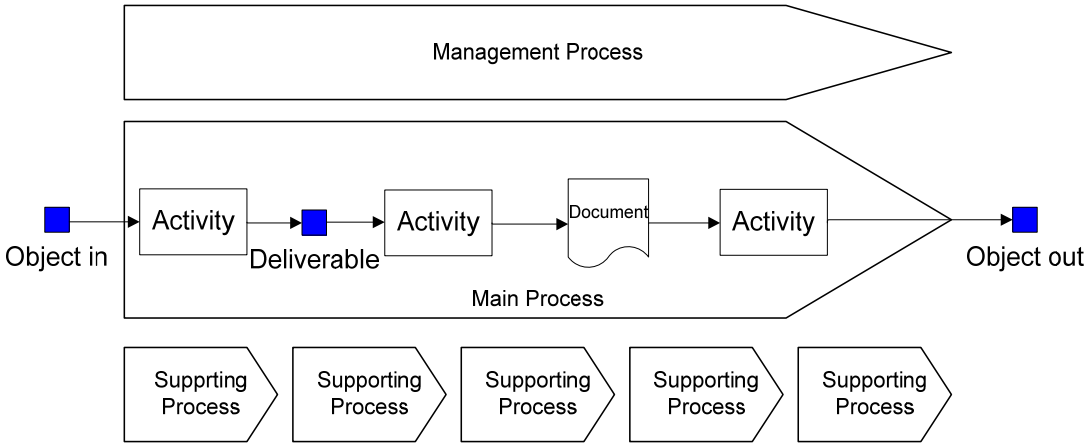

Figure 4-1, Schematic picture of the different processes and the general components within the process.

4.4.2 Mapping the process

There are several common ways of gathering the needed information to establish a process map. Three different ways will be presented here; "*Walk through*", "*Virtual walk through*" and "*Process design*". The single, most important factor, despite the method used, is the communication and acceptance between all involved and affected that the mapping are useful and needed.[68]

Walk through is what it sounds like, a mapping by walking through the process and interview responsible persons along the activities in the process. The result of the walk through is then presented in a graphic way by the responsible process mapper. Advantages with this method are that the short time and relatively low level of resources needed to establish the map. One negative aspect is that only the responsible people will gain full understanding of the process and activities. If people do not have full understanding of the process the likelihood that the commitment to the process will be low is severe.[69]

Representatives from all parts of the process are gathered and each responsible describe his part of the process, the mapping method is called *virtual walk through.* The meeting is lead by a map responsible that makes sure that all information is communicated and agreed during the meeting. The pros and cons of this method are much like the walk through method except for that the acceptance of the process probably will be higher because more people are involved in the mapping.[70]

The last method is called *process design* which is used when the object is to map a non formal process or the personal initiative by the "mapper" potentially can impact the result. It is therefore very important that everyone affected by the process understands and accepts the process design. An example here is a specific project process which is not formal and only previously used by a specific project manager.[71]

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[67] Handfield, Robert B & Nichols, Ernest L (2002) *Supply Chain Redesign,* p. 40-49
[68] Ljungberg Anders, Larsson Everth (2001) *Processbaserad verksamhetsutveckling*, pp.204-205
[69] Ibid p. 204
[70] Ibid pp. 204-205
[71] Ibid p. 205

4.5 Process analysis

4.5.1 Value analysis

When performing a value analysis the sub processes and activities need to be classified into three categories which are attacked with different strategies.[72] The categories are:

Value adding activities can be explained as activities which the customers are willing to pay for. These activities are directly contributing to creation of customer value and solving its problem. The strategy for these activities is to develop them.[73]

Non value adding activities cannot be derived from the creation of customer value. These activities are supporting the value adding activities and/or create value for other stakeholders instead of the customer. Non value adding activities shall be minimised.[74]

Waste, do not create any value for neither the customer nor the company itself. The strategy for waste activities is to eliminate them.[75]

Dividing activities into these categories is useful for the company to reach a unified view upon the internal activities. To reach a unified view, the classification needs to be done in cooperation with different levels of the organisation. After classifying the activities, the internal focus should not only be on minimising and eliminating the two last types of activities. The value adding activities may not satisfy the customer's need totally, improvements in this area may therefore lead to great leverage.[76]

4.5.2 PDCA – analysis

PDCA (Plan, Do, Check and Act) is a classic model from the quality management. By planning an improvement before it is executed the result will be improved compared to non planned improvements. PDCA also points at the importance to do follow up analysis on the improvement and take new actions if the achieved result is not satisfying.[77]

Processes that are well developed shall contain activities from all of these four steps in a chronological way. Of course the majority activities shall be of Do-character but not to forget is the planning before doing and also the follow up to make sure that the supposed needs are satisfied. If not, actions are needed to be taken to prevent it in the future.[78]

4.5.3 Lead-time analysis

Lead time analysis points at finding time consuming activities within the process. A definition of lead time is; *"Number of minutes, hours, or days that must be allowed for the completion of an operation or process, or must elapse before a desired action takes place."*[79]By analysing and focusing on time consumption throughout the organisation, outcomes such as higher market price for the product or service and at the same time decreased internal cost can

[72] Ljungberg Anders, Larsson Everth (2001) *Processbaserad verksamhetsutveckling*, p. 279
[73] Ibid pp. 279-280
[74] Ibid pp. 279-280
[75] Ibid pp. 279-280
[76] Ibid pp. 279-280
[77] Ibid p. 281
[78] Ibid p. 281
[79] http://www.businessdictionary.com/definition/lead-time.html, 2008-09-26

be achieved. By shortening the lead time to customer, the company will be able to satisfy the customer demand in a shorter time and acquire market shares from competitors.[80]

Measure and analyse lead times often demand for a certain amount of time due to the use of new tools to measure useful data. The focus of the measurement should be on non value adding activities, sequences of the process and the process as a whole. These differ from the often function-, operations and individual oriented historical measurements. A good start on lead time measurements is to focus on non value adding activities and the so called unnecessary activities (waste).[81]

4.5.4 Process map analysis

This method has its take-off in the process map from where personal opinions and perceived problems can be discussed. Five useful steps;[82]

- "Walk through" the process map from its start to finish and let the participants connect the problem to the process.
- Categorise the problems in form of type, cause and possible provision.
- Investigate the effects of occurring problems.
- If needed, investigate the underlying causes.
- Identify and focus on the most important causes.

4.6 Foundations and Purposes for Measurement

This chapter is a short introduction to the concept of measurements. The chapter will include differences of single and multiple measuring, the seven purposes[83], types of measures and common difficultness with implementation of measurements.

4.6.1 Single vs. Multiple measures

The measures can be divided in single and multiple measures. The single measure only gauges a single area at the time, for example earnings, operational efficiency. The disadvantages with single measures are that they do not reflect the whole picture of the performance and non-measured areas will be sacrificed at the expense of measured areas. If the company have several areas that are not measured, the result will be distortion in the organisation. To resist this dysfunctional behaviour a multiple measurement can be used, which is several single measures that are connected to reflect a more complete picture of the overall performance of a process.[84]

4.6.2 The seven purposes of measurements[85]

There are seven foundation purposes within the concept of measurement and the number of used purposes depends on the size of the organisation. Large companies require more from their measurements than small companies. Therefore the larger company should design their own measures based on all of the seven purposes to create a stable foundation for measurement. The seven purposes of measurement are:[86]

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[80] Ljungberg Anders, Larsson Everth (2001) *Processbaserad verksamhetsutveckling*.
[81] Ibid.
[82] Ibid.
[83] Ibid.
[84] Marshall W Meyer (2002) *Rethinking performance measurement*, p 21
[85] Ibid pp. 30-34
[86] Ibid pp. 30-34

- *Look Ahead*. This purpose measures and suggests possibilities of future improvements or potential problems
- *Look back*. This purpose reviews and collects historical information about the past to make clear about tendency within the measured area. The past is significant for the knowledge receiving for future improvements.
- *Motivate*. This measure purpose stimulates and motivates employees to future work with improvements and secures a social comfortable working environment.
- *Compensate.* This purpose compensates for employees.
- *Roll up.* The Roll up purpose explains that measures can be designed for low level gauges within the organisation, transferred and used on a higher level with sufficiently the same set and without significant modifications.
- *Cascade down.* The Cascade down purpose explains that measures can be designed on a high level, transferred and used on a lower level with sufficiently the same set and without significant modifications.
- *Comparison.* Significant that different measures can be compared to each other. For example; comparisons between business and functional units.

For smaller companies it is enough to design the measures based on look ahead, look back, motivate and compensate for employees. In more complicated and larger companies the measures are expected to be used at different levels of the organisation to facilitate the purposes of Roll up and Cascade down are needed. The purpose of Comparison is especially significant for larger companies when comparing different organisational units. For these seven purposes there is a triangle of performance measurement, figure 4-2.[87]

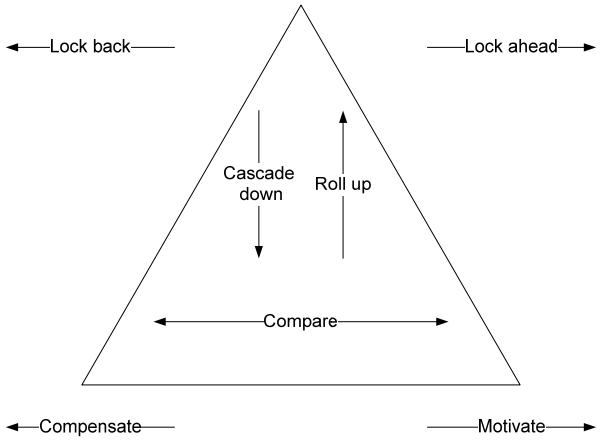

Figure 4-2, Performance measurement purpose triangle.[88]

4.6.3 General difficulties in implementing a measurement system

The most common difficulties of implementing measurements are too much or too little data collection. The consequences are that part of the data might be ignored or that the data are used ineffectively. Other areas to consider are:[89]

- Not enough focus on long term measures. The company only collects short term financial and operational data and forgetting the long term measures.

[87] Marshall W Meyer (2002) *Rethinking performance measurement,* p. 30-34
[88] Ibid p. 31
[89] Fiorenzo F, Maurizio G, Domenico M (2007). *Management by Measurement*, p 112

- Collecting of inconsistent, conflicting, and unnecessary data.
- The measures are not connected to the company's strategic target.
- Measurement process done too often or not often enough.

4.7 Performance Measurement Systems

In this chapter the performance measurement systems are explained. First an introduction with concept, level and type of measures, team and constellation is made. Followed by these subchapters the design, development and implementation stages are explained.

4.7.1 Introduction and concept

Business performance tells the companies how well they perform compared to the targets. There are several purposes why business performance should be followed up. Examples of purposes are;[90]

- Monitoring trends.
- The result as a basis for improvements.
- Evaluate improvements.
- Prioritise improvements.
- As a warning bell for potential problem.
- Designed to give feedback to employees and stimulate them through future improvements.

This can be compared to the purposes of measurements, chapter 4.6.2, where the purposes of business performance is a mix of some of (compensate, motivate, look back and lock ahead) the seven purposes of measurement.
The performance measurement system is defined as a set of metrics used to quantify the effectiveness and efficiency[91]. According to this definition the performance measurement system uses multiple measures which reduce the risk for dysfunctional behaviour in the organisation. There is a simple concept of performance measurement that says: "you get what you measure, and you cannot manage a system unless you measure it"[92]. Because of this the organization must put efforts in the design phase, especially in what to measure and why the measurements are important. The fact that measured and rewarded things also are being done the measures must be balanced to avoid sub-optimisation.[93] Performance measurement is an effective tool to understand and improve the activities. To create this effective and reliable tool the gauges must answer the company following questions:[94]

- Are we reaching our goal?
- How well are we doing?
- Are our customers satisfied?
- Do we have process control?
- What areas need process improvements?

[90] Samuelsson L (2004) *Controllerhandboken*
[91] Tangen S (2003) *An overviewof the most frequently used performance measures*, p 348
[92] Fiorenzo F, Maurizio G, Domenico M (2007). *Management by Measurement*, p 109
[93] Larsson E, Ljungberg A (2001), *Processbaserad verksamhetsutveckling*. p 215
[94] Fiorenzo F, Maurizio G, Domenico M (2007). *Management by Measurement*, p 110

The performance measures are valuable but it is lacking in a few areas. For example, the causes and effects of outcome are not easy to establish. To realise the causes, collaborated data must be applied. Unfortunately performance information does not always provide the reason why something is wrong, it just raises a warning flag that something must be done.[95] The specifications of the performance measures should include information of the purpose (what it is used for), how to gauge and instructions about the analysis phase to secure a correct usage.[96]

4.7.2 Levels of performance measurement

Different levels within the organisation need different levels of measures. There are three measure levels; Strategic, Tactical and Operational. The linkage between them are important, otherwise there is a risk that the employees and department not working towards the same targets. A performance measure should be able to be set on a strategic level and broken down to a tactical level and further on broken down to operational level.[97] Compare with some of the ground purposes for measurements, cascade down in chapter 4.6.2.

Figure 4-3, The different levels of performance measurements.[98]

Measures on strategic level have a time scale for several years and most of the decisions are taken at the top management level. Measures on tactical level have a time frame from a month up to a year. This level of performance measurement is the linkage between strategic and operational level. For measures on operational level the gauges are done intervallic, on a basis of every day or up to every month.[99]

4.7.3 Types of measurements

The performance measures have various purposes and it is significant to understand their importance. For example the employees must know if the measures have strong impact on the organisation or only informative. The classification of the measure types are divided in three categories Indispensable (Strong impact on the organisation), Useful (Meaningful but not vital) and Informative (Low impact, only for informative reasons).[100] There is also other names such as; Key Performance Indicator, Performance Indicator and Key Result Indicator for the types of measurements.

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[95] Fiorenzo F, Maurizio G, Domenico M (2007). *Management by Measurement*, p 111
[96] Tangen Stefan (2004) *Evaluation and Revision of performance Measurement system*. p. 126
[97] Ibid p. 56-57
[98] Ibid p. 57
[99] Ibid p. 56-57
[100] Ibid p.128-129

Key Performance Indicators
There are three types of performance measurements from a KPI perspective and the definitions are described below.

- *Key result indicators*. The key result indicators (KRI) reflect a clear picture of where the company is heading but not what the company must do to improve the result and performance. The KRIs does not need to be measured as often as the KPI and once a month is enough
- *Performance indicators*. The PIs describes what the company should do.
- *Key performance indicators*. The KPIs describes what the company should do to increase the performance dramatically. Key performance indicators are the most critical measurements for the current and the future success of the company. The KPIs should be gauged frequently, daily or even more often. To secure that the KPI have the correct attention the senior management should have insight in the measurement. For all KPI there must also be a responsible team or owner to the measurement.

It is important that not too many measurements are used. 10/80/10 rule is a good guidance of how many measurements the organisation should use. It must not be; 10 KPI, 80 PI and 10 KRI but this proportion is preferred.[101]

4.7.4 Design phases for performance measurements

4.7.4.1 Design phase 1: Develop and design the performance measurement system

What to measure? – That is the first question to answer in the designing phase of performance measurement system. The selecting and designing phase of measurements should be based on facts from the company's process and the process approach. To increase the understanding of the designing phase, the company should start with process mapping.[102] The documenting of process mapping gains a lot of valuable knowledge to use when selecting the measures.[103] Important areas to consider, when creating a sustainable development base, are the modern quality aspects from a customer satisfaction view.[104] In the design and development phase the concept, about targets and indicators, must be well established and the combination model of top-down and bottom-up should be preferred because all parties with necessary competences within the organisation are valuable for the decision. Another benefit with the combination model is the elimination of the different departments trying to optimise their own performance, which might be leading to conflicting targets and actions between them[105]. Important to remember is that the outcome result is strictly connected with the quality of the inputs. Inputs are commonly taken from the process (for example; information from process mapping) but even the value system and soft measures, like customer satisfaction and suppliers should be considered.[106]

To simplify the identification and selection of measures a success map can be drawn. The success map describes possible ways to success. The success map creation should be based on facts from the process mapping. When the success map is created and described the measures

[101] Paramenter, David (2007) *Key Performance Indicators*. p 1-10
[102] Larsson E, Ljungberg A (2001), *Processbaserad verksamhetsutveckling*. p 234
[103] Andersen B, Faugerland T (2006) *Mät företagens prestation.* p 43-44
[104] Larsson E, Ljungberg A (2001), *Processbaserad verksamhetsutveckling*. p 235
[105] Andersen B, Faugerland T (2006) *Mät företagens prestation.* p 41-45
[106] Larsson E, Ljungberg A (2001), *Processbaserad verksamhetsutveckling*. p 235

can be set. An example; the strategic target is to improve the operating efficiency, and the needs for reaching this must be identified. Example of identified needs might be to improve the delivery performance. Examples of improvement of delivery performance can reduce lead-times and improve stock control. See figure 4-4 for this example printed as a success map.[107]

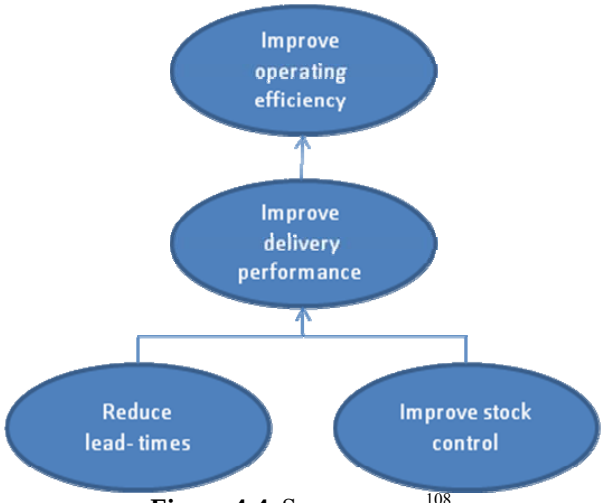

Figure 4-4, Success map.[108]

4.7.4.2 Design phase 2: Secure targets of measurement.

It is important to realise how to measure and report to secure a satisfactory result. Before implementation of the chosen measures the company needs to secure that the gauges are not counterproductive. All the measures should be according to the company's common target to avoid sub-optimisation. The performance measurement system must transfer the right information otherwise the confusion can lead to sub-optimisation. To facilitate this, the measurement should have followed characteristics.[109]

- Easy to understand
- Easy to evaluate
- Designed in consultation with the functions that are being measured
- Stimulate improvements

Targets have different functions. For example the strategy and motivation for planning and coordination can be communicated through targets. The targets should even act as an early warning signal of a potential problem. The targets should be reasonably challenging. Too easily set targets are simple to reach and this might lead to lacking in the motivation of employees and too difficult target will make people give up. The target might also act as a ceiling, after reached target the employees slow down and stop striving for improvements. Because of this, it is important to communicate and review the targets to secure that they are being followed. [110]

[107] Neely A, Bourne M (2000) *Why measurement initiatives fail*, p. 3-6
[108] Ibid p. 4
[109] Tangen Stefan (2004) *Evaluation and Revision of performance Measurement system*, p 121 ff
[110] Simons R (2000) *Performance measurement and control system for implementing Strategy*

4.7.4.3 Design phase 3: Eliminate unnecessary measures

Many measurements need much time when being analysed. The unnecessary measures just require resources and this waste must be eliminated. One way to do this is by limiting the numbers of measures and only gauges the very important ones which add value to the organisation or only measures the details that are used. [111]

4.7.4.4 Secure the implementation

The measurements often fail because of difficulties in the implementations phase. Three main area reasons are political, infrastructure and focus. If people feel worries about how to deliver instead of deliver the right performance or if they are threatened of the measures, the failure is categorised as political. Well defined measures can fail due to lacking of infrastructure. An example of this failure is when unlinked measures and data are processed in unrelated databases, which results in laggard compilation. Focus failure can appear when the process of infrastructure implementing takes long time and the involved parties get tired and lose focus.[112]

4.7.4.5 Secure the execution

Keywords for a punchy measurement system should be owner, rewards and dynamic. All the employees, whom are working with the measures, must understand the purpose why the measurements are being done. This is not enough; there must also be an owner to avoid that the measurement system becomes malfunctioned. The most common owner of the measurements is the process owner of the specific area where the measuring is being done. The owner is responsible for; that the gauges are being done, the reporting of the result and the execution of changes. The rewards should reflect the most important things but when designing the reward system the company must be careful. Not rewarding the right aspects can lead to sub-optimisation, because of the fact that rewarded areas often are being done on the expense of the areas that are not. Because of this it is important to carefully select the areas of rewarding. The performance measurement system must be dynamic which means that the system has to continuously improve. To continually develop and improve are a natural part in activity development and include improvements of target, methods to perform measures and the use of the result. The purposes with continually improvements are to secure effectiveness and efficiency within the organisation in a volatile environment.[113]

4.8 Analytical Hierarchy Process – AHP

AHP is an approach to structure decision making based on multiple choice criteria into a hierarchy where each criteria's importance relative to the other criteria's are ranked. The method is commonly used and applicable to many areas, for example different KPIs relative importance. After going through all the steps of the AHP method, an overall importance ranking of the alternatives is obtained.[114]

The four steps of the AHP method are presented in chronological order below.

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[111] Tangen Stefan (2003) Utformning av framgångsrika prestationsmått. p 8-9
[112] Neely A, Bourne M (2000) Why measurement initiatives fail, p 3-6
[113] Larsson E, Ljungberg A (2001), *Processbaserad verksamhetsutveckling*. p 236
[114] http://rfptemplates.technologyevaluation.com/Analytical-Hierarchy-Process-(AHP).html, 2008-10-29

1. *"Decide upon the criteria of selection."*[115]This criterion scale are set as; equal, moderately more, strongly more, very strongly more and extremely more with corresponding numerical values ranging from 1-9. The scale can be adjusted to fit for the specific decision purpose but shall always be designed as a verbal judgement.[116]

2. *"Rate the relative importance of these criteria using pair-wise comparison.*[117]*"* Each criteria is compared to the other criterions and the relative importance, using the predefined scale, are determined.[118]

3. *"Rate each potential choice relative to each other on the basis of each selection criterion – this is achieved by performing pair-wise comparisons of the choices.*[119]*"*By setting up a matrix with the same number of columns/rows as number of criterion to compare. The rating developed in step 2 is inserted in the matrix.[120]

4. *"Combine the ratings derived in steps 2 and 3 to obtain an overall relative rating for each potential choice.*[121]*"* After the matrix is fully filled you divide each cell by the sum of its column creating an eigenvector. After this is done and the new value for each cell is inserted, the sum of each row (one criterion) is its relative importance compared to the other criterions.[122]

4.9 Six Sigma Framework

4.9.1 DMAIC

The DMAIC-model is a methodology for process improvements. There are 5 phases in the methodology and each one is briefly described in this thesis.

Define

The define phase includes 4 tollgates[123]:

1. *Generate projects and prioritise.* Generation of project is about identifying opportunities of improvement and prioritisation about focus on right improvements.
2. *Develop project and team charter.* The team members and the manager are chosen.
3. *Identify y or ys to be improved.* All Six Sigma improvements promote a simple x-y model where y stands for output variable and x for input factors. The project team need to identify one or more areas of the product/process that they would like to improve. These areas should be critical-to-quality factors and they are known as the y or ys in the improvement project.
4. *Determine performance/map process*. Before measure phase is entered two questions should be asked. One; do we know the current performance of y? Two; does the group share a common understanding for the project?

[115] http://www.ijee.dit.ie/articles/Vol14-3/ijee1017.pdf. 2008-10-29
[116] How to make a decision: The analytical hierarchy process, Thomas L. Saaty. 1990
[117] http://www.ijee.dit.ie/articles/Vol14-3/ijee1017.pdf. 2008-10-29
[118] Saaty, Thomas L (1990) *How to make a decision: The analytical hierarchy process*
[119] http://www.ijee.dit.ie/articles/Vol14-3/ijee1017.pdf. 2008-10-29
[120] How Saaty, Thomas L (1990) *How to make a decision: The analytical hierarchy process*
[121] http://www.ijee.dit.ie/articles/Vol14-3/ijee1017.pdf. 2008-10-29
[122] Ibid
[123] Magnusson, Krosslind, Bergman (2003). *Six Sigma The pragmatic approach*,

The current performance of y sets the benchmark for the project and provides other important information, for example cost savings potential. A capability analysis is an effective way to determine performance.

Measure

The second phase is the measure phase. The measure phase includes 3 tollgates[124]:

1. *For each y, identity xs*. The measure phase starts with identification of xs, which might influence y. There are two types of x, Control factors and noise factors. Control factors are controllable and noise factors are uncontrollable, too costly to control or not desirable to control.
2. *Develop measurement plan*. The team must develop a measurement plan. Examples of pieces in the measurement plan: Interval of measuring. Total time for measuring, responsible person for the specific measurement. Important question in this part of the project is: Will it be any measurement error in y?
3. *Data collection of y and xs*. It is important that the data collection is according to the measurement plan and all deviation is documented.

Analyse

The analysis phase is the third phase in the DMAIC methodology. The analysis phase includes 3 tollgates.[125]

1. *Get to know the y*. In this tollgate it is important to learn how the y is based on the new collected data. Examples to consider are; the size of y, performance of y expressed in dpmo, predictability.
2. *Identify xs that influence y*. This tollgate resides the core efficiency of Six Sigma. Through improvement tools the group is able to pinpoint which of the xs that influence y and then it is relatively easy to design an improvement solution. If none of the xs influence y the group needs to go back to the measure phase to measure other xs
3. *Establish improvement targets*. When the group has found the xs, they can set the improvement targets. If y is funded as unpredictable the important target should be to reduce and remove xs influence, to gain the predictable of y. The standard order of Six Sigma is:
    - Eliminate special causes of variation
    - Reduce variation
    - Improve positioning

Improve

The improvement phase includes 3 tollgates.[126]

1. *Design solution*. The group finds the solution through identifying one or more ways to improve the performance with the assistance of the knowledge they have about xs and y.
2. *Cost/benefit analysis.* For every suggestion a cost/benefit analysis should be done and based on conservative estimates on both cost and benefit side
3. *Implement best solution.* The suggested solutions will be evaluated and based on cost/benefit analysis and the best suggested solution should be implemented. Necessary information, training and involvement of all affected employees need to be included in the implementation.

[124] Magnusson, Krosslind, Bergman (2003). *Six Sigma The pragmatic approach*.
[125] Ibid
[126] Ibid

Control

The last phase in the DMAIC methodology is the control phase. The control phase includes 4 tollgates.[127]

1. *Verify the planned improvements in y*. When the solution has been implemented the y should be monitored to make sure that the targets have been achieved. The performance of y needs to be predictable but it often takes time to stabilize the process.
2. *Estimate the cost saving*. When y has become predictable the cost savings can be used.
3. *Institutionalise and document*. Institutionalise the results is an important activity in the control phase. If flowcharts or process drawings do not exist they must be made and the existing flowcharts and drawings might need to be updated. This will simplify further communication of the results.
4. *Communicate and visualise*. The project result and experience should be distributed through the organisation. This communication and visualising improve knowledge within the company and make employees work in the right direction together.

4.9.2 Six sigma tools

Pareto Analysis

Pareto Analysis and Pareto Chart is used for ranking the projects and based on Pareto (80/20) rule. The analysis is known as a tool that identifies the vital projects from the trivial and which that should be pursued first. The pareto should be used in qualitative improvements to determine which step to take next, for example what type of defect/area the group should focus on. [128]

How to perform a Pareto Analysis[129]:

1. Determine the Pareto categories.
2. Select a time interval for analysis. It should be long enough in order to be representative for the typical performance.
3. Determine the total occurrence (like cost, defect counts) for each category and even for the grand total.
4. Compute the percentage for each category.
5. Rank the category from larges to smallest.
6. Compute the cumulative percentage.
7. Construct a Pareto Chart, see figure 4.5

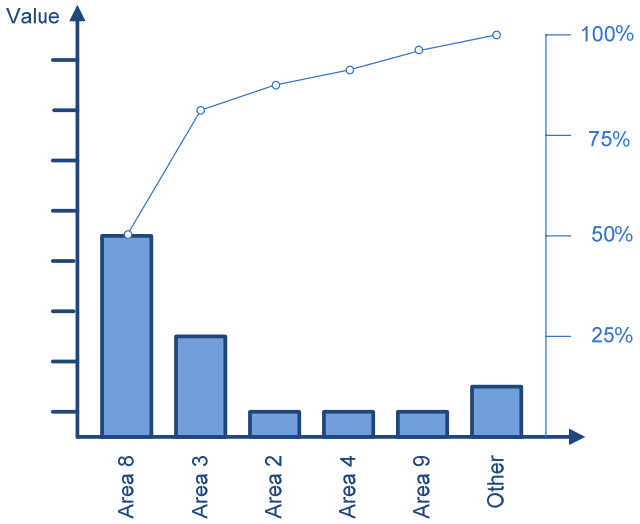

Figure 4-5, Pareto chart.[130]

Ishikawa diagram[131]

Ishikawa diagram can be drawn to visualize relation between y and the xs and to find the root causes to the problem. It is often useful to include as many x as possible when creating a

[127] Magnusson, Krosslind, Bergman (2003). *Six Sigma The pragmatic approach*.
[128] Pyzek, Thomas (2001). *Six Sigma Handbook*
[129] Ibid p. 279
[130] Ibid p. 155
[131] Ibid p.161

diagram and then highlight the selected xs. There are three levels of x, Main cause, cause and root cause.

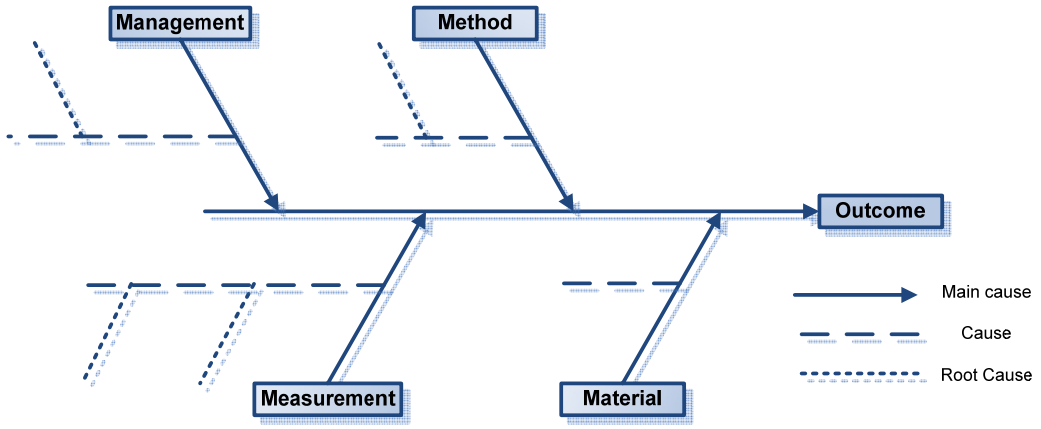

Figure 4-6, An example of an Ishikawa diagram. [132]

Affinity diagram[133]

Affinity-diagram is a tool for both generation and prioritisation of projects. This diagram is a vital support especially in the beginning of the project. Affinity diagram should be created by cross-functional teams brainstorming about areas for improvements or causes of a problem. During the brainstorming the team members write down short statements on notes. Afterwards the team together clarify, map and prioritise the content.

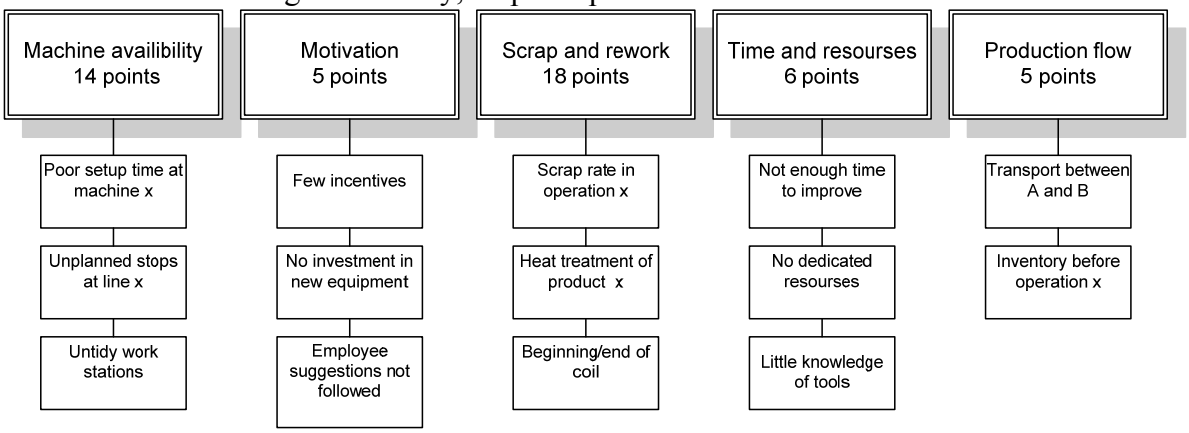

Figure 4-7, An example of an Affinity diagram. On the top there are five key areas for improvement. For this example the diagram shows that the main area for improvement should be Scrap and rework, and Machine availability.[134]

4.10 Supplier Relationship

To succeed in the relation with suppliers the company must know the answer to two key questions. One; "Which governance structure or relational design should the company choose with their supplier under different circumstances?" Two; "What is the appropriate way to manage each different type of relationship?"[135] The first question is important because it

[132] Magnusson, Krosslind, Bergman (2003) *Six Sigma The pragmatic approach*. p. 161
[133] Ibid p. 154
[134] Ibid p. 154
[135] Bensaou M (1999) *"Portfolio of Buyer-Supplier relationships"*

affects how the company defines their boundaries and core activities. The second one answers the organisational questions.[136]

4.10.1 Types of relationship

The relation between supplier and buyer can be divided into four different categories depending on the degree of investment the parties involves in the relation. The four categories are named as Strategic Partnership, Captive Buyer, Captive Supplier and Market Exchange. The connections are visualised in the portfolio of buyer-supplier relationship, Figure 4-8.

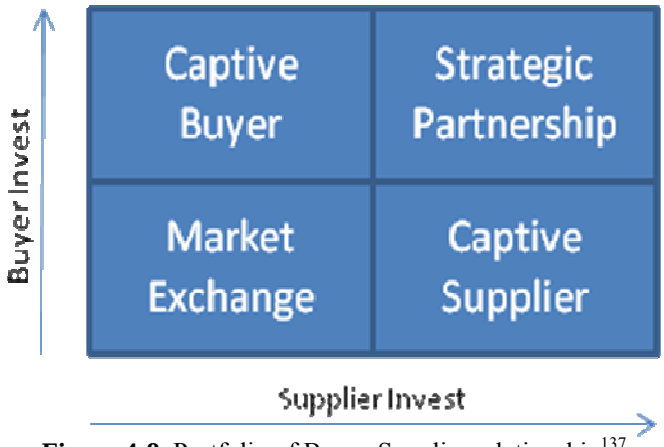

Figure 4-8, Portfolio of Buyer-Supplier relationship[137]

Market Exchange. This type of relationship is typically used with highly standardised products The products do not need to be customised to fit into the buyers end product and are often based on mature technology that involves little engineering effort and expertise from the supplier. The suppliers often manufacture to the customers specification and are not involved in the design of the components. In the Market Exchange segment the buyer can easily find several suppliers that are capable of design, manufacture and deliver the products. The target for buyers is to minimize the cost and control the economics of scale through large volume relying on a number of suppliers. Significant to remember is that the supplier can easily and cheaply shift their production to fit another buyers business. In Market Exchange the relationship can be collaborative and positive without being a strategic partnership because they do not make long term commitments and can easily switch to another supplier or customer.[138]

Captive Buyer. In this segment the supplier has the power. The characteristics of the upstream market and the availability of suppliers are more depending than the characteristics of the products. In Captive Buyer the products are based on a well-understood and stable technology but require some customisation because of involvement of some complex components. If the suppliers terminate the contract the buyer will have major difficulties and face a costly procedure to relocate and shift to other sources. One way to compensate the dependencies on the supplier, the buyer keeps some in-house capability for involved products.[139]

Strategic Partnership. The relationship within this segment is heavily customised and the buyer has done significant investment. The buyer ties key function to the supplier which

[136] Bensaou M (1999) *"Portfolio of Buyer-Supplier relationships"*
[137] Skøtt-Larsen T, Schary P (2003) *Managing the Global Supply Chain*, p 197
[138] Bensaou M (1999) *"Portfolio of Buyer-Supplier relationships"*
[139] Ibid

increases the potential risk of damage if supplier behaves opportunistic. On the other hand the supplier invests in fundamental research and development, in some case even jointly with the customer. Because of the risk and opportunities the partners chose to create and develop a long term relationship. Strategic partnership relations are well formed for products that are significant for the customers business.[140]

Captive Supplier. In this segment the relationship involves complex products that are based on new technology, owned and developed by the supplier. To secure the suppliers market involvement, strong design reputation and superior capability of engineering and manufacturing they need to invest heavily in capital investment. Customers are flexible to shift supplier when new products are developed or when other suppliers have a better product that improves the functionality and the performance of the customer's product. The customer has the power and the suppliers, which are preferred, in general accept to make the investments requested by the customer to get a part of their business.[141]

4.10.2 Managing the relationship

This subchapter will describe how to manage the different types of relationship and what to consider when designing the relationship.

Managing the four types of relationship
Market Exchange management. To create a high performing relationship the information exchange between supplier and customer must take place in the bidding and contract negotiation phase. In the continual work the parties should exchange information, more than when problems occur, to secure high performance in the relationship. Mutual trust, cooperation and jointly effort do not usually exist in this type of relationship and are not that important, but the supplier and customer should fairly share, reasonable risks and benefits.[142]

Captive Buyer management. The complexity of components requires exchange of detailed information and high level of communication on continuous basis to secure a successful relationship. In contrast to Market Exchanges, with little information flow, the two parties' functional areas as design, purchasing and sales work together with a wide channel of information flow. Often there are mutual distrusts between the parties and the suppliers can have poor reputation and negative track record, in some cases despite that the customer provides the supplier with technical support and training to perform better. The result is that the information flow must be well established to secure that the both parties receive correct information.[143]

Strategic Partnership management. To ensure a high performed managing of the relationship the both partners must exchange information directly and recurring trough standardised rules and operating procedures. The other partner's engineers should be integrated in the teams, for example to be involved as a member of the team in the design phase. In the markets where the technology and design change in fast pace, and the forecast and decision quickly can become irrelevant and obsolete, it is important that the information flow is well established within the relationship. Often the partnerships need a trusting and collaborative social environment. To involve the supplier in an early stage in the component designing and long-term planning increases the outcome of the relationship because of the product and its process can be

[140] Bensaou M (1999) *"Portfolio of Buyer-Supplier relationships"*
[141] Ibid
[142] Ibid
[143] Ibid

designed after both companies and their areas of interest. Significant to both companies is that they need to share risk and benefits to ensure success with the relationship.[144]

Captive Supplier management. In this type of relationship it is significant to consider and improve the information exchange. The buyer should spend more time on negotiating the contract and monitoring the supplier to secure a good relationship with clear guidance for correct way of working between the parts to secure that the right supplier is chosen. The social environment should include a high level of mutual trust but not necessarily jointly planning or development as in strategic partnership.[145]

4.10.3 Design a successful relationship

When designing a relationship there are three main areas to consider. One, the strategic type of relationship must be conformably with the technology, market and the external condition for the product. Two, for each type of relation an appropriate management profile must be identified. The third step is to match the design of the relationship to avoid under and over designed relationship.[146]

To succeed with the relationship there are two kinds of relationship to prefer. High requirements - high capabilities and low requirements - low capabilities, which is when the type of relationship match the product. The failures of managing the relationship often appear because of under designed or over designed relations are used.[147] A matrix for the under designed, over designed and the matched investments are shown in figure 4-9. An Example of an over designed relation; The company invest in building trust through frequent visits, integrated engineers and cross-company team when product and market calls for simple impersonal control with low information exchange. This behaviour is costly and risky because of the company gives specific investment to wrong supplier might result in that the right supplier does not receive correct treatment needed to deliver value to the buyer.[148]

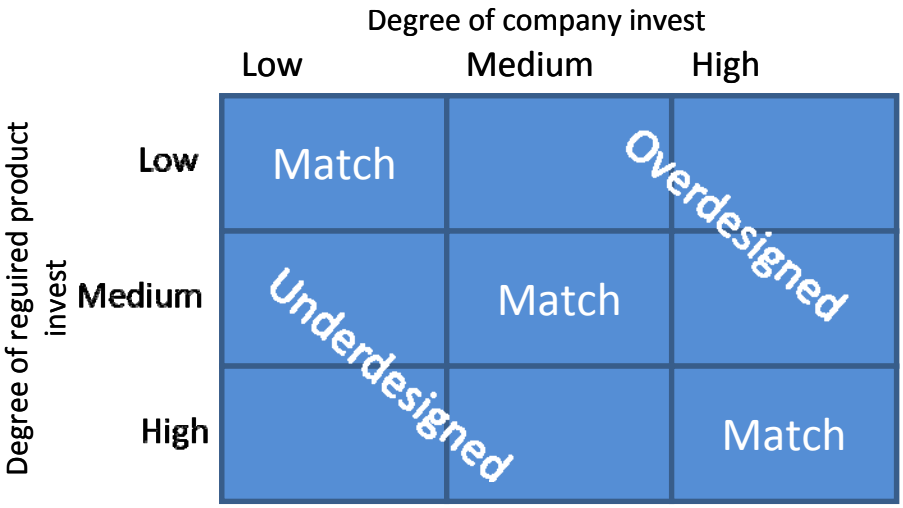

Figure 4-9, Relationship design matrix.[149]

[144] Bensaou M (1999) *"Portfolio of Buyer-Supplier relationships"*
[145] Ibid
[146] Ibid
[147] Ibid
[148] Skøtt-Larsen T, Schary P (2003) *Managing the Global Supply Chain*, p. 99
[149] Ibid p. 99

4.10.4 Levels of relationship[150]

The relationship within two companies can be ranged from arm's length relation to vertical integration. In arm's length relationship the supplier, in almost all cases, offers standard products to several customers. In this relationship joint commitment or joint operations do not exist and when the exchange end, the relationship ends. There are three levels of partnership and depending on the level the benefits for both parts might increase. Type I is the lowest level and level III is the highest. If the company needs more integration than partnership they can build a joint venture or a vertical integration with their supplier or customer. This thesis will only cover the partnership relations.

Figure 4-10, Levels of relationships[151]

Level I. The partnership has a short-time focus and both parts recognize each other as partners. They coordinate activities and planning on a limited basis. On this level only one division from both parts is involved in the relationship.
Level II. Long-time focus, several functions within both companies is involved in the relationship.
Level III. Long-term exist without any end date of the relationship. For example; Coca Cola distribute soft drinks to McDonalds worldwide. Both companies shares significant level of integration and see the other part as an extension of their own company.

Most of the partnership relations are classified as level I. Only a few are classified as level II and Level III is reserved to the supplier and customer that is critical to the own company's long-term success.

4.10.5 Partnership model[152]

There are three main elements that affect the outcome of the relation. The Elements are drivers, facilitator and components. ;

Drivers. The drivers are the reasons why the parts will create a partnership. The drivers must exist on both side of the relation and both parts must believe that they receive benefits when joining the relationship. Even that some benefits not can be reached without the partnership must be considered. The drivers do not need to be the same for both parties but still they must be strong. Strong drivers are necessary to secure a successful partnership and the benefits must be sustaining over a long term.

Facilitator. The facilitator is the environmental factors that make the relationship grow and develop. The Facilitator serves as a foundation for a well established partnership and cannot easily be developed. The results are that facilitators either exist or not. The degree of their existence often determines the success or failure of the partnership.

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[150] Stock J, Lambert D (2001) *Strategic Logistics Management*, pp. 508-509
[151] Ibid p. 509
[152] Ibid pp. 509-513

Components. This category includes activities and processes that the management establishes and control throughout the life of the relationship. Components make the relationship operational and they help mangers to create benefits through the partnership. Planning, risk/reward sharing, joint operating controls are examples of components.

When implementing a supplier partnership, whatever type, the effectiveness must be evaluated and possibly adjusted. The key to effective measurement and feedback is how well the drivers are developed. Metrics of measurement should be clear and these measures should become the standard in evaluation of the relationship outcome. Feedback from the outcome can be referring to any step of the areas in the partnering process model.

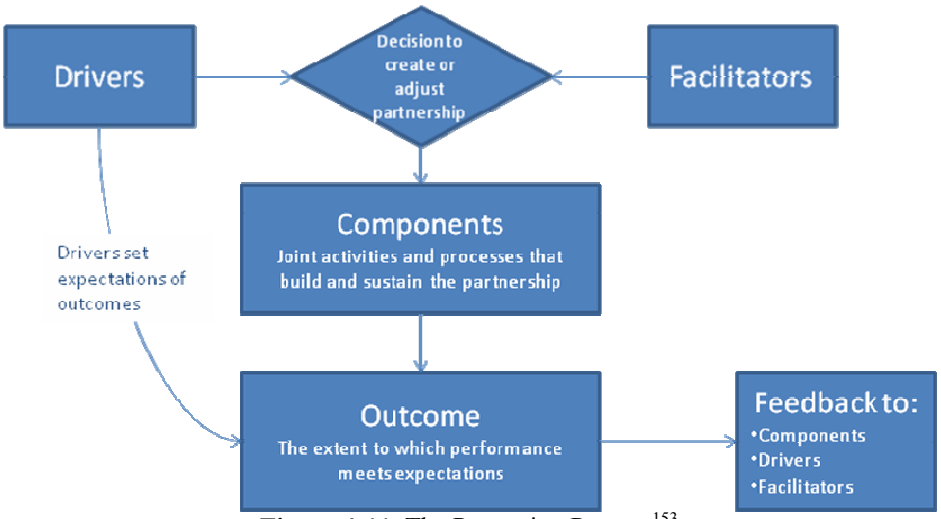

Figure 4-11, The Partnering Process[153]

4.11 Managing Working Relations through Working Relation Index

The strength with Working Relation Index (WRI) is that the framework can be used to describe working relation between purchasing areas, divisions and geographic areas as well as the overall company. In this case the relation between supplier and company is used.

4.11.1 Theoretical framework for WRI

"To receive long-term competitive advantages the company must lock beyond itself. The company with most positive supplier working relation will have the greatest sustainable competitive advantage".[154] To realise what the supply base can provide the company must actively be engaged in the development and maintenance of the supplier relation. The challenge is to measure the working relation of the suppliers.[155] A good model to use is WRI, Working Relation Index, which is a concise quantitative measurement of supplier relations. The comparison between suppliers can easily be done with this quantitative model.[156]

[153] Lambert D, Emmelhainz M, Gardner J (1996) *Developing and implementing supply chain partnerships,* p. 4
[154] Ph D. JohnW Henke, Marketing Professor, Oakland University
[155] Henke John (2007) "*How your supplier relations measure up*", p. 1
[156] Seminar with Lennart Aveling. 080826 Stockholm

WRI is comprised of 5 components and 16 variables see, figure 4-12. The analysis of the components and variables identify weak and strong areas of the relation. The analysis does not always give the explanation why the relation is as the components indicate. Because of this it is necessary to add further questions to get a plenary understanding of the relation. The knowledge received through a questionnaire can be used by the company to improve the supplier relation. To secure that the variables can be determined and action can be taken. The supplier-related policies, practices and procedures need to be included in the questionnaire. One of the best parts with WRI is that the variables are independent of cost reductions.[157] The benefits can be:

- The suppliers share their innovative technology with the company
- The suppliers invest in new technologies for the company
- The suppliers offer better services and the deliveries reach a better quality.

Most important to remember is that no single activity or variable, which is done well, can create a positive supplier relation. However a single activity or variable, which is done poorly, can negate the positive impact of the other activities. The reason is that all activities / variables comprise inter-related activities that enhance the supplier's perception of the company's attitude to their supplier.[158]

Working Relations index Components	Working relations Variables
Relationship	1. Supplier trust of Company 2. Supplier perception of working relations with company
Company Communication	3. Company has open and honest communication with supplier 4. Company communicates timely information 5. Company communicates adequate amounts of information
Company Help	6. Help Company gives to supplier to reduce costs 7. Help Company gives to suppliers to improve quality
Company Hindrance	8. Company late/excessive engineering changes 9. Conflicting objectives across Company functional areas 10. Supplier given flexibility to meet piece price/tooling cost objectives 11. Supplier involvement in company product development process
Supplier profit opportunity	12. Company shares savings from suppliers' cost reduction proposals 13. Company rewards high performance suppliers with new/continued business 14. Company covers sunk costs on cancelled or delayed programmes 15. Company concern for supplier profit margins when asking for price reductions 16. Suppliers' opportunity to make acceptable return over long term.

Figure 4-12, Working Relation Index, Components and variables[159]

[157] Henke John (2007) *How your supplier relations measure up*, pp. 2-6
[158] Ibid p. 2
[159] Ibid p. 2

4.11.2 Benefits of WRI

When a company engages in building strong relations it normally takes a long term perspective with the supplier. Both company and supplier receive short-term and long-term benefits through the WRI perspective. Examples of benefits are shown below.[160]

- Lower transaction cost
- Reduced piece price
- Lower product development cost
- Higher quality
- Greater end-user satisfaction
- Improved scheduling/forecast
- Improved product development
- Shorter time-to-market
- Greater supplier support/value
- Supplier provide greater support beyond contract obligations

4.12 Customer Satisfaction

The extensive amount of literature written in the area of marketing and customer satisfaction makes it hard to find high level literature that describes the interrelations between different concepts of how the customer is evaluating the service or product delivered. According to Wen-Bao Lin's research published in 2006 there are several concepts that together add up to what the authors will call customer satisfaction.

Service encounter and its types; meaning the level of interaction between customers and service providers.

Service value is the benefits gained by the customer relative the cost paid for the service or product.

Service quality is classified into two areas, functional and technical quality. The functional area of service quality emphasises the content of service that the service provider can offer, i.e. the concern of the service provider on internal clues. The technical quality emphasises the concerns of the service provider on internal clues.

Relationship involvement is the capability for a company to consent the customer interest and the managing of the relationship.

Customer satisfaction refers to the gap between the expected service and the actual perceived service. The entire above, customer related, dimensions do impact on the perceived customer satisfaction which is illustrated in figure 4-13.

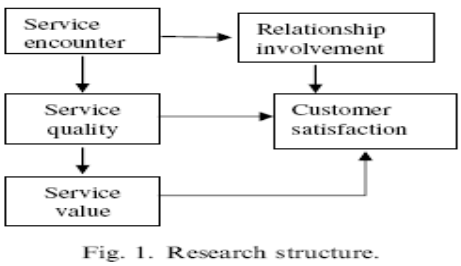

Figure 4-13, Illustration of service/product related dimensions and how they affect the customer satisfaction.[161]

[160] Henke John (2007) *Working relation that drive success*, p 24
[161] Lin, Wen-Bao (2006) *The exploration of customer satisfaction model from a comprehensive perspective*

5 Empirical Framework

In this part the empirical data gathered for the study will be presented. The information has been collected through interviews, surveys, and from the EMP internal data sources.

5.1 The structure of the Procurement & Supply Department

There are two main objectives for the department; to procure and supply components to internal projects[162] and external customer and to manage, develop and improve the supply chain. The master thesis will be focusing on the measurements established for the procurement of direct material and therefore the other part of the department will not be further explained.

The buyers' purchasing responsibility is divided into two categories; PCB (Printed Circuit Board) and components. The components are further divided into three (1, 2 and 3) different classes (see
Table 5-1 for definitions of the classes). The buyers at the site in Lund, where the department is located, are responsible for the buying of class 1 and 2 components. The class 3 components are generic components and are procured by the prototype factory[163].

The entire PCB supply is managed by one person, who also is the team leader for the rest of the buyers. The other buyers are responsible for the supply of class one and two components and a supplier base of approximately hundred suppliers, distributed over four buyers. The number of suppliers is not consistent over time due to the fact that different development projects require different technology/components (different features in the mobile platforms) and suppliers therefore change, to some extent, with the birth of new projects.

As stated in the objective of the department in the first section of this chapter; "to procure and supply components to internal projects and external customer", it is important to have in mind that the department is only securing material for reference design and prototype ASIC demand. After the ASIC has reached a specific level of maturity the responsibility of supplying the end-customer with material is handed over to the supplier. This way of doing business is founded in the EMP business model and the objective is to minimise the monetary risk.

5.1.1 Material Supply Project Manager

The basic data that is forwarded to the buyers showing the actual demand is compiled by the MSPM (Material Supply Project Manager). MSPM is the interface between the development projects, build management and the buyers. MSPM is receiving the so called MBP (Master Build Plan), which states all the production occasions (the builds[164]) that are planned to start the coming six months. The MBP also includes which quantity to build and the build number. The MBP is typically to be sent out one to two times a week, depending on the rate of change, by respective responsible person at the build management function. After MSPM has received the MBP, the MBP will be forwarded to all the buyers.

[162] Will be referred to as; Internal Customer, R&D and reference design
[163] Will also be referred to as MIC
[164] The "build" cover everything from test modules for specific ASICs/applications to fully developed platforms. Each build belongs to a specific project, which is the overall name for a specific platform model.

5.1.2 Material Supply Project Manager – Bill of Material

BOM (Bill Of Material) is a file distributed by each project manager specifying what components each build contains. In order to procure the components and place orders to the suppliers with agreed order lead time, the BOM shall arrive to the MSPM twelve weeks before the scheduled start of a build.

5.1.3 Material Supply Project Manager – Deviation List

Deviations from the first BOM are probable to occur during the development phase. If this happens, depending on the project management, two options are possible. The project management can either change the BOM and redistribute the BOM to the MSPM or create a deviation list. The deviation list is much less resource consuming activity than the creation of a new BOM. The deviation list specifies which component that shall be used/ordered instead of the ones specified in the BOM. The deviation list is also sent to the MSPM who saves all the deviation files at a shared drive which is accessible for all the buyers. Thereafter it is the buyers' responsibility to look regularly to see if any deviations have been added or not.

5.1.4 Buyers – Class 2 Components

Described in the MSPM role, the buyers are responsible for different suppliers. Within the responsibility lies; updating the personal build plan with information gathered from the BOM, making sure the prototype factory has stock on the components when the build is scheduled to start, ordering and following up on orders.

Reference design (internal development projects) is the only customer of the class two components.

5.1.5 Buyers – ASICs

Some of the buyers also have the responsibility to procure ASICs. The demand of ASIC does both come from internal and external customers. The internal demand derives, just as for the class 2 components, from the reference design and the external demand is what customers outside of the organisation order in form ASICs (called PAS, Prototype ASIC Supply) for customer internal development. This demand is gathered by the CPM (Customer Project Manager) and KAM (Key Account Manager) together, who are responsible for the business execution with a specific customer.

5.1.6 Buyer – PCB

Procurement of PCBs is taken care of by one person. The PCBs are only ordered for internal use in form of reference design builds, which can be test boards of different kinds or S&B board (Small and Big board) that is sold to the customer. The PCB buyer uses the MBP to find out how many boards are needed for a specific build. The second source of input is the PCB CAD drawing (Computer-Aided Design), which the buyer receives from the projects[165] and hands over to the appropriate supplier.

5.1.7 Procurement Process

After the demand is gathered either for the PCB, components or ASICs the orders need to be placed (if sufficient stock is unavailable). Depending on what kind of component it is, a

[165] Project or Project management is another name for the internal customer, also referred to as reference design.

certain additional amount of components are added to the needed quantity stated on the MBP (normally ten percent of the quantity, depending on the expensiveness of the component). The additional quantity is needed due to the loss of components in the production process.

Orders are created in the business system called SAP, logged with all its information in their build plan (based on Excel) and thereafter sent to the supplier by e-mail. When the order is sent to the supplier, the buyer adds the requested delivery date and the PO number generated by SAP in the build plan. When the delivery date on the order is confirmed by the supplier, the buyers update the information in the build plan. After the order has been delivered and the delivery note is received from the prototype factory, the actual date of delivery is added to the information

5.1.8 Purchase system for order status

Through the interviews that were carried out within the procurement and supply department, variation among the buyers on how they use the system was found. The three different types of buyers; PCB, ASIC and Class 2 components (some are buying for more than one category) all use different system support.

Class 1 and class 2 components
Information regarding the class 1 orders are gathered in an excel file which is created by each responsible. These files do not look the same for all the ASIC buyers, which make it hard to follow up the POs that are placed to a specific vendor

For the class 2 components, each buyers has an excel file called build plan that is described in the previous section. When the authors looked at each buyer's build plan they saw that the way of working was not the same for all buyers. For example, all the builds stated in the MBP were not added in all buyers own build plans. One reason is that the buyers have experience and knowledge of which builds that include their components, even before the BOM arrives.

PCB
The PCB system is a modification of what the class 2 buyers use (also an Excel file), and different information is compiled here. Only one person handles all the PCB orders which lead to only one order book for the PCB orders.

5.1.9 PO LOG file

The PO-LOG file is a new supporting system for the purchasers and the P&S will start using it fully in January 2009. The new system will force all buyers to use the same layout on their build plan/order book. It will also be possible to compile the information from all the buyers' build plans/order books into a master file. This will increase the information transparency and simplify the compiling of performance data.

5.1.10 Supply chain process

The information regarding the supply chain process which is presented above is gathered using the walk through method. Each responsible person is interviewed to make sure that each step of the process is correctly understood.

5.2 Component Classification

There is an existing classification of all components that are being procured. It consists of three different classes; 1, 2 and 3.
Table 5-1 shows the characteristic of the different components, whom is responsible for the purchasing, and what level of relationship is strived for.

The classification explained is not based on any specific classification model, which also goes for the operational relation management.

Table 5-1, Description of the component classification.

Class	Component characteristic	Responsible for purchasing	Operational relation characteristic
1	This class consists of primarily ASIC components. The components are jointly designed together with a supplier, which also manages the production of the ASIC. Easier describes as all the components that consists of EMP developed IP (Intellectual Property). Three categories of ASICs exist: ABB (Analog baseband), DBB (Digital baseband) and RF (Radio frequency). These components are the core of what EMP is offering the customer and therefore extremely critical for the business success (both from a platform functionality and monetary perspective). Both EMP and supplier invest in the design and therefore the monetary risk is shared between the two parties. The cost of shifting supplier is considered as very high.	EMP	High strategic importance. Extensive communication between the parties from many different functions. Monthly follow up on performance and progress to maintain and develop the relation (from a supply perspective)
2	Components with a higher level of technology complexity than the class three components and they have specific demands defined by EMP. These components are important for the functionality of the platform and a part of the platform design that EMP offer its customer. The cost of shifting supplier is varying from different components, from high to low.	EMP	Communication related to operational matters such as order confirmation and deliveries. No process established regarding delivery performance follow up.
3	Generic components that does not need to be customised to fit the designated design. Many possible suppliers do exists, off the shelf components, and the shifting cost is considered low.	The prototype factory	All communication, ordering etc. is done by the purchasing organisation within the prototype factory. Limited insight in the relations from an EMP perspective
PCB	There is no existing classification on the PCBs today. The PCBs are always customised for the specific purpose and therefore only produced towards an purchase order from EMP.	EMP	All communication between the PCB supplier and EMP is done by the dedicated PCB buyer.

5.3 Measurements

The department of P&S measures different areas within the procurement process and most of them are gauged as KPI measurements. P&S had not the resources to measure all components, therefore P&S started with class 1 component because of their high degree of importance for the platform. Except the KPI measurements of the ASIC components P&S measures the PCB process and some other class 2 components, but these measurements are not reported in any performance report.[166]

5.3.1 ASIC measurements[167]

All the ASIC measurements are established to secure a correct way of handling the components and to describe the department's performance regarding the supply process. These KPIs are owned by a KPI responsible and analysed on a monthly basis and reported to

[166] Interview with KPI responsible, Annica Torkelsson, 2008-10-16
[167] Interview with KPI responsible, Annica Torkelsson, 2008-10-16

the head of P&S. Further information about the monthly report, see chapter 5.3.5. Within the organisation there are nine key performance indicators that gauge and describe the performance. Except from these KPI measurements there is also one measurement that gauge when the last component is received. Listed below is all ten measurements.

- No of days before receipt of BOM to build date
- Agreed order lead time
- Order acknowledgement responsiveness
- Delivery precision first confirmed
- Delivery precision requested
- Stock out
- Overall supply index
- Delivery precision first confirmed, yearly result
- EMP delivery precision towards customer vs. requested
- Last components received.

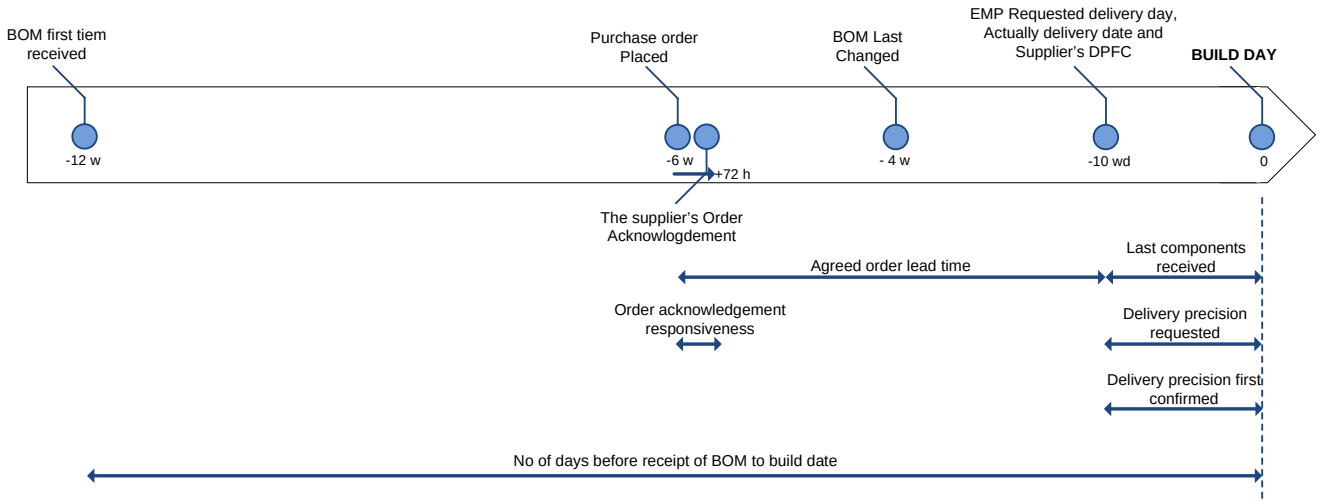

Figure 5-1, The six first ASIC KPI measurements and their targets compared to the build date.

The first six measurements (from the list above) are gauging the purchase order process. Figure 5-1 shows how these measurements (small arrows) are gauged. The large arrow describes the ASIC order process. Below all the ten measurements are further described.

No of days before receipt of BOM to build date. The measurement gauges when the first BOM for a specific build is received by the MSPM (Material Supply Project Manager). Target is that the first BOM shall arrive 12 weeks before the scheduled build start. The time frame is important, within this time the buyers have to place orders and the suppliers need to deliver a complete the order before the manufacturing can start.

Agreed order lead time. The measurement gauges the department's precision to place order with correct and agreed (by the contract) order lead time. It measures if an order item is placed with the correct lead time (as agreed or longer) or not (shorter than agreed) compared to the total number of order items sent to the supplier.

Order acknowledgement responsiveness. Order acknowledgement measures the supplier's respond time on a order compared to the agreed time. A more detailed description: the actual number of order items acknowledged within the agreed lead time for responsiveness, compared to the total number of order items received by the supplier.

Delivery precision first confirmed. This KPI measures the supplier's capability to deliver at their first confirmed delivery date. The calculation; The actual number of order items that is delivered on the first confirmed date (or earlier) compared to the total number of order items confirmed for delivery to the department.

Delivery precision requested. This KPI reflect the supplier's capability to deliver on the requested delivery date. The requested delivery date is the date P&S wants the order to be delivered on. This KPI can be calculated as the actual number of order items delivered on the requested day (or earlier) compared to the total number of order items requested for delivery to the department in the measured period.

Stock out. The stock out measures if any component causes a production stop (also called stock out). By definition, a stock out occur if the component is not in stock 9 am the day before build date.

Overall supply index. The Overall Supply Index is established to give the top management a clear picture of the department's performance. The index is based on six KPIs and weighted to give the most important KPI the greatest impact on the index. The index is calculated both for the last month and the whole year's performance. Further descriptions of today's weighting see Appendix 2, look for the structure of the overall supply index.

Delivery precision first confirmed per year. This measurement compiles the total outcome of delivery precision first confirmed for the present year. The measurement is calculated as for the *Delivery precision first confirmed* but compiled for the present year instead of month.

EMP delivery precision towards customer vs. requested. This measurement gauges the EMP's capability to deliver on-time towards the external customers.

Last components received. The measurement measures when the last component for each build is received by the prototype factory. This measurement is not reported in the monthly report.

5.3.2 PCB measurements[168]

Except the ASIC Measurements the department measures, as said before, the PCB (Printed Circuit Boards). The PCBs are measured on 3 different areas; *CAD-drawing received on-time, On-time delivery,* and *confirmed order.* The owner for these measurements is the PCB-responsible. The PCB measurements are gauged but not reported in any monthly report.

CAD-drawing received on-time. This measurement gauges the CAD-department's capability to transfer the PCB-drawing on-time to the PCB-responsible/buyer at P&S. Target is that the CAD drawing shall be received by the PCB-responsible/buyer 20 workdays before scheduled build start.

[168] Interview with PCB responsible, Julia Moore, 2008-11-02

Confirmed order. Measures if the supplier confirms the order on the requested date of delivery or earlier.

Supplier on-time delivery. This measurement gauges the supplier's capability to deliver on-time according to the requested delivery date.

5.3.3 Thresholds of the measurements

There are owners to all of the measured areas. In most cases the process owner of the specific area where the measuring is being done, is also the owner of the measurement. Appendix 2 describes the measurement owners' threshold value and threshold limitation. The threshold value for all measures is divided into Robust, Committed level and Stretch. The suppliers that perform below robust level are not committed with the department's targets. Suppliers between Robust and Committed level are just below the departments target and the supplier are on their way to perform as P&S request. When the supplier reaches the committed level the supplier's performance is aligned with P&S's target. Stretched level means that suppliers are over-performing according to the targets.[169]

5.3.4 Root-cause categorisation

Root-cause categorisation

Procurement and Supply started to discuss the using of root cause analysis of the KPIs in the middle (Q2) of 2008. The root cause analysis is used to categorise and map which failing areas that have the greatest impact on the KPI. The KPIs that are involved in the root cause analysis is agreed *order lead time, order acknowledgement responsiveness, delivery precision first confirmed, delivery precision requested*. After taking the decision to start using root-causes information was gathered from the suppliers on failing orders (in any of the above mentioned KPIs) during the past year. This was used to create a foundation for categorising the root-causes. The information for categorisation is collected and based on abnormality of the KPI measured during 2008. To find the root causes, buyers and KPI-responsible uses the 5-Why methodology to reach the final causes to failure. The P&S created a draft of 6 categories that included all possible root-causes for the selected KPIs.[170]

Communication. Include all activities connected to lack of information, which lead to that the process/procedure is not able to be followed correctly.
Distribution. All activities connected to the distribution process from supplier warehouse to customer warehouse are included in this category.
Planning. The planning category includes all activities that enable deliveries; of the right product, in right quantity, at the right place, in right time, and right condition to the right cost
Production. All activities within the production process are included in the production category
Product. Product category includes activities connected to the product design.
Other. Contains environmental disasters neither managed by Ericsson nor the supplier.

Today's status of the root-cause categorisation

The Pareto Chart in Figure 5-2 shows all the collected root cause categories from the ASIC suppliers. The diagram shows that planning is the most frequent occurring category that has

[169] Interview Buyers
[170] Interview buyers and Internal data sources

an impact on failures of the measurements. Planning stands for almost 40 % of all failures and together with communication these categories are the root cause to failure in the KPIs in 60% of all failures. Notable is that the unknown root causes, marked by "?", is 18 %.

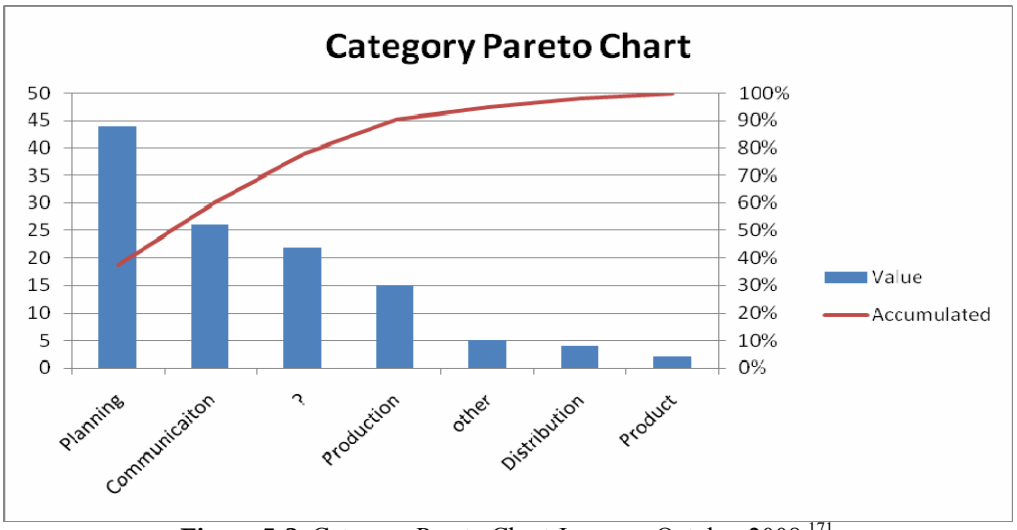

Figure 5-2, Category Pareto Chart January- October 2008.[171]

The data for each measurement is shown in Appendix 3.

Delivery precision first confirmed
The Appendix shows that the main reason to failure in delivery precision first confirmed for 2008 is production and planning. Production and planning represent 55% of the root categories to failure in this KPI. Notice that 16 % have not been categorised.

Delivery precision requested
The main reasons to failures in delivery precision requested are planning and production. The planning category is twice as big as production and together they represent 60 % of all the failures. For this measurement the not defined category is the third largest with 16%.

Order acknowledgement responsiveness
Appendix 3 explains that communication problems represent 46 % of all failures in order acknowledgement responsiveness. The not defined category for the order acknowledgement measurement is the second largest. Not defined represent 1/3 of all failures.

Agreed order lead time
The agreed order lead time failure is only categorised by planning (78%) and communication (6%). Also in this case not defined is the second largest category (16%).

Future improvements
In Q3 2008 P&S started investigate root causes for PCB. These categories are not developed as much as in the ASIC categories. This master thesis will continue the root causes work. The thesis will analyse the root causes and develop, and if necessary change, the root-cause categorisation to fit both ASIC and PCB-measurements. [172]

[171] EMP-data, Jan-Oct 2008
[172] Interview PCB responsible

5.3.5 Monthly Report

The monthly report (MR) only includes the ASIC measurements. The report is divided in three different parts. First part describes the most important measurements and includes the outcome of the measurement, comments about the outcome and action points to improve them. The second part describes some of the KPIs and only briefly the action points how the KPIs might be improved. The third part deeply describes three of the most important measurements from the first part.[173]

The P&S buyers are responsible for data collection of the selected KPIs for the second part. If any of the KPIs is failing the buyer should receive a root-causes analysis from the supplier. The KPI-responsible compiles collected data, from all buyers, into the monthly report. The person on this position also puts action points into the failed KPI.

The third part is a deeper calculation and visualisation of the outcome for three of the most important measures that are shortly described in part one. The responsible person, both PCB- and PSM – responsible, collects data and compiles the result into the Monthly report.

PCB-, PSM,- and KPI- responsible together create the first part in the monthly report.

5.4 Order Process

This chapter will describe the targets and actual status of the order process. All figures in this chapter are calculated with target as baseline. For example; Requested delivery date is set at 10 workdays (wd) before build date. The data behind this chapter and related appendix are collected and calculated from different internal data sources.

5.4.1 Today's Order process Target

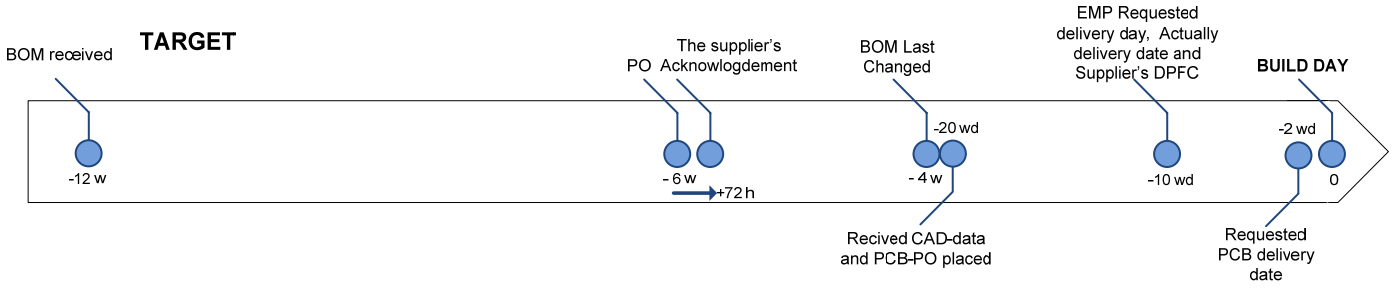

Figure 5-3, Targets for the order process. W=week, WD=workday.[174]

The EMP order process of ASICs and PCBs involves several departments. The foundation for ASIC orders is created by the project. The descriptions of which components and in what quantity they are needed for each build are documented in a BOM. This BOM is later transferred to the P&S where the purchase order (PO) is created. The target for transferring of the BOM between the departments is 12 weeks before build date. Changes in the BOM should be placed at the latest 4 weeks before build date, according to the process. P&S must place the purchase order no later than 6 weeks before build start. The PO limitation is set by the agreed

[173] Internal data sources
[174] Interviews; Components buyers, PCB-buyer, and BOM responsible

order lead time on 4-5,5 weeks (varies between different suppliers) towards the suppliers and that the components must be delivered at least 2 weeks before build date. This time frame is set in order to avoid late deliveries affecting the build start. When the purchase order is placed the supplier must respond the order acknowledgement within 72 hours.

No later than 20 workdays (4 weeks) before build date the P&S must receive the CAD-data for the PCB from the CAD-department. The limitation of 20 workdays is established to secure that PCB-PO is placed within correct lead time and that the delivery arrives 2 workdays before build start.[175] The target for the order process thresholds is further described in appendix 2. [176]

5.4.2 Today's status of order process

The diagram, figure 5-4, illustrates the average of the actual status on the order process. The colour describes how the milestones differ from the targets. Blue means that nothing have changed, green that mean value is better than target and red that mean value is worse than target.

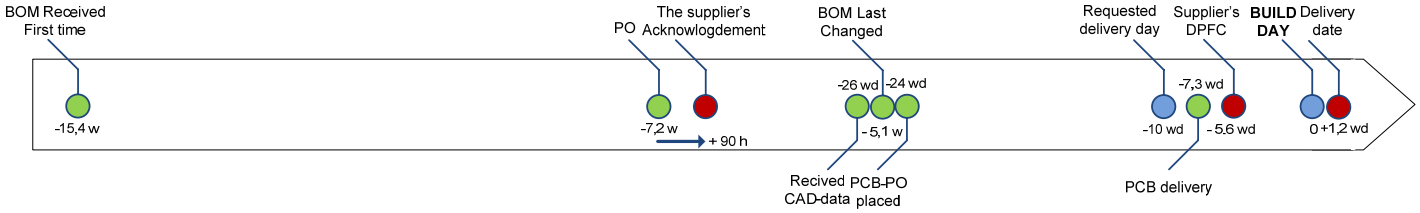

Figure 5-4, Actual status of the order process (average values).[177]

The average only point at a trend for each step. A quick look at the diagram shows that six measures are better and three is worse than target. A further investigation of trends and variation is described in the following three sub-chapters.

5.4.3 Order process, BOM[178]

At the actual status diagram shows that the average of BOM first received is better than target. Unfortunately the diagram does not describe the variation of when the BOM is received. BOM first received target is 12 weeks before build start and 40 % of all BOMs are not reaching the target. Figure 5-5 illustrate the P&S first received date (weeks before build date) of the BOM.

[175] Interviews; Components buyers, PCB-buyer, and BOM responsible
[176] Interviews and internal data sources
[177] Data-collection, EMP-document, Jan-Oct 2008.
[178] Data-collection, EMP-document, Jan-Oct 2008

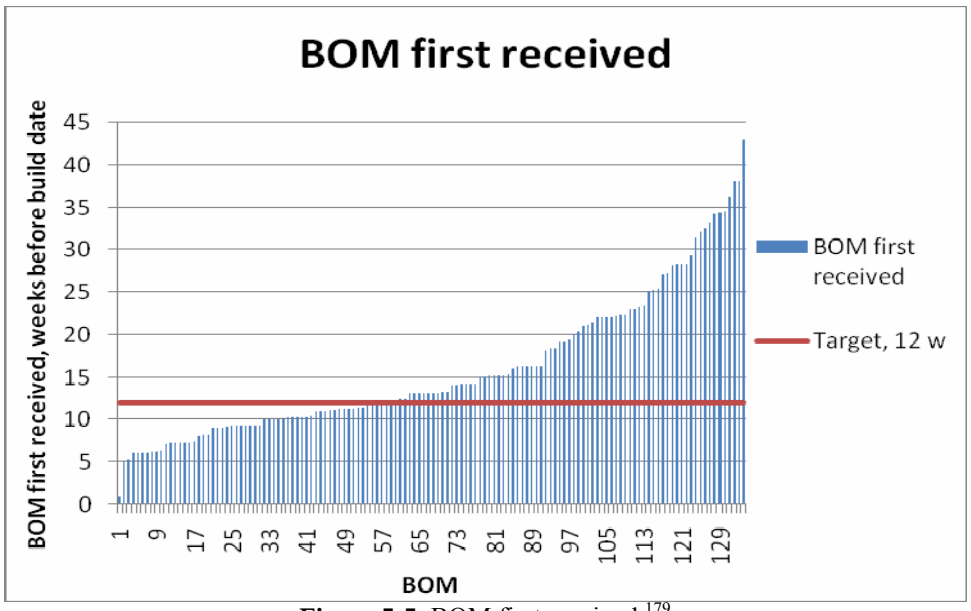

Figure 5-5, BOM first received.[179]

The average for BOM last changed is 5,2 weeks before build date and is better than target (4 weeks). The value is derived from the empirical investigation. The variations of all BOM last changes are shown in Figure 5-6. The diagram shows that 51 % of all BOMs are changed later than 4 weeks before build start. Also BOMs that are received before the 12 week target have late changes. Figure 5-7 combine the BOM first received, BOM last changed and targets.

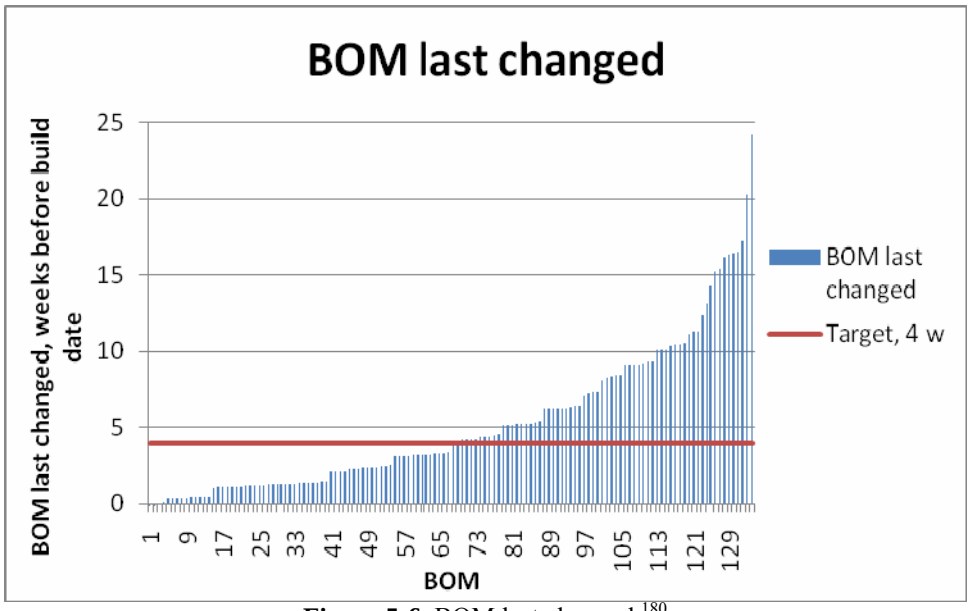

Figure 5-6, BOM last changed.[180]

[179] EMP-data, Jan-Oct 2008
[180] EMP-data, Jan-Oct 2008

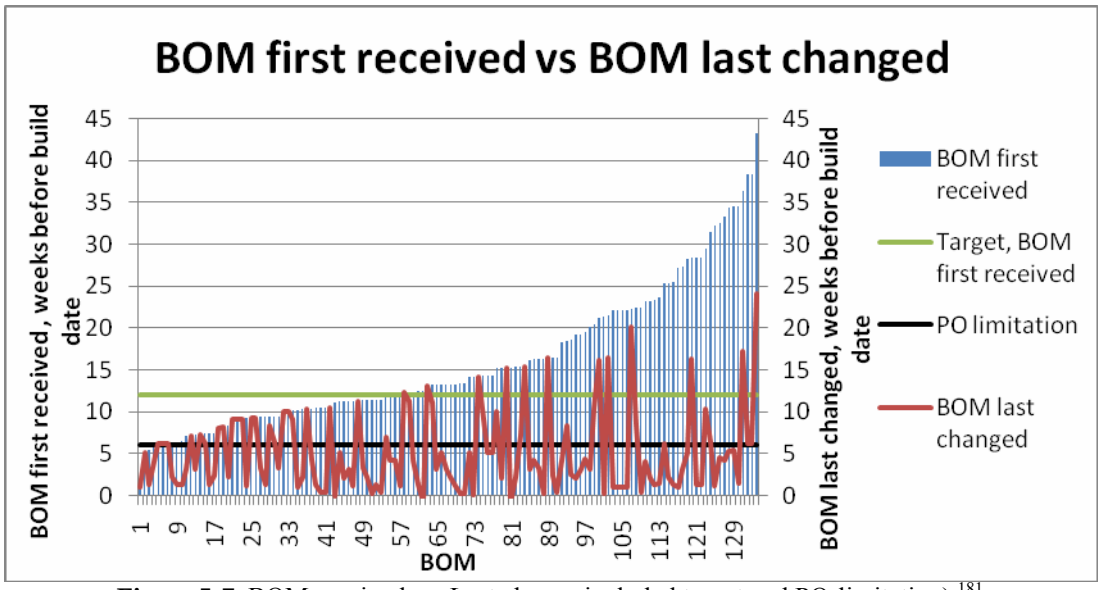

Figure 5-7, BOM received vs. Last change included target and PO-limitation).[181]

5.4.4 Order process, ASIC PO[182]

This subchapter will describe the performance of the purchase order process. The PO-process have four point of measuring, KPIs (Agreed order lead time, Order acknowledgement responsiveness, Delivery precision first confirmed, Delivery precision requested). The purchase order process starts with the BOM. Based on the BOM the buyers, at P&S, place purchase orders to secure material for reference design. Towards the suppliers, P&S's target is to give an order lead time on 4-5.5 weeks from placed order to delivery (varies between the suppliers). Delivery must take place 2 weeks before build date and the result is that the PO must be placed 6 weeks before build date. The average of when the PO is placed is 7,2 weeks before build date.

Agreed order lead time

The average for the order lead time (OLT) towards the suppliers is 5.2 weeks. Figure 5-8 shows the OLT. The order lead time is specific for each supplier and is agreed to between 4 and 5,5 weeks. Notice that 27% of all PO-rows are placed with shorter lead time than 4 weeks.

[181] EMP-data, Jan-Oct 2008
[182] Data-collection, EMP-document, Jan-Oct 2008

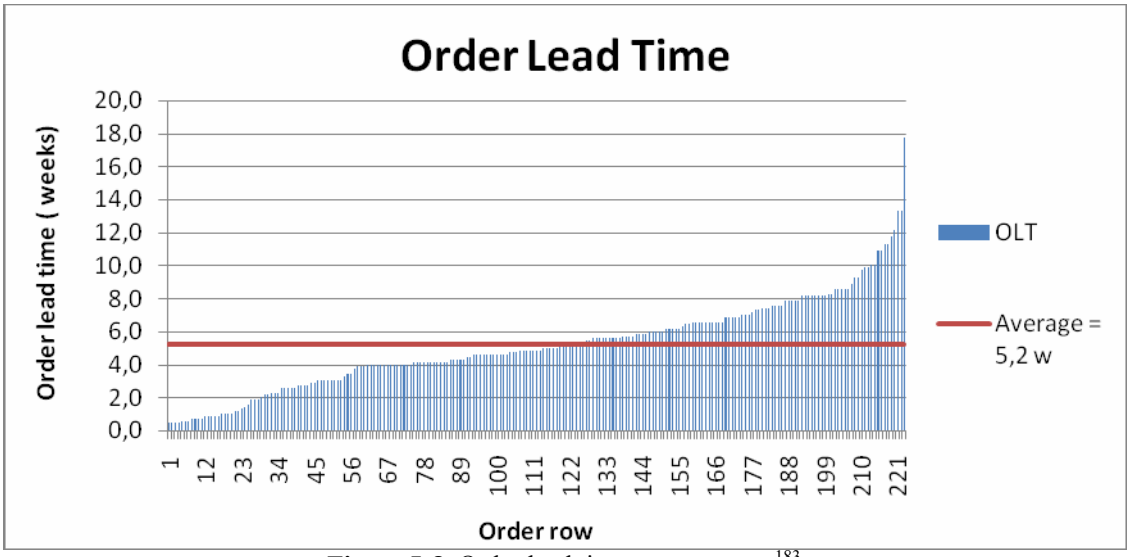

Figure 5-8, Order lead time, components.[183]

Order acknowledgement responsiveness

After the purchase order is placed the supplier has 72 hours to respond to the order. In the acknowledgement the suppliers confirm when they are able to deliver the components, hopefully at the same date as requested. Figure 5-9 shows the order acknowledgement responsiveness in hours. The average is 90 hours and 71% of the orders are acknowledged within 72 hours.

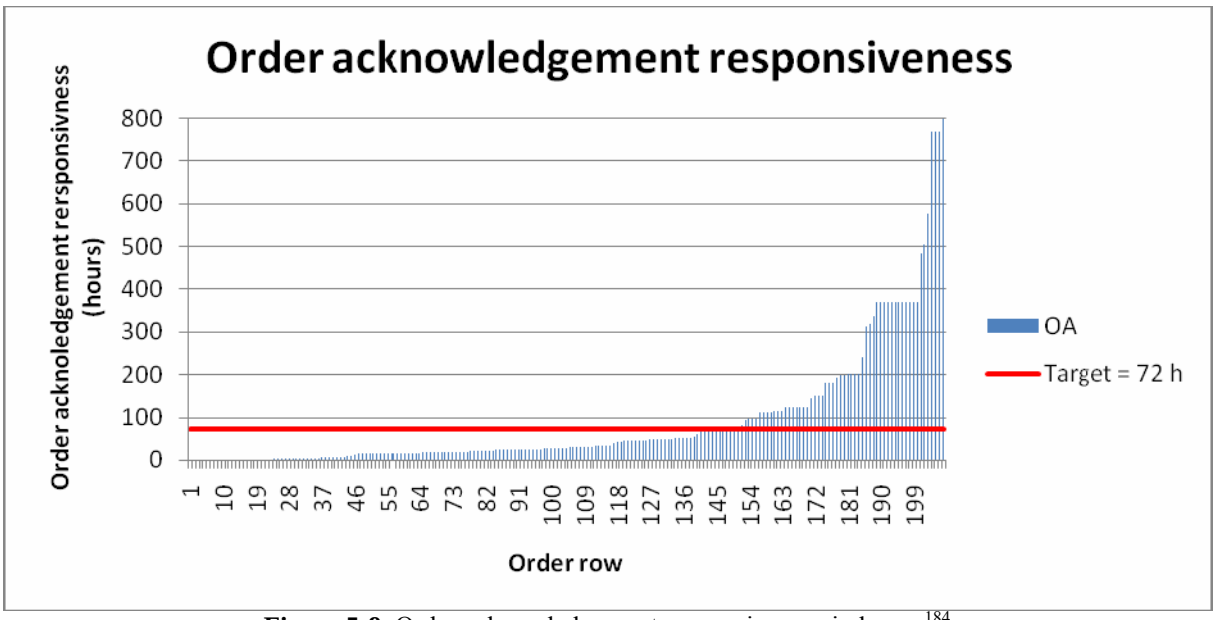

Figure 5-9, Order acknowledgement responsiveness in hours.[184]

Delivery Precision Requested

The diagram for the Delivery precision requested is shown in figure 5-10. The Average delivery precision is 2,18 days after the requested delivery date.

[183] EMP-data, Jan-Oct 2008
[184] EMP-data, Jan-Oct 2008

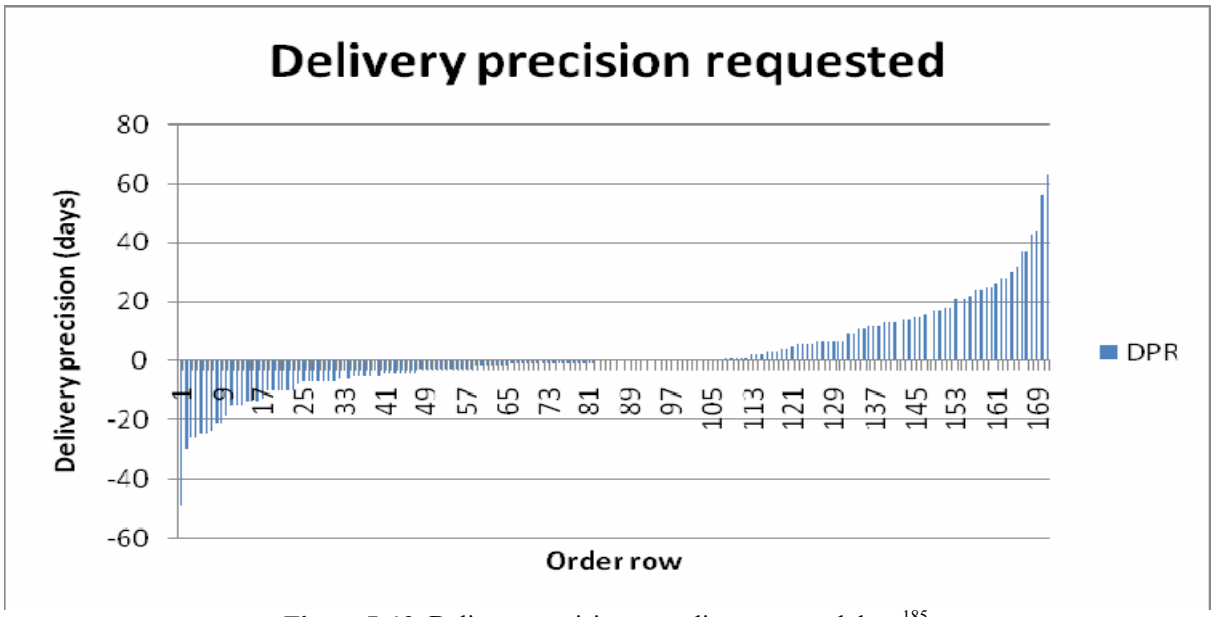

Figure 5-10, Delivery precision regarding requested date.[185]

Delivery Precision First Confirmed

The diagram for the deliver precision first confirmed is showed in figure 5-11. The average of the delivery precision against the first confirmed date is 2,09 days before first confirmed date. The average difference between the requested delivery date and the, by the supplier, first confirmed delivery date is + 4,5 days, which means that the supplier confirms the delivery to 4,5 days after the requested date in average.

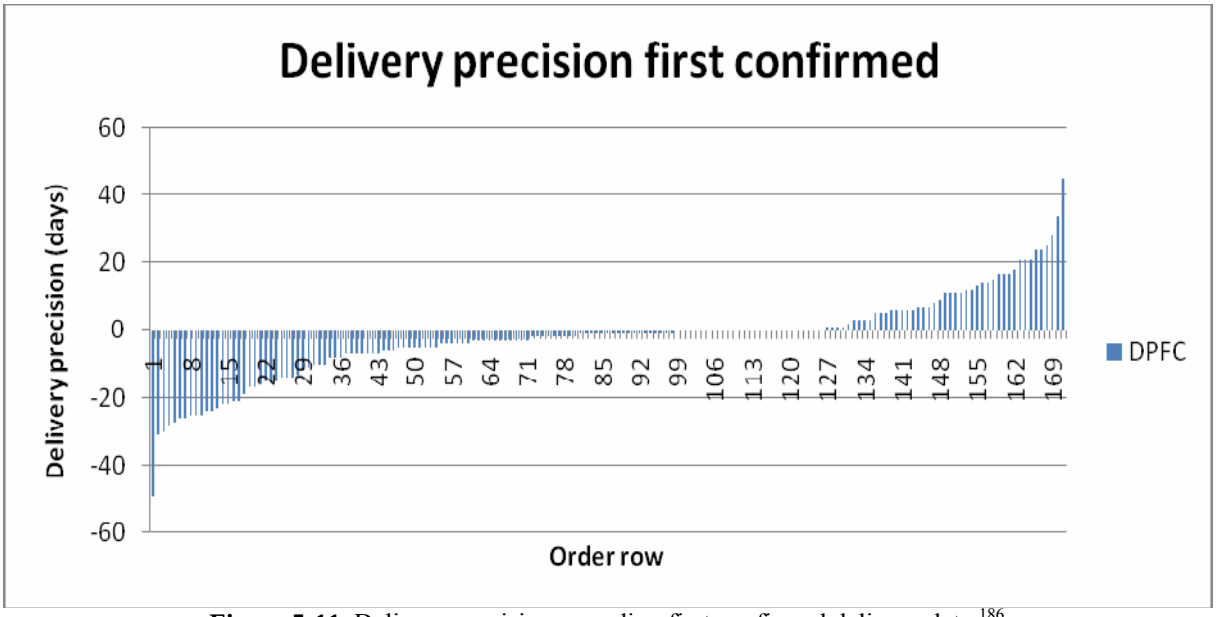

Figure 5-11, Delivery precision regarding first confirmed delivery date.[186]

[185] EMP-data, Jan-Oct 2008
[186] EMP-data, Jan-Oct 2008

5.4.5 Late deliveries and stock outs[187]

Because of gaps in the information the forecasted build date is based and calculated on the requested delivery date. There is a stock buffer time (2 weeks) to secure that all components are stocked before build date. If the supplier's delivery is later than requested date it will affect the buffer. When the delivery is later than 2 weeks the build start might be affected. In those cases, when the build start is affected, the build date must be rescheduled. Otherwise there is a risk for stock outs.

Table 5-2, Stock Outs and late deliveries.[188]

	Late deliveries	Delivered after forecasted build date
Number	64	27
%	37%	16%
Total PO-rows	171	

The figures in this sub-chapter are based on the targets and do not take the build reschedules in consideration. The PCB deliveries are not included in the figure. Between January and October 2008, 171 order rows with information about the requested delivery date where delivered. 64 of the order rows were delivered after requested delivery date and are indicated as late delivery in table 5-2. Out of these 64 order rows 27 were delivered more than 14 days late which is after forecasted build date. Notice that all delivered order rows that arrive later than forecasted build date are possible stock outs. The only way to avoid stock out, caused by late deliveries, is to reschedule the build date[189].

5.4.1 Order process, PCB

To be able to analyse the order process for the PCB POs, data have been collected from the responsible buyer's spread sheet. From the beginning it contained 185 order rows for the year of 2008 until October. Due to missing data and that the authors started their analysis before all orders for 2008 have been placed, confirmed or delivered the spread sheet was narrowed down to 106 order rows. The order rows that have been disregarded from did not contain data on all the parameters needed for the analysis or were not finished, see appendix 7 for extract of the spread sheet.[190]

To be able to manufacture a PCB the suppliers needs CAD-data on the PCB design. EMP internal process is saying that this data shall be transferred from the CAD department to P&S and the PCB responsible no later than 20 working days before scheduled build start. Figure 5-12 show that the average of all CAD data received is 26 workdays before build start. 36 % of all CAD data is received by the P&S later than 20 workdays before build start.[191]

[187] Interview Buyers
[188] EMP-data, Jan-Nov 2008
[189] Interview; Buyers, BOM-responsible, PCB-responsible.
[190] Extracted data from EMP internal system, Jan-Oct 2008
[191] Extracted data from EMP internal system, Jan-Oct 2008

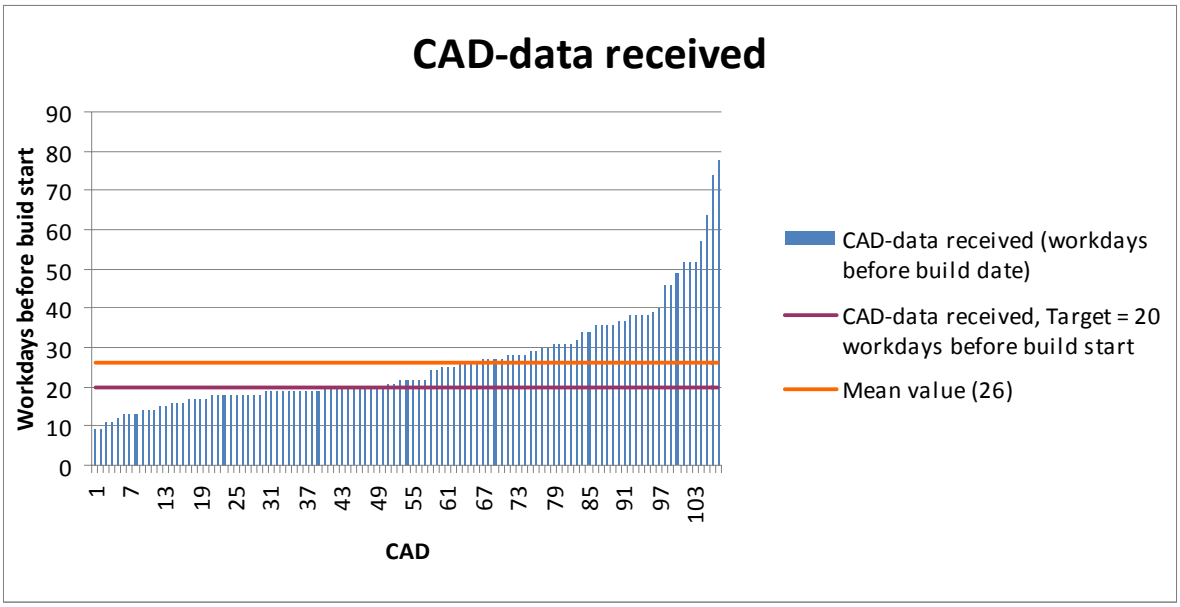

Figure 5-12, CAD-data received (workdays before build date).[192]

Figure 5-13 shows the number of workdays between the reception of CAD-data and the order being placed to the supplier. The average of order handling time (between reception of CAD-data until order being send to the supplier) is 3,2 workdays. It also shows that three orders were placed before the CAD data was received.[193]

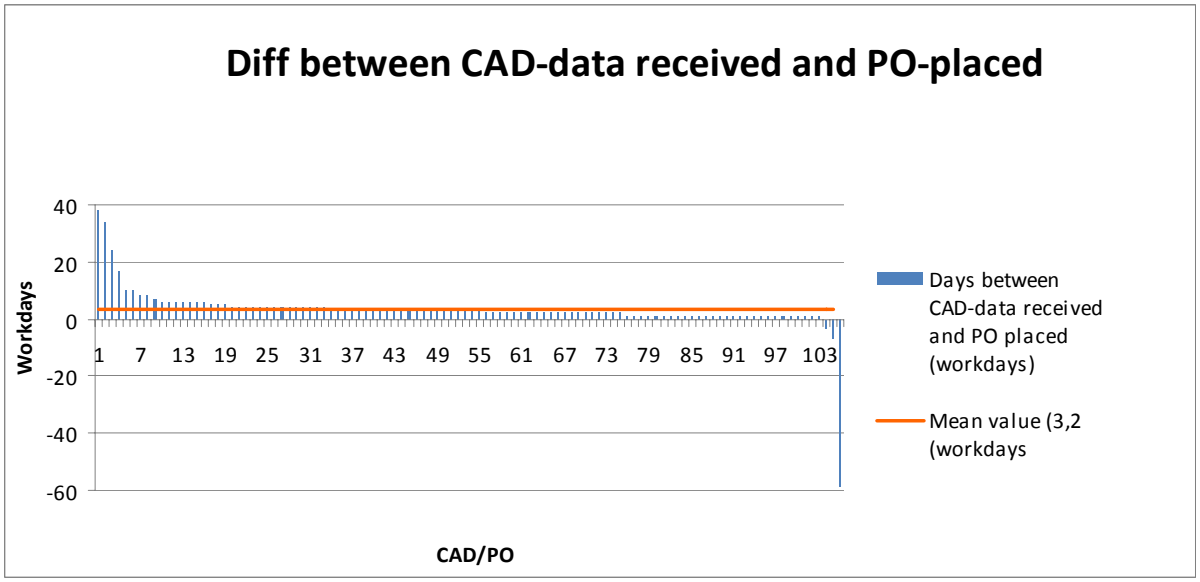

Figure 5-13, Order handling time, from reception of CAD data to order being placed.

If the order is being placed the same day as the CAD data arrives the supplier gets 18 days to manufacture and deliver the PCBs. This is under the condition that all targets are reached and the CAD data arrives on time (20 workdays before build start). PCB price is inversely proportional to the length of the lead time, the shorter lead time the higher price and vice versa. The price together with what the supplier can perform is the base for how the timeframe on 20 workdays is set. The target date for reception of the PCBs is two days before

[192] Extracted data from EMP internal system, Jan-Oct 2008
[193] Extracted data from EMP internal system, Jan-Oct 2008

the build is scheduled to start. These two days are due to the preparation of builds in the prototype factory. Figure 5-14 shows when the PO is being placed, compared to first promised delivery date on average 18 workdays before delivery.[194]

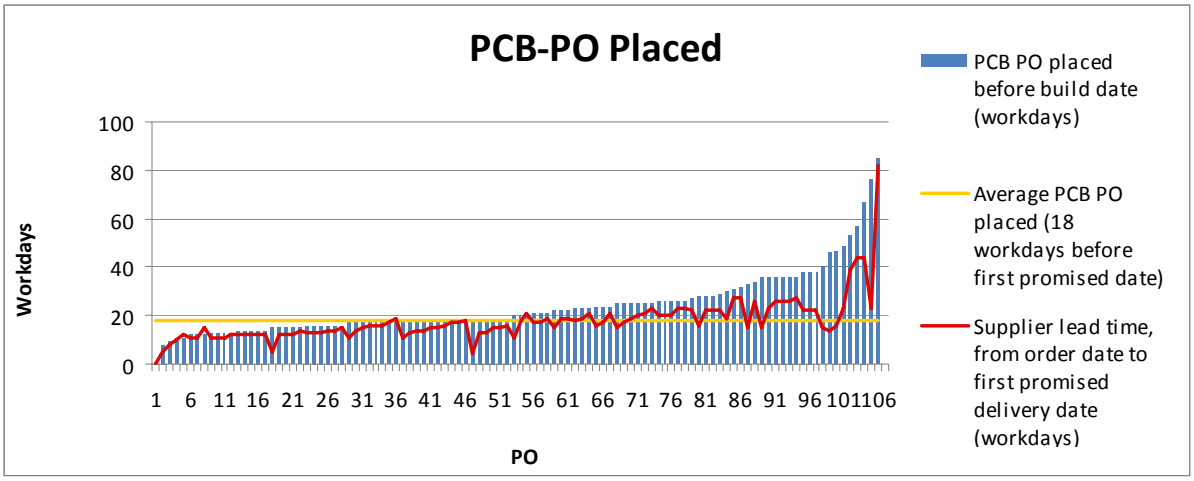

Figure 5-14, The diagram shows the lead time given to the supplier.

The average of PCB delivery precision is 1,1 day after the first promised delivery date. Out of all delivered orders, 39 % were delivered after the first promised delivery date (see figure 5-15). Notable is that 32 % of all orders are delivered (+-) 1 workday from first promised delivery date.[195]

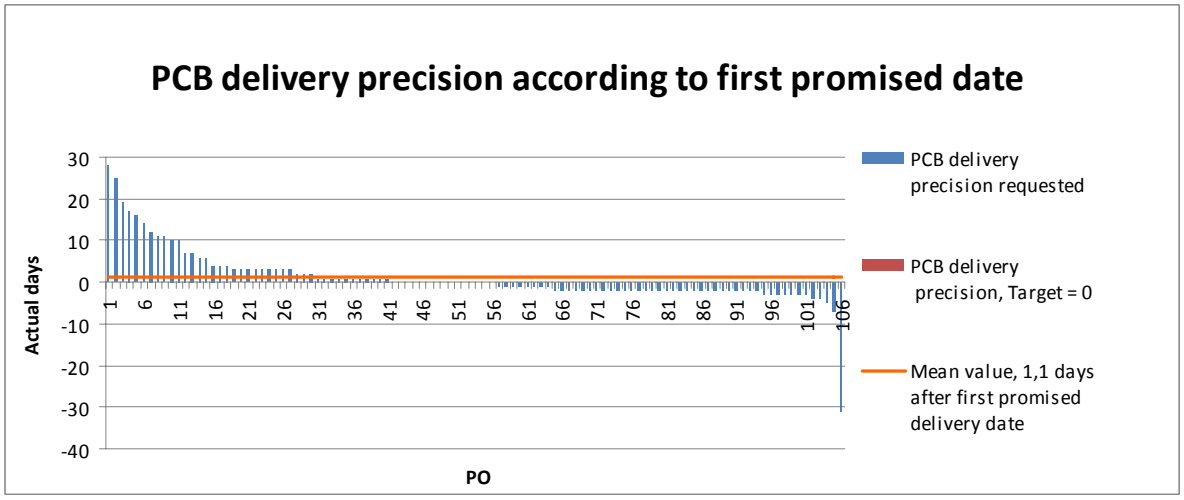

Figure 5-15, PCB delivery precision. Zero means delivered on the first promised date, (-) before and vice versa.[196]

[194] Extracted data from EMP internal system, Jan-Oct 2008
[195] Extracted data from EMP internal system, Jan-Oct 2008
[196] Extracted data from EMP internal system, Jan-Oct 2008

5.5 Six Sigma Project - PCB

During the autumn of 2008 EMP started a Six Sigma project with the objective to decrease the cost of PCBs and increase the delivery performance of PCBs. The project will continue until the spring of 2009. The authors have been a part of the project but only during its first phases because of the time frame and only in the delivery performance part. The team involved in the analysis of the delivery precision included representatives from Procurement and Supply, CAD department and Quality Department to secure that correct improvement decisions were taken.

Some of the information presented in the PCB process above was also used in the project when analysing the delivery performance of PCBs.

5.6 Supplier Relations

There is no specific expressed strategy on how to specifically work with supplier relations within the department from an operational perspective. In general the Sourcing department uses the Ericsson general strategies for working with strategic supplier relations. For the operational working relation it is up to each buyer to prioritise their work regarding supplier relations. The classification, see table 5-1, is used as a guideline for the buyers.

5.6.1 Supplier relations Class 1 components

The strategic relations with the most important suppliers/components, the ones classed as class 1, are more important than the relation with lower classed suppliers/components. This is something that all buyers are aware of and as said in the table, it is also those suppliers that are measured and followed up on their performance on a monthly basis.

For the class 1 suppliers there are also phone-conferences regularly to coordinate the forecasted demand and actual orders with the available capacity and possible supply.

If there are issues regarding the order and the delivery the issue is root caused by the supplier using the five why's method (if it is a supplier caused problem). The root cause and preventive actions is presented in an EMP-designed template and discussed at the monthly meeting with each class 1 supplier.

In some cases a supplier supplies both class 1 and 2 components, in such a case performance measures and root causes are only being done on the class 1 components.

5.6.2 Supplier relations Class 2 and 3 components

The authors have found out during the interviews that the operational communication with the class 2 and 3 suppliers mostly is related to the order placement and issues regarding these orders. The issues are solved if they occur and there are in general no preventive actions carried out to improve or change the relation between the parties.

For the class 3 components, EMP's visibility in how the factory works with their suppliers are limited. Because the nature of the components are generic and are bought at the best market price the need for a supplier relations program is not relevant.

5.7 Supplier Survey – Background and Design

In order to get the suppliers' opinion and perception on EMP's performance and the relation between the two parties, a survey was designed for the suppliers to take. It focused on three specific areas; Working relations, Operational and Other (profitability and product development). Within the relation area four statements were asked regarding trust, working relation, communication and information. Operational statements are related to orders and the category other consists of statements related to supplier profit and the development process. The choice of statement topics are based on the WRI model presented in chapter 4.11.

As earlier described, the objective of the survey was to increase the buyers' knowledge of how their work is perceived and within which areas improvement is needed. The statements in the "other" category were asked to see if factors not owned by the P&S department were perceived at a good level. Because of those objectives the survey was sent for the supplier to answer anonymous. A determining factor for having the suppliers answering the survey anonymous is that the reliability of the answers is considered to be higher. The respondent rate is considered to be higher if the suppliers know that their answers are anonymous.

When designing the survey we also had in mind that the statements should be possible for the buyers to ask. All buyers who are working with suppliers that are a part of the study were asked to take the same survey and answer the statements as an evaluation of themselves and how they think that the suppliers perceive EMP. Because of this the network of connections can be evaluated from both the supplier and the buyer side. The survey was sent out to four buyers who all answered the survey.

5.7.1 Choosing respondents

EMP is using a classification system that is thoroughly described in chapter 5.5. The authors decided to send the survey only to two ASIC suppliers (class 1 components) and thirteen class 2 component suppliers. Only two ASIC suppliers were chosen because of EMP internal circumstances. To be able to separate the answers from the two different classes of components/suppliers they were asked to answer different surveys, though the same statements. Class two suppliers were chosen based mainly on annual spend. Suppliers with a greater annual spend than 250´ SEK are included in the study, the annual number of POs and components were also taken into consideration when choosing the respondents.

The suppliers' employees were chosen based on whose opinion was of importance for the Procurement & Supply department. The authors therefore tried to send the survey to two persons at each supplier; the KAM (Key Account Manager, owner of the relation) and the responsible customer service/sales person.

5.7.2 The scale and the statements

The survey was web based and consisted of ten statements; see below for the statements given to the suppliers' (appendix 10 and appendix 11 for buyers' statements). Each statement should be answered with a number from 1,5 - (-)1,5; 1,5 meaning that "I totally agree with the statement" and -1,5 meaning that "I totally disagree from the statement". After each statement the respondent was asked to rank the previous statement's importance from their point of view. The ranking scale is set from 1,5 - (-)1,5; 1,5 meaning that the topic is "Very important" and -1,5 that it is "Not important at all".

Scale	Statement	Ranking
1,5	I totally agree	Very important
0,5	I agree	Important
0	Neither agree nor disagree	Neither important nor unimportant
-0,5	I disagree	Not important
-1,5	I totally disagree	Not important at all

Statement (Scale; 1,5 "I totally agree" to -1,5 "I totally disagree")

Area: Relation

1 The level of trust within the relation, between You and the suppliers, is satisfying.
2 Working relations, between You and the suppliers, is perceived as satisfying.
3 The communication, between You and the suppliers, is perceived as open and honest.
4 EMP communicates timely and adequate information to the suppliers.

Area: Operational

5 EMP places orders with shorter lead time than agreed.
8 Late order-changes after order is placed are frequently recurring.
9 Late order-changes after order is placed affect the suppliers' ability to deliver according to first confirmed delivery date.
10 Late order-changes after order is placed affect the suppliers' cost of manufacturing and delivery.

Area: Other

6 The suppliers are sufficiently involved in EMP's development process of new products.
7 EMP gives the suppliers the opportunity to make acceptable profit over long term.

Ranking (Scale; 1,5 "Very important" to -1,5 "Not important at all"

1-7 Rank the importance the statement.
8 How important do You think (or what You have heard from the suppliers) it is, from the suppliers' point of view, that the orders not are changed after the suppliers have received them.
9 How important do You think (or what You have heard from the suppliers) it is, from the suppliers' delivery precision perspective, that the orders are not changed after they have received it.
10 How important do You think (or what You have heard from the suppliers) it is, from the suppliers cost perspective, that the orders are not changed after they have received it.

5.8 Supplier Survey – Results

All persons asked to participate in the study were given more than two weeks to take the survey. After one week, an e-mail was sent to the suppliers reminding them about the survey. When the result was gathered from the two surveys a surprisingly high respondent rate was noted. All of the four persons, at two different ASIC suppliers, answered the survey. Out of twenty one persons at thirteen different class 2 component suppliers, seventeen answered the

survey (81% respondent rate). Follow will the result presented by respondent group; Class 1 component suppliers, Class 2 component suppliers and EMP buyers.

5.8.1 Class 1 component (ASIC) suppliers

Statement 1 to 4 goes under the category relations, see figure 5-16 for the answers and appendix 8. The suppliers do totally agree with statement 1 and 2; that the levels of trust and working relations are satisfying. They think that the level of trust is very important and the working relations almost as important. For statement 4; "EMP communicates timely and adequate information" the suppliers more than agree and they think that it is very important. Regarding statement 3; "The communication between EMP and the supplier is perceived as open and honest" they almost disagree. The suppliers think that open and honest communication is more than important.

Statement 5,8,9 and 10 is related to operational matters. Regarding statement 5 the suppliers, to some extent, agree that EMP have placed orders with shorter lead time than agreed and they think that this is almost important. For statement 8, 9 and 10 they disagree (at least). Statement; 8 is ranked as neither important nor unimportant, 9 as more than important and ten as almost not important.

For the two statements in the "other" category, statement 6 and 7 they almost agree and between "I agree" and "I totally agree". Statement 6 is ranked as more than important and 7 as almost very important.

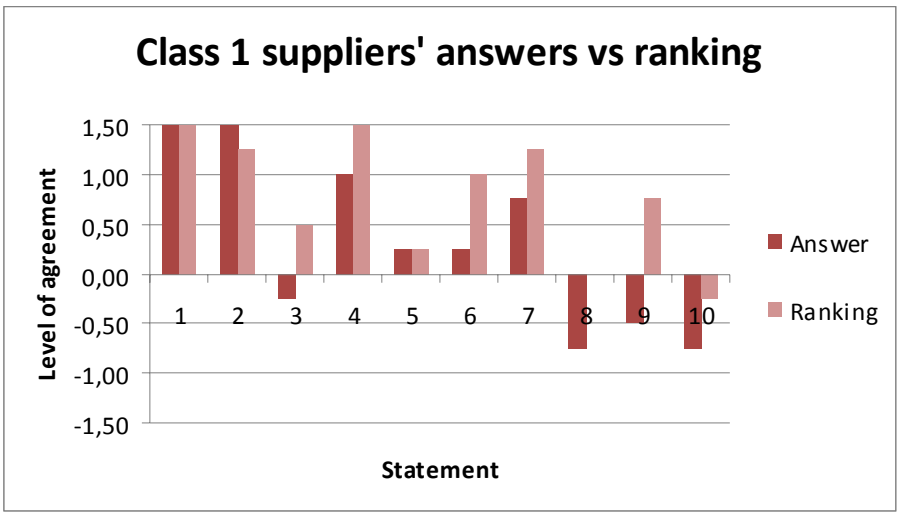

Figure 5-16, Class 1 component suppliers' answers vs. ranking.

5.8.2 Class 2 component suppliers

As described in the previous chapter, Statement 1 to 4 goes under the category of relation. Given the scale and the suppliers' answers, they almost totally agree that EMP and the supplier's relation are satisfying (see figure 5-17 for answers). The suppliers do almost totally agree to that the level of trust, working relations and communication (open and honest) is perceived as satisfying by the supplier. The suppliers do more than agree that EMP communicates timely and adequate information (see appendix 9). These four statements, in the category relations, are those that are ranked the highest by the supplier. The suppliers think that these areas are very important, especially the level of trust and that EMP communicates timely and adequate information.

Statement 5, 8, 9 and 10 are statements related to operational matters such as order placing and changes in orders. Statement 5 has an, in comparison, big difference between the level of agreement with the statement and the importance of it. The suppliers disagree to the statement that "EMP places order with shorter lead-time than agreed". The suppliers also think that it is more than important that EMP does not place order with shorter lead-time than agreed. The suppliers more than disagree with statement 8; "late order changes after order is placed is frequently recurring". On the other hand the suppliers neither think that this statement is important, nor unimportant. Regarding statement 9 and 10 the suppliers do think that it is important that orders not are changed after they are sent to the supplier. This will affect the delivery precision according to the suppliers. The late order changes do also increase the cost of manufacturing.

Statements that go under the category "other", statement 6 and 7, the suppliers almost agrees to that they are sufficiently involved in the development process and that EMP enables long term profit for the suppliers. These two statements are ranked as more than important by the suppliers.

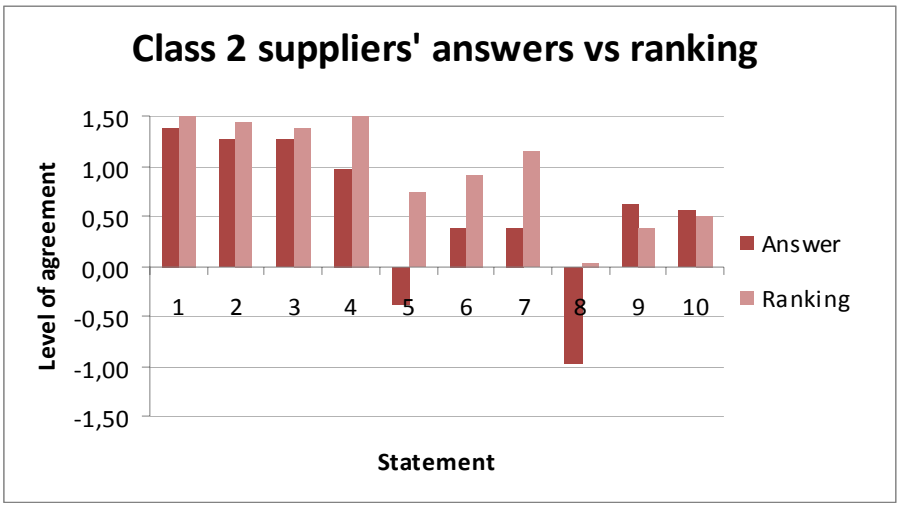

Figure 5-17, Class 2 component suppliers' answers vs. ranking.

5.8.3 EMP buyers (internal)

The first category, relations, which is statement 1 to 4 there is a big difference between the answers (see figure 5-18 for answers). For statement 1 and 3, the buyers more than agree to that the level of trust within the relation is satisfying and communication with suppliers is perceived as open and honest. Statement 1 is ranked as very important and statement 3 as almost very important. Regarding; "Working relations between EMP buyers and suppliers are perceived as satisfying" statement two, the buyers almost totally agree. This is ranked as very important by the buyers. The last statement in the category, statement 4 "EMP communicates timely and adequate information to the suppliers", the buyers disagree but think that this is almost very important.

In the category; Operational, the buyers almost agree to statement 5 and 9 ("EMP places order with shorter lead time than agreed" and "Late order changes after order is placed affect the supplier's ability to deliver according to first confirmed delivery date"). Statement 5 is ranked as almost important and statement 9 as more than important. "Late order changes after order is placed are frequently recurring", statement 8, the buyers do neither agree nor disagree. This

is ranked as neither important nor unimportant. The buyers agree to statement ten and rank it as important.

In the "other" category, the buyers almost agree to statement 5 and more than agree to statement 6. Statement 5 is ranked as almost important and statement 6 as more than important.

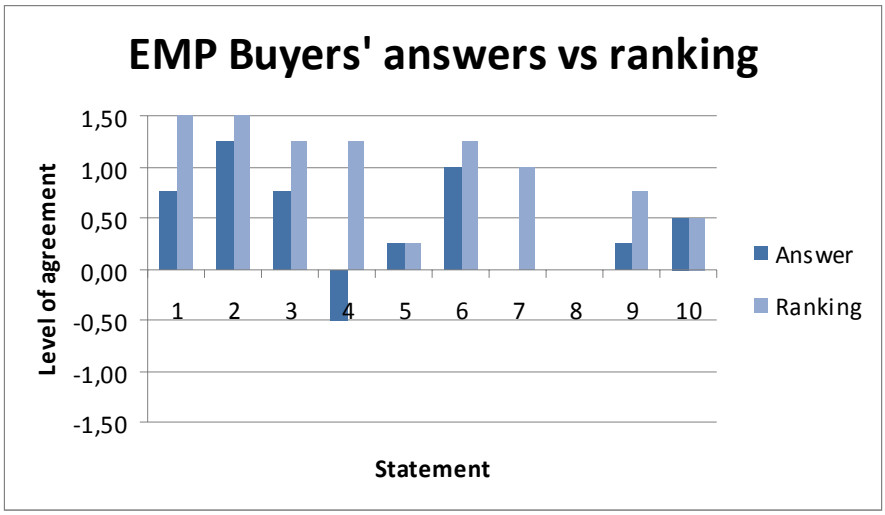

Figure 5-18, EMP buyers' answers vs. ranking.

5.9 Customer Satisfaction

There are no structured proactive activities carried out at the P&S department to establish and increase the communication between the department and the end customer. The P&S department and the PAS responsible are responsible for shipping the PAS and S&B[197] board to the end customer. If something goes wrong and the customer does not receive the product on time they do contact the CPM who thereafter contacts the PAS responsible.

Between P&S and the internal customer, the communication is extensive. Well established communication channels enable a good transfer of information regarding delivery status and supplier information to the internal customer.

[197] Small and Big Boards. Small Boards; fully functional test phones based on the platform offer, used for development, testing and evaluation of applications. Big Boards; same as small board but the component mounted on open circuit boards where new components, configurations and applications can be tested on. These are sold to the phone manufactures, as a part of the EMP offer, and used in the development of consumer phones.

6 Analysis

The analysis of the empirical study, based on the theoretical framework, will be presented in this part. The chapter includes the authors' findings and suggestions regarding the areas that were found in the empirical study.

Two major information gaps in the traceability within the order process for ASICs were found during the analysis work. The first one is the connection between BOM data and the purchase order data. The second one is between the purchase order data and the build data. There is also an information gap between the ASIC-data and the PCB-data, which blocks the connection between specific components and PCBs. Figure 6-1 shows the gaps in the order process. All these gaps will be discussed, together with suggestions on how to eliminate them, in the analysis chapter. Through introduction of measurements, new report templates and monitoring of performance status within P&S, the gaps will be eliminated. The order processes will receive full traceability, the gaps will be closed and the control of the processes will increase. Figure 6-2 illustrates the outcome of the suggested improvement.

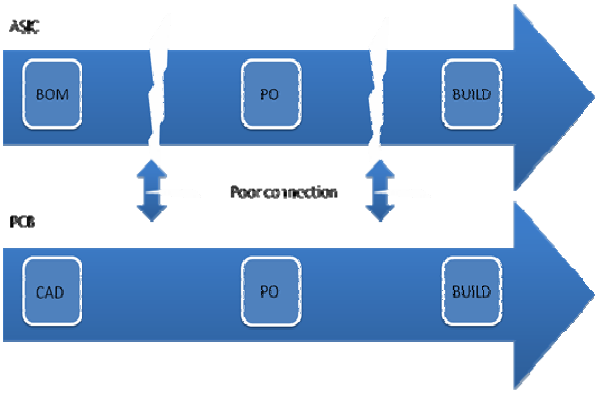

Figure 6-1, Gaps in the order process

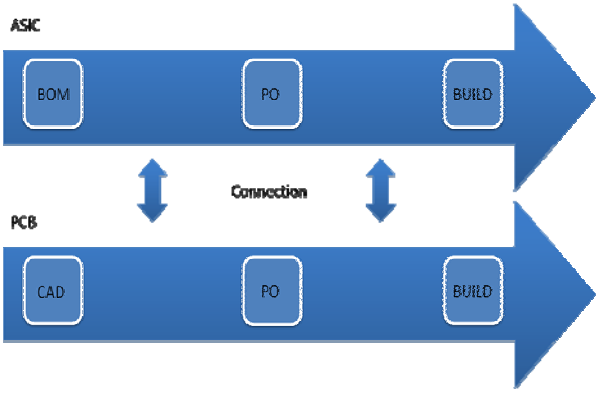

Figure 6-2, Outcome of the suggested improvement

6.1 Measurements

In chapter 6.1.1 a list of all the metrics proposed for the new performance measurement system is presented. Some of the measures are kept as before and are explained in the empirical chapter. Other measures are changed or totally new and explained further in 6.1.1. The authors have looked at the process as a whole in order to find gaps were sufficient measurements not were established. The overall objective was to change or establish new measurements to make sure that each important activity of the processes were measured. The proposed measurement system measures all the critical activities within the process and also its inputs and deliverables.

The poor connection between BOM data and purchase order data have been solved by using the same typing format for build name in both the BOM data file and the purchase system. This will make the data sources linkable and a specific BOM can be connected to a specific purchase order. By using this format when marking for which build a specific purchase order is placed, the connection between purchase order data and the build is established. For the PCB case, the department have started using the same purchase system as for the components, which makes the connection between the two categories possible.

When the new measures have been defined (listed in chapter 6.1.1.) two new supply indexes was designed using the AHP method. The overall supply index shows the overall process performance. From the input to the process (BOM/CAD data) to the process' affect on the builds (Rescheduled builds and Line stops). The second index, supply index shows how well the activities controlled by EMP and its suppliers perform, without taking the BOM and CAD data into account.

6.1.1 Performance Measurement System - New and changed measurements

All ASIC measurements

- BOM first received
- BOM last changed **(new)**
- Order Lead Time **(changed)**
- Order Acknowledgement Responsiveness
- Delivery Precision Requested
- Delivery Precision First Confirmed
- Delivery Precision Expected Delivery date **(new)**
- Component received on time **(new)**
- Build Rescheduled **(new)**
- Line stop **(changed)**
- Quality Issues, after delivery **(new)**
- Overall supply index **(changed)**
- Supply index **(new)**
- EMP delivery precision towards customer vs. requested

All PCB measurements

- CAD data received on time
- Order lead time **(new)**
- Delivery precision requested
- Build rescheduled **(new)**
- Line stop

In this part all the new and changed measurements will be further discussed regarding area of measures, KPI target and objectives. Almost all the measurements from the list above must needs to be reported in the root-cause report if they fail. A description of how the measurements shall be reported and the root cause document is described in chapter 6.1.4. All these measurements must be included in the next revision of the PO-LOG file to secure the transparency and that all important information is gathered at one single place. After the execution of the next revision of the PO-LOG file some of the measurements should be reported in the monthly report. For more information on the monthly report see chapter 6.1.4. When the authors designed the new and the changes for the existing measurements the theories according to measurement design were used. Common for all measurements except the BOM measurements and CAD measurements is that they are designed to be used on both class 1 components and PCBs. Below are the new and the changed measurement described.

BOM last changed. The BOM last change measurement reports when the last change for the BOM have been received by the P&S. The new limit will different for the components depending on its classification. For more information on the classification, see chapter 6.7. For Class 1 components the limit will be set based on the OLT + the stock buffer time. For class 2a and 2b components the limit will be based on a fixed order lead time relative build

date. The recommendation for class 2a and 2b components is 4 weeks before build date (exactly the same as today). This limitation of the BOM last change will help the projects to place the last change with sufficient lead time for P&S to secure the delivery before build date.

Order lead time (OLT). The new order lead time measurement, for the class 1 components, will be based on the specific component's maturity level. For the class 2a and 2b components the order lead time will not be defined in this thesis. The maturity level will be counted from the component's birth. Today the order lead time does not take the ASIC maturity level into consideration, which leads to that the order lead time does not reflect the real order lead time the supplier needs to deliver the component. The order lead time for each supplier and component must be set and calculated together with the supplier and the projects. For the project, the order lead time will be a baseline for when the BOM needs to be created and when the last change can be done. For P&S the order lead time will be a measurement to secure that the purchase order is placed with correct lead time. For the supplier the order lead time will be an agreement on which lead time the supplier needs in order to deliver the requested order. To this measurement a category, sub category and root-causes must be identified.

Delivery precision expected delivery date. This measurement is based on the expected delivery date given by the supplier. Today P&S is measuring the supplier's delivery precision regarding requested and first confirmed date. This measurement will fill the information gap about when the delivery is expected. After the purchase order is confirmed the supplier must inform the P&S every time the supplier's expected delivery date is changed. The expected date will help P&S to schedule the date of delivery and possible late deliveries (or early deliveries), and possible build reschedules. This information does not exist today and is necessary in order to achieve process control. The outcome of this measurement is the supplier's delivery precision regarding the expected delivery date.

Component received on time. Today late deliveries are not reported per order row. The P&S only measures when the latest component is received and the delivery precision regarding the first confirmed and requested delivery. The result is that an information gap is created in the order process. To fill this gap, all order rows must be measured on when the component is received compared to build date. The new measurement's name is component received on time. The limitation is set to 2 weeks before build date in order to be sure the component is in stock before the build. When the suppliers' deliveries are predictable and reliable the target for component received on time will be set to 1 week before build date. This target can only be achieved if the deliveries are predictable and reliable. Shorter time in stock buffer results in lower cost and shorter lead time in the order process. This measurement need to be inserted in the next revision of the PO LOG file. In the PO LOG file the date of when the purchase order is received inserted and based on this date and the build date the component received on time measurement can be measured. The component received on time measurement is shown as a yes or no in the root cause report and should be connected to the purchase order row.

Build Rescheduled. The build rescheduled measurement is not measured today and is established to create a more correct picture of how the order process is affecting the builds. The builds are rescheduled when they can not be produced due to missing components. The number of build reschedules must be measured per order row to fill the information gap in the order process. Late BOM, Late BOM changes, short OLT and supplier delaying orders are example of when a delivery fails. The late deliveries can cause build reschedules (to avoid

line stops) and must be counted to create a better picture of which order rows that causes the build reschedules. The build rescheduled is reported as a yes or no in the root-cause report and should be connected to the build name and the order row that causes the build reschedule.

Line stop. Today this measurement is known as, stock out, build stop, and line stop. In order to unify all affected parties to use the same name we suggest that line stop shall be used. The line stop will and must be counted per order row to achieve the process control of the order process. The line stops can be caused by both the components and the PCBs. The line stop occurs if the components are not in stock 9 am the day before build date and is reported as yes or no in the root cause report.

Quality Issues after delivery. This measurement gauges the quality aspect after the orders have been delivered. For example; if there is a production stop in the MIC-factory caused by poor quality on the supplier's component, this will be logged in this measurement. The measurement is hard to connect to an order row (because sometime a purchase order row is delivered to more than one build) and should be connected to the ROA/build number. Category, sub category and root-causes must be identified for this measurement in the root cause report.

Overall supply index. This KPI already exists today but the weighting between the included measurements are changed. The overall supply index describes the performance of the order process in one metric including external factors (BOM, CAD), suppliers' performance and what affect the supply process has on line stops and build reschedules. The description of the weighting is discussed in chapter 6.1.2

Supply index. Supply index is a new measurement, which only describes the P&S performance in one metric, external factor such as BOM and CAD data are not taken into consideration. The weighting between the included measurements is described in chapter 6.1.2

All measurements used for the PCBs is defined exactly as for the class 1 components. The only measurement that is used solely for PCBs is; CAD data received on time. This measurement measure to what extent the CAD department hands over the PCB drawing on time (20 workdays before build start). The PCB will be using the same system setup as the other buyers, which makes it possible to link the PCBs with the components to a specific build name.

6.1.2 Weighting of measurement

To secure a correct weighting of the overall supply index and the supply index and to receive acceptance for the indexes, the employees at P&S have been involved in the development. The buyers, MSPM, PCB responsible and the head of the department were invited to a workshop to discuss the measurements importance and weighting. The weighting of the both indexes were done in three steps, first the class 1 components' measurements and then the PCBs' measurements. After this the relative importance of the two components were weighted. In all weightings the AHP method were use to define the relative importance of the measurements and the components. The results are illustrated in appendix 15 and 16 and the scale used for the pair wise comparison is shown in table 6-1.

Table 6-1, Verbal judgement scale.

Verbal judgment or preference	Numerical scale
Extremely more important	5
Very strongly more important	4
Strongly more important	3
Moderately more important	2
Equally important	1

A document to calculate the overall supply index and the supply index have been created. The document is easy and not time consuming to use. The weighting between the measurements are easy to redefine if needed. The structure of the document is shown in appendix 15

6.1.3 PO-LOG file

The calculations on the data collected from the EMP/P&S department data have been very time consuming. There is no data file that compiles the information into one document, as said before, and the traceability between BOM/CAD, purchase orders and build names is not possible to create in hindsight. Four silos of information sources have been identified, BOM, PO data, build data, and PCB data. In order to remove the information gaps there must be connections between the information silos. The first revision of the PO-LOG file was already executed before this analysis was done and does not cover all the information gaps that the authors have found. There are changes and additions that should be included in the next revision of the PO-LOG file to eliminate all the gaps. The major parts that should be included are;

BOM-data. Data regarding the BOM (first received date, last changed date) need to be connected to the purchase order, item and the ROA-number. This shall be done to simplify the visualising of the BOM performance, the root cause analysis of the measurements and increase the transparency of the order process.
Delivery precision expected delivery date. Include data in the PO LOG file regarding when the delivery is expected. The expected delivery date enables a better control of the delivery date for the purchase order. Increased control over the deliveries lead to less unexpected line stops or late rescheduled builds.
Data regarding delivery date related to build date. Insert the date when the delivery was delivered and the build date in the PO LOG file. From these dates the component received on time measurement can be calculated.
Build rescheduled data. Add the information if a purchase order causes builds reschedules because of late announcement of delayed order.
Line stop data. Data regarding line stop must be inserted in the PO LOG file. The line stop data must be connected to the ROA-number and related order row to that a line stop can be connected to a specific order/component/supplier. Increased control is crucial in order to proactively trying to minimise the line stops.
Quality Issues, after delivery. Include data regarding quality issues after the delivery. This data can be collected from FIDO[198] and inserted in the PO LOG file.

6.1.4 Root-cause analysis

In this sub-chapter the thesis's conclusions of the root cause analysis, including subcategories and root cause report, is described. First a description of why the category, sub-category and

[198] FIDO = Internal system for quality issues registered by the prototype factory in Kista.

the root cause methodology is used. The second part describes the new root-cause report document.

Categories, Subcategories and root causes
The category explains the main area of the failure for a specific measurement. The sub-category is the main area of failure for a specific category. Both the category levels are standardised for each measurement. The root-cause is a free text alternative and should describe the final root cause in an understandable way. To find the root causes, the 5-why methodology is used.

The categorisation is used on the quality issues after delivery, order lead time, order acknowledgement responsiveness, delivery precision requested, and delivery precision first confirmed. The categorisation and sub-categorisation methodology is established to improve the supplier's and P&S's work with root cause analysis. The using of subcategories will simplify the root cause analysis. The supplier is forced to investigate further, because it is not enough to state the sub-category as a final cause to the problem. The category methodology help the supplier to chose from a specific list of possible subcategories instead classify and describe the truly root causes by themselves. When doing the root cause analysis the subcategories are a natural way of the 5 why analysis. The more information there is from the beginning the more time effective the analysis will be.

Today there are 6 categories and the first five categories can be used for all the measurements. For these five categories there are established possible sub-categories. To find these sub categories affinity and ishikawa diagrams from the six sigma tool box have been used. The sub categories are described in appendix 13. These sub categories are only a foundation for the root cause analysis. The longer the department works with this methodology more generic sub categories can developed and revised in order to simplify the root cause work.

Root cause report
If the proposed suggestions are established in the next revision of the PO LOG file the connection between the different measurements will be possible and easier to do. As said earlier, during the analysis the authors found that the information was separated in four different silos with no or weak connections between them. If these recommendations are to be established a full analysis of the order process will be possible and each order can easily be connected to a specific BOM/CAD and build. The increased transparency in the process will make it easier for the department to analyse what has gone wrong in the process if line stop occur or a build is rescheduled.

From the analysis a document has been created, called the root cause report, where all failures in the order process are collected and reported. The root cause report can be seen in appendix 14. The report will create a picture of related failures and the traceability of connected and depending failure can be done in this document. For some of the measurements there will be done a root cause analysis together with the supplier The root cause analysis include three levels of causes. Figure 4.6 show these three levels. The first level is the category, the second is the sub-category and the third is the root cause. The root cause level is not predefined as the first two levels. The target is that all information should be collected from the PO-LOG file. Today it is impossible. After the executing of next revision of the PO-LOG file the target will be achieved. Until then the root cause report collects its figures from the PO-LOG file, BOM

file and information collected from MIC[199]. This must be changed when the next revision of PO-LOG file is installed otherwise it will not simplify the work with root causes. Below are the major key words for the root cause report described.

- *Yearly basis*. The P&S must be able to trace all the phases in the order process. The order process time frame is more than 12 weeks and therefore the report should be based on yearly basis and not monthly as it is today.
- *One compiled document*. The report is a compiled document which is used for all suppliers and all measurements. There is also an attached document which shall be used to collect information about root causes from the supplier. The supplier document will simplify the work load for the buyers.
- *Supplier document*. The supplier document is divided into two parts. One where the information of the failed purchase order is reported and one sheet where the supplier should chose category, sub- category, root causes and action points to avoid future issues.

The supplier document should be sent to the supplier when every third issue occurs or at least once a month. The document must be responded as soon as possible after sending. If some failure occurs in the beginning of the month it should be solved as soon as possible. If the problem can be solved within that month maybe the same failure can be avoided on other orders before the end of the month.

6.1.5 Monthly report

Depending on the measurements importance they should be categorised as key performance indicators (KPIs) or key result indicators (KRIs). Only the most important measurements, the KPIs, are reported in the monthly report.
Compared to today's monthly report there are 3 new measurements and 2 changed. The key result indicator measurements measure the performance but are not that important that they need to be transferred to a higher level within the EMP organisation.

Categorisation of the measurements

	KPI	KRI
BOM first received	X	
BOM Last change **(new)**	X	
Order Lead Time **(changed)**	X	
Order Acknowledgement Responsiveness	X	
Delivery Precision Requested	X	
Delivery Precision First Confirmed	X	
Delivery Precision Expected Delivery date **(new)**		X
Component received on time **(new)**		X
Build Rescheduled **(new)**	X	
Line stop	X	
Quality Issues, after delivery **(new)**		X
Over all supply index **(changed)**	X	
Supply index (**new)**	X	
EMP delivery precision towards customer vs. requested	X	

[199] Prototype factory

6.2 Order Process

This chapter will describe the analysis done on the order process.

6.2.1 Conclusion of the order process

The conclusion of the order process improvements will be briefly described in this sub-chapter. Further investigations of each step in the process are done in the following sub-chapters.

The information gaps. The investigation found that the areas measured by P&S are not performing as target. And unfortunately there are major information gaps between different areas. For example there are gaps between:

- BOM and ASIC PO data
- ASIC PO data and build data.
- Poor connection between the ASIC and the PCB flow

The gaps between the areas are not the only problem. Also within the areas there are information gaps (blank areas without any information). For example; Out of 230 placed ASIC purchase order rows there are only complete data for 148 order rows. All these gaps must be filled to achieve process control. The process control and the transparency are important to improve the efficiency and effectiveness in the process. These gaps must be filled and to achieve this objective there will be a few new measurements and new way of reporting the measurements. The measurements were discussed in chapter 6.1.1.

Delivery precision depends on the order lead time (OLT). The major problem found in the investigation is that the suppliers are not able to deliver at requested date even when the purchase order is placed with correct and agreed order lead time. This result proofs that the order lead time is not correctly agreed with the supplier. The investigation (see chapter 6.2.3) shows that the suppliers are better at delivering at requested date if the purchase order is placed with short OLT compared long OLT. The conclusion, based on the information the authors have, is that orders with longer OLT are orders placed for components earlier in the maturity phase compared than the orders with short OLT. It is obvious that the suppliers have problem to deliver components that is in an early maturity phase within the agreed order lead time. Therefore the agreed order lead time needs to be based on the maturity level of the component. The order lead time is further discussed in chapter 6.2.3.

The OLT as a foundation for BOM-changes. The order lead time needs to be considered when setting the latest target for accepting BOM changes. If so, EMP can avoid that orders are being placed with shorter order lead time than agreed. In many cases the BOM last change does not affect the orders that have been placed (the department have already been informed or the component is a stock item) still it needs to be considered. If all orders will be placed with correct lead time the possibility of supplier delivering as per requested will increase.

The BOM measurement. Today P&S only measures if the BOM is received on time. The more important measurement is when the latest changes have been done. Today the target, for BOM last changed, is 4 weeks before build date. This limit should be changed. The last change must be depending on the component. For example; ASICs cannot be changed as late

as 4 weeks before build date but a standard component (that even might be a stock component at MIC) can be changed even later than 4 weeks before build date. There cannot be a separate last change limitations for all components, but one limit for the class 2a and 2b components and one for ASIC can be done. The ASIC's last BOM changes should be based on OLT and the other components on a fixed limitation.

The order acknowledgment measurement. The investigation reflects that late responded order acknowledgement often results in a confirmation date that does not correspond to the requested delivery date. The late responsiveness is also related to bad delivery precision on both requested and, by the supplier, first confirmed delivery date according to the data. The investigation of order acknowledgement is further discussed in chapter 6.2.3. This measurement shall act as a warning signal that the delivery might not take place as requested and P&S can increase the contact with the supplier to secure the delivery.

The Order Lead Time measurement. The Order lead time is the foundation for when the purchase order must be placed to secure a reliable delivery precision. The order lead time is also the foundation for when the last changes can be done in the BOM.

6.2.2 Order process, BOM

As described in chapter 5.3.3 the date of when the BOM is received at first time is sprawled. Table 6.2 shows the result from the study. Figure 6.3 shows the correlation, between the BOM first received date and the BOM last change, for each BOM.

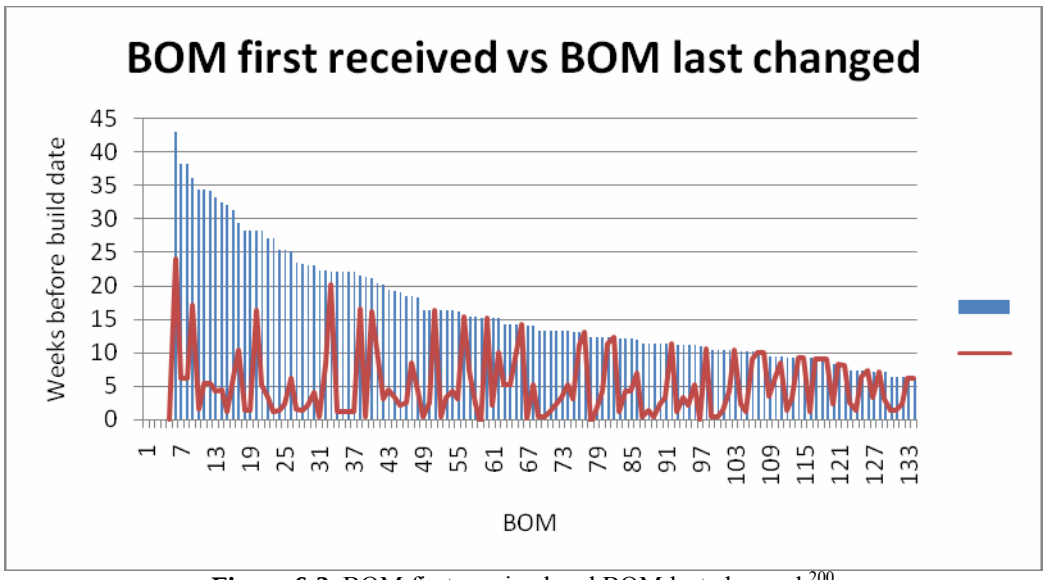

Figure 6-3, BOM first received and BOM last changed.[200]

The diagram, figure 6-3, shows that BOMs that have been transferred to the P&S more than 15 weeks before build date always have changes. 50% of the BOMs that are received with shorter lead time than 15 weeks have changes. The result is that in most cases the BOM is changed and therefore the BOM first received can only be seen as a forecast. The target for BOM received on time is 12 weeks before build date. The target is important because the BOM is, as said before, the foundation for the purchase order. The components must be in stock at least 2 weeks before build start and the agreed order lead time for each supplier is at least 4 weeks. The results is that the purchase order must be placed at least 6 weeks before

[200] EMP-data, Jan-Oct 2008

build start (when order lead time = 4 weeks). Today there is a conflict between the date when the purchase order needs to be placed and the target of the BOM's last change. The BOM must not be changed after 4 weeks before build date and this date is after the theoretical date of when the purchase order needs to be placed. Because of this fact the last change target must be changed. The BOM last changed target should be individual and based on the component and not be the same for all the components.

The table 6-2 shows that the figures of the BOM first received and BOM last changed are really poor. Only 60 % of all BOMs are received on time (>12 w) and 49% of all BOMs are changed with acceptable lead time before build date. Notable is that only 52% of all BOMs reach the target on both first received and last changed. If last change target is changed to 6 weeks (OLT + Buffer time, 4 + 2 weeks) the proportion of achieved BOM first received and BOM last changed decrease to 32%.The figures show that several of the BOMs are changed late and close to build date. If these components need to be ordered there is a risk that the components not will be delivered before the build date. P&S together therefore need to work on improving the performance on last BOM time changes. The projects make the decisions about BOM changes and when the BOM is placed, and they must be involved to achieve the improvements.

Table 6-2, Data regarding BOM first received and BOM last changed.

BOM < 12w	40%	BOM > 12w	60%	BOM > 12w , LC > 4w	52%
LC < 2w	30%	LC > 2w	70%	BOM > 12w, LC > 5w	41%
LC < 4w	51%	LC > 4w	49%	BOM > 12w, LC > 6w	32%
LC < 5w	58%	LC > 5w	42%		
LC < 6w	65%	LC > 6w	35%		

Visibility of the BOM

The limitation of the BOM's traceability in the order process is that there is not a well defined connection with the PO-data for the components that are included in the BOM. This information silo results in a dissatisfactory transparency about the components and what they might cause later in the order process. It also results in difficulties to visualise the causes occurred because of the BOM changes. As said earlier, the connection between BOM data and order data is poor. In several cases the late BOM changes can probably result in purchase order changes, which may lead to build reschedules and line stops. Figure 6.4 illustrates when the BOMs have the last changes and the purchase order lead time towards the supplier.

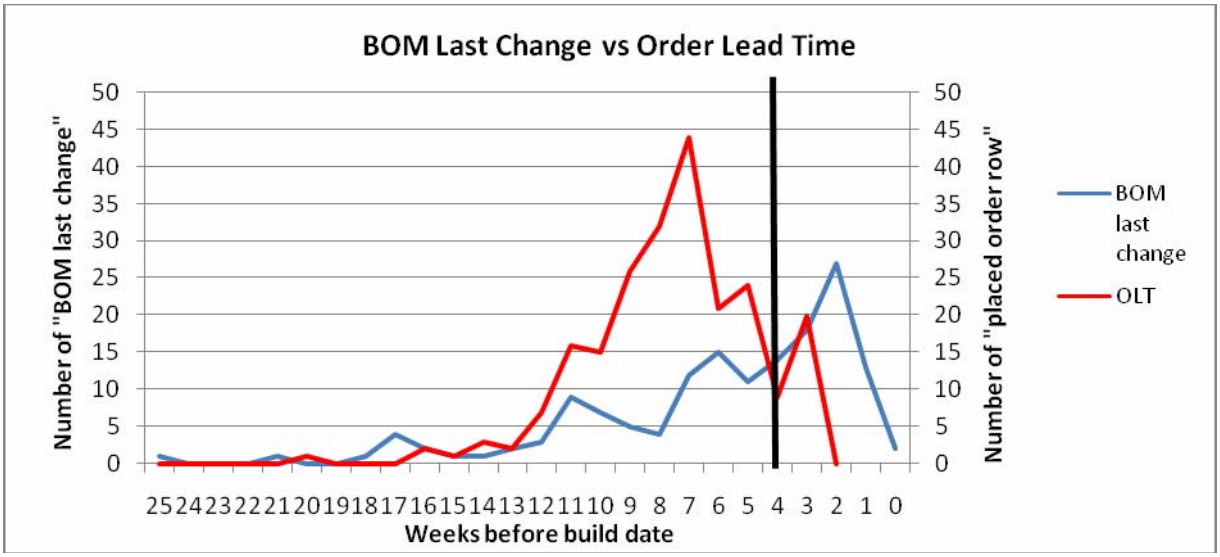

Figure 6-4, BOM last change vs. order lead time.

The diagram only shows the placed purchase order, not if there have been any changes. Most of the purchase orders are placed before the BOMs last change and this should affect the purchase order changes or the build date. For example; 30% of the BOMs late changes occur when it is less than 2 weeks left to build date. If the component must be ordered the delivery precision and order lead time will be affected. BOM changes can lead to build reschedules if the purchase order is changed or late placed, and cannot be delivered before build date. The reschedules raises the cost of manufacturing and increases the time-to-customer. The worst case is when the build not can be rescheduled and line stop is a fact.

Documentation changes

Today it is not possible to insert the BOM data calculations in the PO-LOG file. Further description about the PO-LOG file, see chapter 6.1.3. BOM data calculation must be inserted in the next revision of the PO-LOG file to secure a satisfactory transparency of the order process. The BOM first received and BOM last changed that is connected/related to the failed purchase orders will be inserted and used in the root cause analysis and report, further information see chapter 6.1.4.

Conclusions of the BOM

Today the BOM first received date is the one P&S measures, but the latest changes should have more focus. The first received date is important in the way that the buyers need sufficient time to secure the delivery of components to each build. The last change, on the other hand, is important because late BOM changes can cause purchase order changes, purchase order cancellations and purchased orders placed late. The purchase order changes and new placement of purchase orders must also be done within the agreed lead time to secure that the deliveries are received on time before the build starts.

6.2.3 Order process, ASIC PO

Order Acknowledgement Responsiveness

As described in the empirical chapter, the target for order acknowledgement responsiveness is only reached for 72 % of all purchase order rows. For the 149 order rows, counted here, the

figure is 69%. There cannot be seen any clear correlation between the late responsiveness and failures in order lead time. On the other hand there is a correlation between the responsiveness and the suppliers' availability to deliver at requested date. Table 6-3, 6-4 and Appendix 4 shows the calculations on the correlation between order acknowledgement responsiveness and delivery precision. The results from the calculation show that late order acknowledgement responsiveness often results in orders not being confirmed on the requested delivery date by the supplier. 31 % of all responded order rows are responded later than 72 hours after the PO is placed. Of these 46 order rows 31 (67%) could not be delivered at the requested date. Compared to order rows that were responded within 72 hours, only 23% were not delivered at requested date. What can be said from this is that P&S need to pay attention if the purchase order not is responded within 72h. The late respond also can be seen as first sign that the supplier is not able to deliver the components at the requested date. Table 6-4 shows similar result between OA and delivery precision first confirmed.

Table 6-3, Correlation between OA and DPR.

Total number of responded order rows = 149					
	#	%		#	%
OA>72	46	31%	OA < 72	103	69%
DPR >0	31	67%	DPR >0	24	23%

Table 6-4, Correlation between OA and DPFC.

Total number of responded order rows = 149					
	#	%		#	%
OA>72	46	31%	OA < 72	103	69%
DPFC >0	18	39%	DPFC >0	12	12%

How to act in the situation when the supplier responds later than 72 hours;
Close contact with supplier. Before the purchase order is responded (but after the limit on 72 h) P&S will act proactively to receive the supplier's response. When the purchase order is responded, P&S should have close communication with the supplier to secure that the component will be delivered as confirmed by the supplier. This goes especially for suppliers that have a bad performance on responding orders on time.

Order Lead Time

The average order lead time towards the supplier is 5.2 weeks and 27 % of the 223 purchase order rows are placed with shorter lead time than 4 weeks. The agreed order lead time is not fixed on 4 weeks but is measured towards 4 weeks. There have been some measurements towards the agreed order lead time for supplier A during the year. These measurements have not been reported towards the agreed and measured order lead time, instead the measured order lead time has been reported against the 4 weeks target. The authors do not know for how long the measuring has been towards the agreed lead time. The supplier's contract includes different agreed order lead times and these should be the value from which the supplier is measured. It is important that the measurement limitation is clear and shows which order lead time the supplier is measured against. Figure 6-5 and table 6-4 present the class 1 suppliers' order lead time compared to measured and agreed order lead time.

The order lead time reflects the date when the PO is placed compared to when it should be delivered. The components must be in stock at least 2 weeks before build date. Because of these facts, purchase order rows with shorter lead time than 4 weeks can cause late deliveries (if the supplier deliver after their agreed lead time) and purchase order rows placed with shorter OLT than 2 weeks might lead to build reschedules or line stops.

Table 6-5, Order Lead Time for ASIC suppliers.

Supplier	A	B	C	D	Total number of placed PO rows
Agreed Order Lead Time (w)	4	4	5.5	4	
Number of placed PO rows	37	70	93	23	223
Average	4,5	5,3	5,1	6,0	
OLT < 2 w	5	1	20	2	
OLT < 2 w %	14%	1%	22%	9%	
OLT < 4 w	13	10	31	6	
OLT < 4 w %	35%	14%	33%	26%	
OLT < 5.5 w			49		
OLT < 5.5 w %			53%		

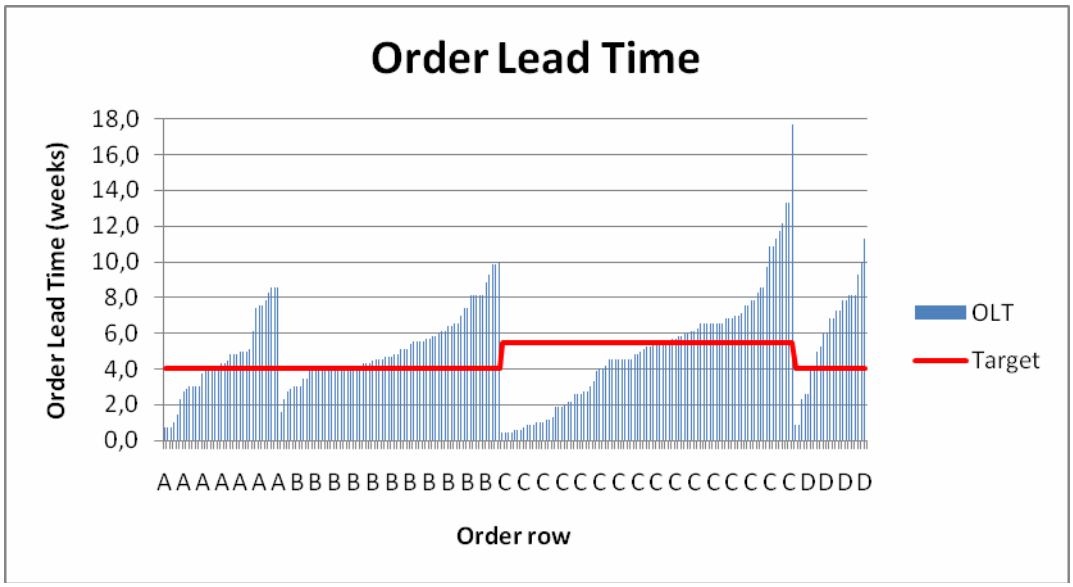

Figure 6-5, Order lead time for ASIC suppliers.

The result from the lead time analysis shows that there are not any clear correlation between order lead time and the suppliers order acknowledgement responsiveness. Appendix 5 shows the details. For Supplier A and supplier D there are no correlations but for supplier B and C there are. The appendix diagram shows that long order lead time leads to longer response time. There is also a correlation between the order lead time and delivery precision. That correlation is described in the delivery precision part.

Delivery precision

The delivery precision is an important area. The precision is heavily connected to the build scheduling at MIC. For example, delivery precisions is the foundation for when the build can start, therefore the delivery precision must be adequate. As can be seen in the figure for each supplier the performance is sprawled. Unfortunately there is only information for the ASIC components. There were found 149 purchase order rows[201] that included data from the whole PO process. For some of the suppliers there have only been 15 to 17 order rows documented. Because of the few order rows the result cannot be statistically secured. In some cases there is a correlation between the supplier's delivery precision and order lead time. The first intuition

[201] Jan – Oct 2008

will say that short order lead time results in poor delivery precision, but that is not the case. The correlation between the four suppliers' delivery precision regarding the order lead time is sprawled. Each supplier's correlation is described and discussed below. All ASIC suppliers are described independently and after that a compiled conclusion is declared.

Supplier A

Figure 6-6 illustrates supplier A's order lead time and delivery precision. The delivery precision is what they confirmed (not the same as what P&S's requests in all cases). There is no obvious correlation between order lead time and delivery precision, except two order rows with less than 1 week order lead time. The information gathered does not lead to any prediction regarding the correlation between the KPIs in the supplier A case. It can be that supplier A has problem to deliver towards short lead time but it can also be a coincidence.

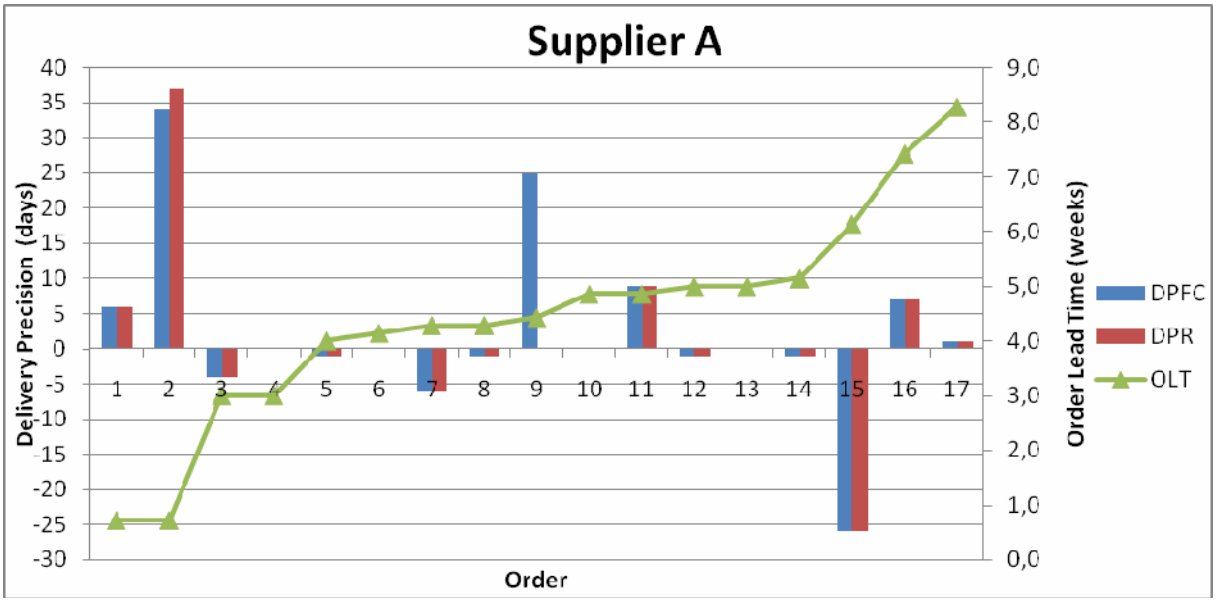

Figure 6-6, Correlation for supplier A

Supplier D

Figure 6-7 illustrates the data regarding correlation between supplier D's order lead time and delivery precision. The correlation in the supplier D case is obvious but not expected. Supplier D does not have any problem to deliver even though P&S gives a short order lead time. They have problem with order lead times over 7 weeks**.** The conclusion of this can be that when orders are placed with that long lead time the component is in an early stage in the product life cycle and the development time is hard to predict.

To avoid this P&S/EMP must have a closer relation and communication with the supplier. The supplier must tell P&S/EMP if the purchase order is placed with too short order lead time. If the order is placed with wrong lead time the result can be late deliveries and in worst case build reschedules and line stops. To receive that information there must be a close and trustful relation.

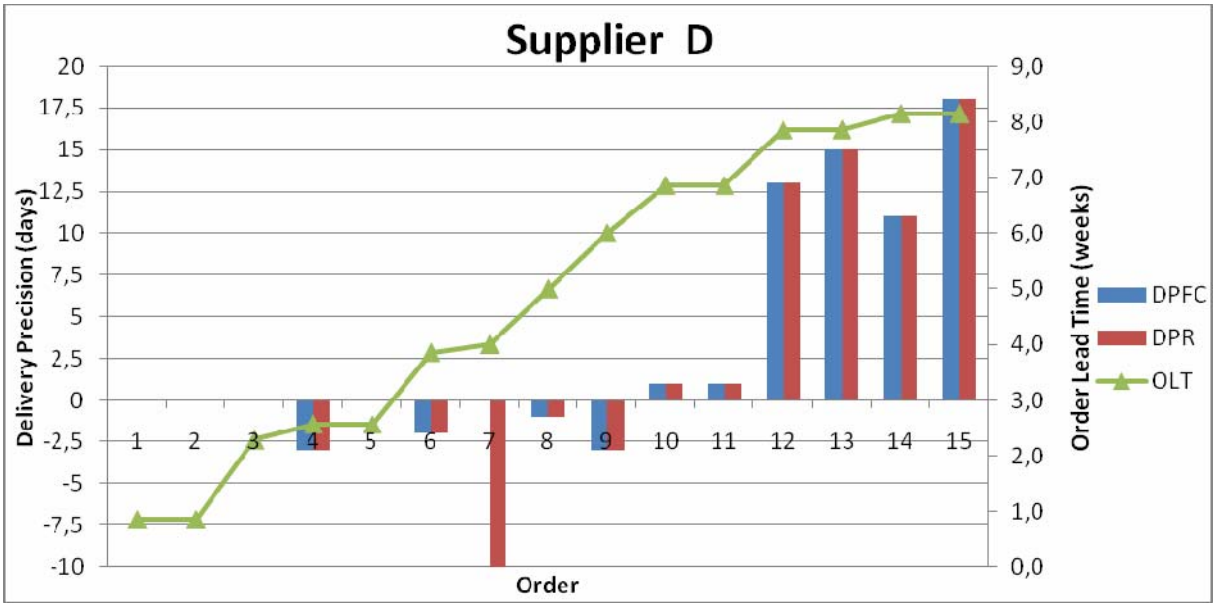

Figure 6-7, Correlation for supplier D.

Supplier B

The performance for supplier B is shown in figure 6-8. The correlation in the supplier B case is similar to supplier D. Except for two deliveries, supplier B does not have any problem to deliver components given less than 6 weeks order lead time (even when the order lead time is less than 2 weeks.) In most cases supplier B deliver earlier than P&S requests. When the order lead time is more than 6 weeks supplier B have problem to deliver on both requested and first confirmed date. The late deliveries can be caused by several things. For example;

- The orders are placed without forecast which makes it more difficult for supplier B to deliver on requested delivery date.
- Supplier B confirms on the requested date which can be interpreted as they do not know when they are able to deliver (they often deliver before requested date and what they first confirm)
- Components are in an early maturity stage, which makes it hard to predict when the component can be delivered.

P&S should have better communication with Supplier B to clarify why they are not able to deliver as requested when the order lead time is considerably long.

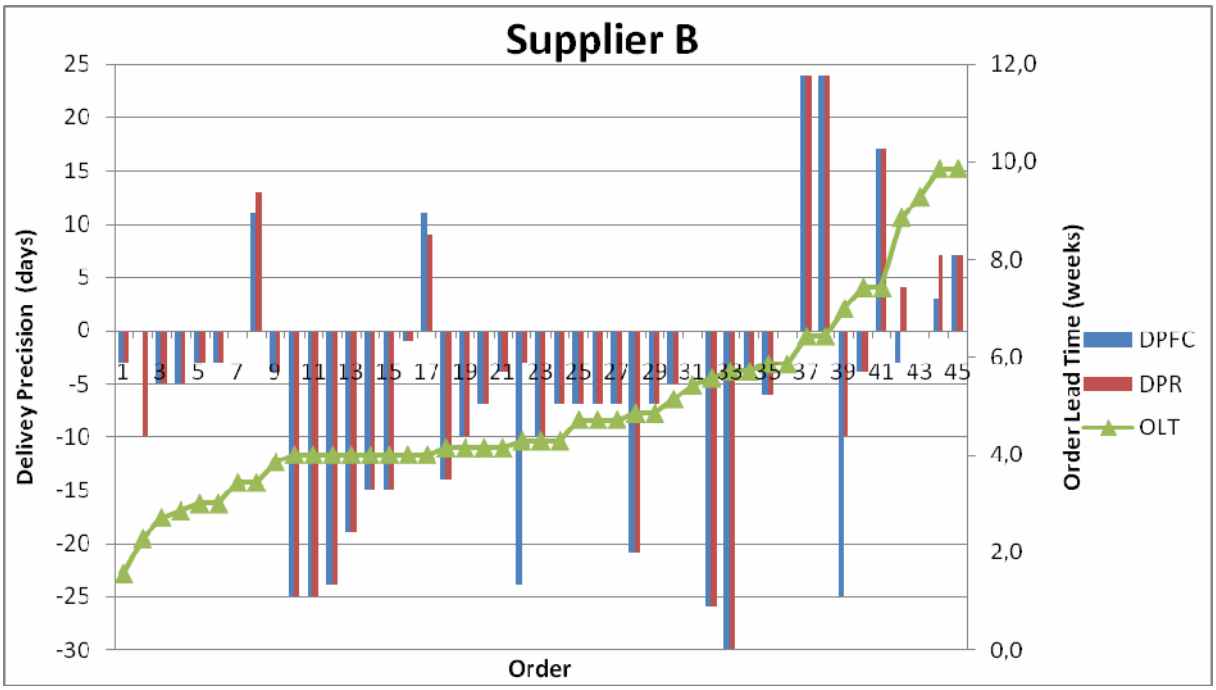

Figure 6-8, Correlation for supplier B.

Supplier C

There is no concrete correlation between order lead time and delivery precision, as can be seen in figure 6-9. Supplier C cannot deliver at requested delivery date, in some case not even on the first confirmed date even though the purchase order is placed with correct order lead time.

To avoid this behaviour there must be a closer relation with more transparency within the relation. Supplier C must understand that within the agreed order lead time it assumes that they manage to deliver on requested delivery date.

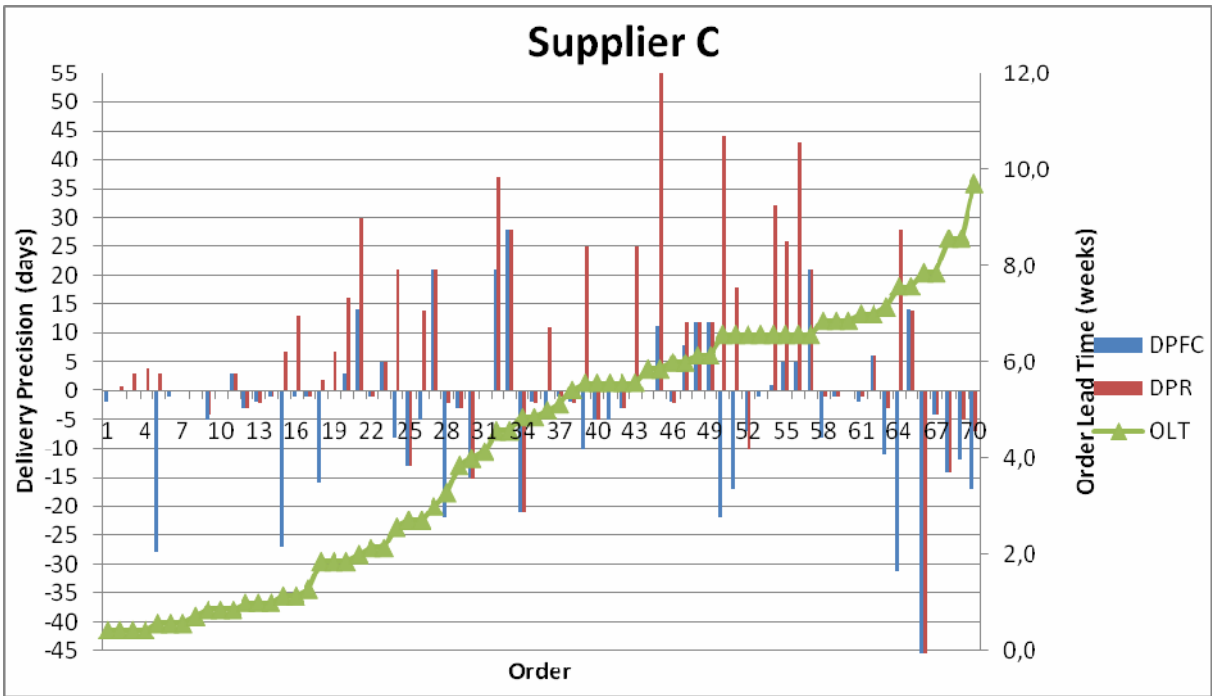

Figure 6-9, Correlation for supplier C.

Order lead time and delivery precision Conclusion
The figures for these four ASIC suppliers indicate that the order lead time and deliver precision are related. The suppliers have problem to deliver on requested and confirmed date when the purchase order is placed with long order lead time. A possible outcome might be longer order lead time for early stage components with low level of maturity. P&S should together with other EMP-departments (Project and R&D) and the supplier redefine the order lead time agreement. The redefinition will create a more correct picture of the real delivery time. The order lead time must be dependent on the maturity level of the component. The individual order lead time cannot be defined for all components. Therefore should class 1 components' order lead time be based on the maturity level and the class 2a and 2b based on a fixed agreed order lead time.

P&S have not solely the correct knowledge to define the order lead time. The responsible departments from the supplier and the responsible EMP-departments (Project and R&D) should together define the order lead time to secure that the correct order lead time is established. After the established order lead time the document/process will be transferred to the P&S to secure that the buyers place orders with correct order lead time. The document will also be transferred to the projects. The projects need to know which order lead time each component have. The OLT document creates a better understanding of when the last change can be done in the BOM. Even when late changes arrive from the project the P&S's buyer can prove that the changes are being done too late and cannot be delivered on time for build date.

The result can be that more exact BOMs (no late changes) and correct placed (correct order lead time) purchase orders, which leads to more correct delivery precisions. A better delivery precision leads to more correct scheduling of the builds. If the builds are scheduled more correct and the components are delivered at promised date the stock buffer time can be reduced. Reduced stock time results in less costs and shorter time to customer. In other terms the supply process will be more reliable and predictable.

6.2.4 Late deliveries and Line stops

Late deliveries
The hypothesis below is based on that requested delivery date always is 2 weeks before build date. It is important that the supplier is able to deliver on requested date. If not, the supplier must confirm the order on the date they are able to deliver. If the supplier cannot deliver on the requested date the first confirmed delivery date must not be later than 2 weeks after the requested. The delivery precision is always important to follow and changes, done by the supplier, regarding expected delivery date must be sent to P&S. The today's delivery precision is not aligned with target. Of all delivered order rows 64 (37%) are delivered after the requested delivery date. These will affect the safety buffer. With the today's measurements only the last component will be classified as late (through the measurement last component received). The measurement will only measure the latest component and if more components are delivered late (for the same build) this will not be counted as late. This measurement need to be redefined to "Late delivery", which is discussed in chapter 6.1.

To avoid the late deliveries the delivery precision must be more reliable. When the delivery precision is reliable and predictable the stock buffer can be decreased. An acceptable buffer target can be 1 week instead of today's 2 weeks. This will lower the cost and the date for

delivery will be closer to the PCB-delivery date. The target for delivery date should be as close as possible to lower the cost of warehousing and lower the time to customer. To achieve the target with shorter stock buffer it is important with predictable and reliable delivery precisions.

Line stops
Line stops can be caused by the components and by the PCBs. As said before 64 PO-rows are delivered after delivery date and can be known as late deliveries. 28 out of 64 order rows are delivered more than 2 weeks after the requested delivery date. These late deliveries affect the build start and there can only be two possible outcomes;

The build is rescheduled. The build cannot be done at the scheduled date and must be rescheduled. Today there is no measurement that gauges this situation. A possible measurement is called build reschedule and is discussed in chapter 6.1.1.

A line stop occur. The build date is not rescheduled and there will be a stop in the production process. This will be the case if the build date is not rescheduled and the component is missing at 9 am the day before build date. To avoid the Line stops the delivery precision must be predictable and reliable.

6.2.5 PO-process, PCB

An analysis over the whole ordering process for the PCB is presented below, from reception of CAD data to delivery at the prototype factory, MIC. Figures that are presented in the text are shown in figure 6-10 and appendix 6.

The PCB purchaser is supposed to get the CAD data 20 workdays before the build is scheduled to start. To be able to give the suppliers as long lead time as possible it is important that the CAD data arrives on time. If the PCB purchaser is forced to place orders with short lead time the price will increase (both cost of PCB and delivery), which are both paid by EMP.

The analysis showed that delivery precision on CAD data was pretty low, see figure 6-10. In 36 % of all cases (all the orders analysed) CAD data was delivered late (after 20 workdays before build start) to the PCB responsible. Looking at the late deliveries towards first promised date, 27 % of all late deliveries had late CAD data.

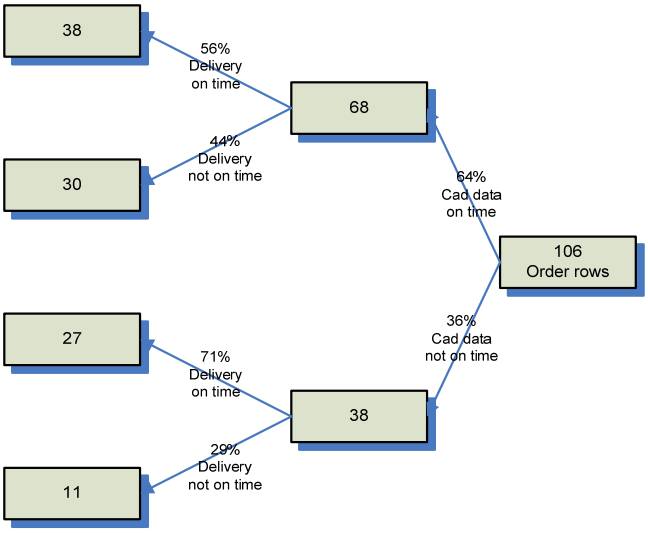

Figure 6-10, Split down of all analysed order rows. CAD data on time=20 workdays before build start or earlier. Delivery on time=delivery at the first promised date or earlier.

When analysing the PCB order data it showed that the average value on lead time from orders being placed until first promised delivery date is 23,8 days. Further investigation showed that out of all 41 registered late deliveries (against the first promised date), the average order lead time was 26,7 days. A conclusion is that short lead can have a negative impact on delivery performance but still, the delivery precision is not increasing with a longer lead time. This is confirmed by figure 6-11, which shows the order lead time versus delivery precision for all investigated orders. As said in the empirical chapter, that price is inversely proportional to the length of the lead time (shorter lead time, higher price and vice versa). In order to keep the total cost per board down it is crucial to have a good precision on the reception of CAD data, which increases the lead time for the supplier.

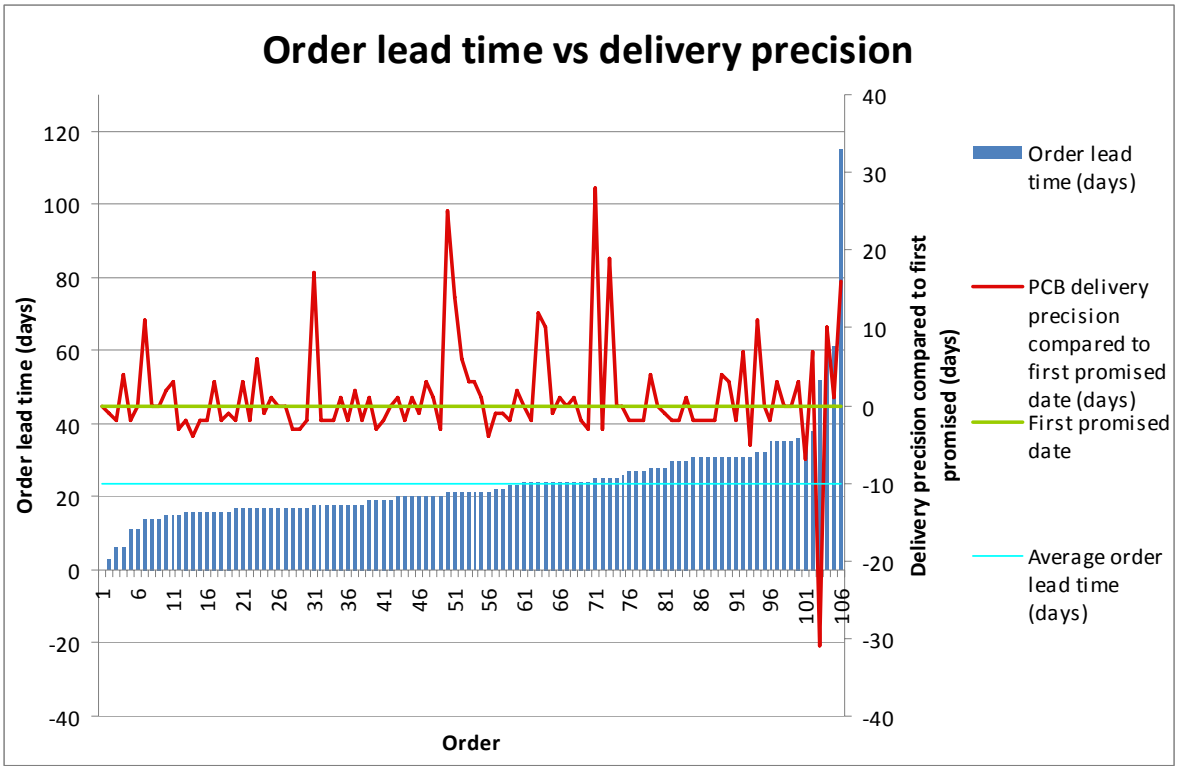

Figure 6-11, Order lead time versus delivery precision for all investigated PCB orders.

If the CAD data can be sent to P&S on time the possibility of orders being placed with longer lead time will increase and maybe also the possibility of orders being delivered on time according to first promised date.

Important, and as the data shows, is that late CAD data is not the single most affecting factor for orders being late. Figure 6-10 shows that in 73 % (30/41) of all late deliveries, CAD data were received by the PCB purchaser on time. The correlation between CAD data and delivery precision is shown in figure 6-12. Still, late CAD data have an affect on the delivery precision but there are also other important factors.

From the information gathered by the PCB responsible it shows that more than 2/3 of all late deliveries were root caused as problems during production at the suppliers. This strengthens the theory that CAD data is not the biggest affecting factor for late deliveries, poor supplier performance is. Except from production problems, problems with the specific product and communication are also things that are mentioned as a root cause for faulty deliver.

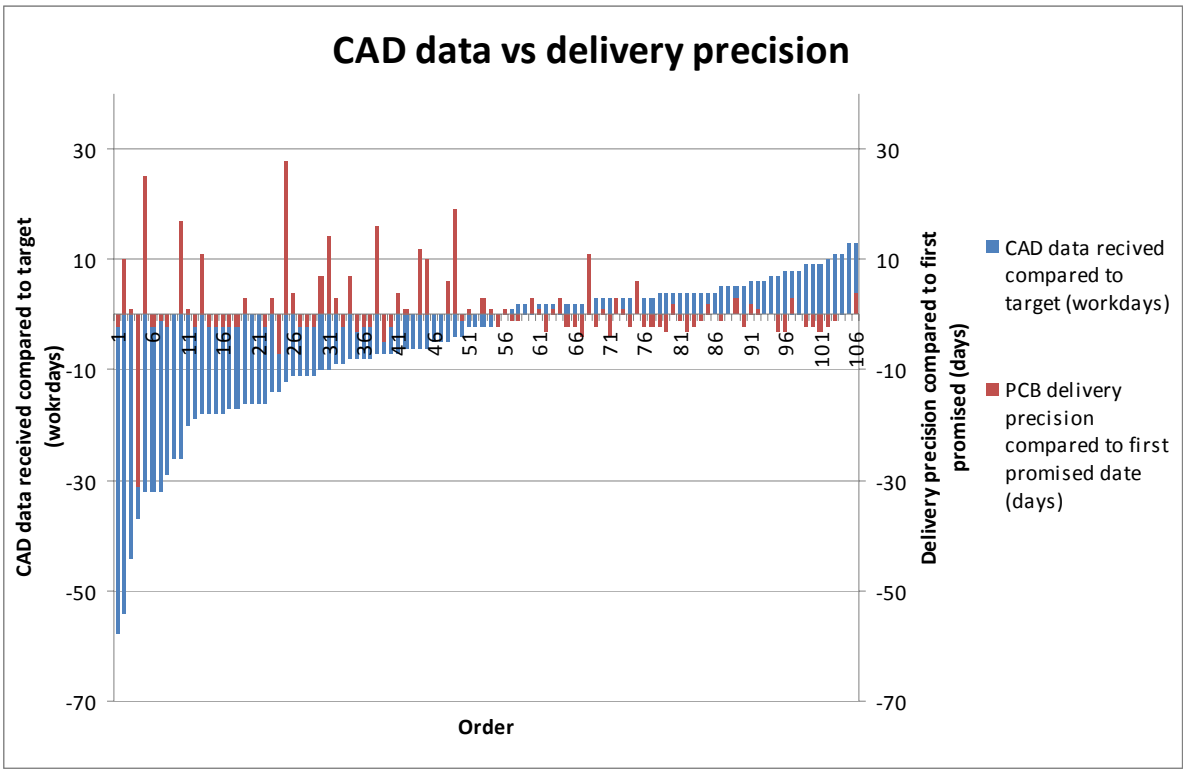

Figure 6-12, CAD data reception (days before/after target) versus delivery precision.

One of the most importance things for the PCB responsible is to make sure no orders are coming in late and causing a line stop in the production. If the PCB responsible gets the information that a PCB will be delivered late and informs the project, the build can be rescheduled to avoid build stop in the production. The analysis showed that 24 % of all deliveries were delivered the day before the scheduled build start or later. As described in chapter five, the prototype factory needs the components at 9 am the day before the scheduled build start in order not to cause any line stops. The analysis also showed that out these 24 % (≈25 orders) of possible line stops only 6 were logged as an actual line stop. This probably means that the other, approximately 19 builds, has been moved in order to not cause a line

stop. There are no data showing the cost or time it takes to reschedule builds but it is most likely an issue that do consume both unnecessary time and drive cost in manufacturing.

Another thing that is not taken into consideration, due to information not being available, is repeat builds. This analysis is based on order rows were all information needed was possible to compile, which is described in chapter four. An extract from the spread sheet and the information used is presented in appendix 7. As the authors see it the CAD on time shall only be measured the first time the CAD arrives. If it is a repeat build using the same CAD data as the previous build, the "CAD received on time" shall not be logged. Because of lacking information this investigation was not possible to conduct. The authors do think that if the CAD received in time only have been logged for the first build it been used in, the performance of CAD data received on time (20 workdays before build start) would have been lower.

6.2.5.1 Measurements

Today the performance of PCB deliveries is not reported in the monthly performance report. The think it should be. In order to standardise the measurements used, some of the suitable ASIC measurements presented above will be used. The measurements that the authors propose are:

CAD data received on time measures if the CAD data is received 20 working days before the build start or not.
Delivery precision requested measures if the order were delivered as requested or not. In the PCB case the order is always confirmed with the supplier before it is being place to make sure the supplier can deliver as requested.
Order lead time, Build rescheduled and *Line stops* are measured in the same way as for ASICs.

By having the same measurements for the PCBs as for the ASIC it will be easier to standardise the reporting and compare the performance between the ASICs and the PCBs. Why these measures are chosen is because of they represent the most important input, activities and outcome or the PCB order process.

6.3 Six Sigma Project - PCB

During the thesis work a project with the objective to improve the knowledge of 6σ tools and frameworks were carried out at EMP. Due to the good fit between the thesis objective and one of the PCB - 6σ project's; "To increase delivery precision of PCBs", the thesis were invited to be a contributing member of the project.

The time plan for the project was set from w838 to w914 why we only participated in two phases of the project; measure and analyse. To increase the understandings of why deliveries not were made on time all suppliers were asked to give root causes on the faulty deliveries. The root cause mapping was done after the orders were completed. The root cause explanations were gathered afterwards and the descriptions of the failures were very short and non-adequately. The root causes were not seen as reliable (briefly discussed in chapter 6.2.5.) and instead the team used an affinity diagram to find all possible causes to the failures. Findings from the affinity diagram work resulted in an ishikawa diagram, see appendix 17, of all possible areas that cause delivery precision failures. The result from these phases is further used by the team in the next DMAIC phases and in the rest of the six sigma project

The knowledge from this six sigma project and the root cause work were used when sub-categories for the measurements where created. More information of the sub category work see chapter 5.1.4

6.4 Supplier Survey – Class 1 Components

Table 6-6, Class 1 component suppliers answers and ranking sorted by highest answer (left) and highest ranking (right).

Question	Average answer	STDEV	Average ranking	STDEV		Question	Average answer	STDEV	Average ranking	STDEV
1	1,50	0,00	1,50	0,00		1	1,50	0,00	1,50	0,00
2	1,50	0,00	1,25	0,50		4	1,00	0,58	1,50	0,00
4	1,00	0,58	1,50	0,00		2	1,50	0,00	1,25	0,50
7	0,75	0,96	1,25	0,50		7	0,75	0,96	1,25	0,50
6	0,25	0,96	1,00	0,58		6	0,25	0,96	1,00	0,58
5	0,25	0,96	0,25	0,50		9	-0,50	1,41	0,75	0,50
3	-0,25	1,50	0,50	1,41		3	-0,25	1,50	0,50	1,41
9	-0,50	1,41	0,75	0,50		5	0,25	0,96	0,25	0,50
8	-0,75	0,96	0,00	1,29		8	-0,75	0,96	0,00	1,29
10	-0,75	0,96	-0,25	0,96		10	-0,75	0,96	-0,25	0,96

Statement (Scale; 1,5 "I totally agree" to -1,5 "I totally disagree")

Area: Relation

1 The level of trust within the relation, between EMP and You, is satisfying.
2 Working relations, between EMP and You, is perceived as satisfying.
3 The communication, between EMP and You, is perceived as open and honest.
4 EMP communicates timely and adequate information.

Area: Operational

5 EMP place orders with shorter lead time than agreed.
8 Late order-changes after order is placed are frequently recurring.
9 Late order-changes after order is placed affect Your ability to deliver according to first confirmed delivery date.
10 Late order-changes after order is placed affect the cost of manufacturing and delivery.

Area: Other

6 You are sufficiently involved in EMP's development process of new products.

7 EMP gives You the opportunity to make acceptable profit over long term.

Ranking (Scale; 1,5 "Very important" to -1,5 "Not important at all"

1-7 Rank the importance the statement.

8 How important is it that the orders not are changed after You have received them.

9 How important is it, from Your delivery precision perspective, that the orders are not changed after You have received it.

10 How important is it, from Your cost perspective, that the orders are not changed after You have received it.

6.4.1 Relation

In the area of relations (statement 1 to 4) number 1, 2 and 4 have high results and the standard deviation from all the respondents' average answers is low. These are also the questions that were ranked the highest, see table 6-6. The average score on question 3 deviate from the three other in the same category. If we look at all the answers we see that 50% (2 out of 4) of the respondents have answered -1,5 (I totally disagree with the statement). When you look at the same two respondents in the relations category they have answered 1,5 on the other three statements. From our point of view the authors see this as a bit of contradictory. They "Totally agree" to that; the level of trust and working relations is satisfying and that EMP communicates timely and adequate information. At the same time they "Totally disagree" to that the communication between the parties is open and honest. One possible and probable reason is that these answers are affected by other things than the specific relation with EMP buyers. For example decreasing business or other issues occurred recently.

The conclusions that can be drawn are that the class 1 component suppliers perceive the relation and the communication as healthy and well developed. This is a good match against how important they think these statements are.

6.4.2 Operational

The operational statements are prioritised lower than the relation statements. Statement 5, 8, 9 and 10 are seen as less important by the supplier than the ones related to the relation statements, see table 6-7. They do, to some extent, think that P&S are placing orders with shorter lead time than agreed. The data presented in table 6-5 shows that (in average) more than 20% of all order rows were placed with shorter lead time than the agreed order lead time. Because of the low number of respondents this shall be seen as a coincident rather than a confirmation of the answer's reliability. For statement 8, 9 and 10, late order changes are not frequently occurring. If it does occur there are more or less no correlation between the late changes and increasing cost of manufacturing and delivery neither on the delivery performance towards the first confirmed date. EMP does not log any data on when and if orders are changed after the order is placed. This statement can therefore not be confirmed with facts. The probability of that late changes affect the supplier's possibility to deliver according to the first confirmed delivery date needs to be taken into consideration. According to chapter 5.3.4 the delivery precision towards DPFC is only 74%. If P&S's late order changes does not affect the supplier's possibility to deliver towards this target then the reason why not all orders are on time according to DPFC is only dependent on the supplier's performance. The authors think that if P&S changes order late it can or will have an impact on the supplier's capability to deliver towards the first confirmed delivery date. Of course there

are other factors, such as those described in the root-cause categories, that can affect the supplier's possibility to deliver on the first confirmed date. The authors think that orders that have been changed closed to the delivery date have a lower possibility to be delivered on time than the ones that not have been being changed.

6.4.3 Other

The two statements in the other category were asked to see if factors that P&S cannot directly affect were perceived to be at a good level. As described in chapter 5.8.1 the suppliers more or less agree that they are sufficiently involved in the development process and that they get the opportunity to make acceptable profit over long term. The long term profit opportunity seems to be at a level where it will not affect their way of answering the other statements, which the authors think it can do if it is at an unacceptable low level. The level of supplier involvement in the development corresponds well with how important the supplier thinks it is. The authors thought that this was something that the suppliers would have ranked as more important than they did. Because of no people contacted at the suppliers are related to the product development their insight can be seen as limited.

6.5 Supplier Survey – Class 2 Components

Table 6-7, Class 2 component suppliers answers and ranking sorted by highest answer (left) and highest ranking (right).

Question	Average answer	STDEV	Average ranking	STDEV		Question	Average answer	STDEV	Average ranking	STDEV
1	1,38	0,33	1,50	0,00		1	1,38	0,33	1,50	0,00
2	1,26	0,44	1,44	0,24		4	0,97	0,80	1,50	0,00
3	1,26	0,56	1,38	0,33		2	1,26	0,44	1,44	0,24
4	0,97	0,80	1,50	0,00		3	1,26	0,56	1,38	0,33
9	0,62	0,99	0,38	0,93		7	0,38	1,05	1,15	0,79
10	0,56	1,14	0,50	0,87		6	0,38	0,93	0,91	0,94
6	0,38	0,93	0,91	0,94		5	-0,38	1,05	0,74	0,90
7	0,38	1,05	1,15	0,79		10	0,56	1,14	0,50	0,87
5	-0,38	1,05	0,74	0,90		9	0,62	0,99	0,38	0,93
8	-0,97	0,87	0,03	1,18		8	-0,97	0,87	0,03	1,18

6.5.1 Relation

The survey showed, as for the class 1 component, that the statements related to the relation between EMP got both high answers and ranking, even higher on some statements than the class 1 component suppliers did. The suppliers value the relation in form of; trust, working relation, open and honest communication and also timely and adequate information the most. For these suppliers EMP does not measure the supplier performance and there is no specific, just a general way of working with the operational supplier relations. The authors therefore find it as a good start to more proactively start working with these subjects in order to maintain and even improve within this area.

6.5.2 Operational

These suppliers do think that it is important that orders not are changed after they have been placed. This do affect, according to the suppliers, their possibility to deliver on the first confirmed date and increases the cost of manufacturing and delivery. In order to decrease the

possibility of orders being late and causing problems in the production, EMP needs a good process structure for minimising number of order changes after they have been placed. On the other hand the suppliers do say that this is not frequently recurring. Another thing that the suppliers not totally disaffiliate is that EMP places order with shorter lead time than agreed. If EMP minimises these two cases (late order changes and order placed with shorter lead time) the possibility of orders being delivered according to the first confirmed day will increase. As discussed before EMP does not measure these suppliers performance but will be able to do so from next year. Therefore there is no way of following up on old supplier performance data.

6.5.3 Other

The answers the authors received on these two statements are that the supplier almost agree to that EMP provides the opportunity to make acceptable profit over long term and that they are sufficiently involved in the development process. According to how the supplier have ranked these statements (more than important) they are most likely to think that they would like to be more involved in the development process and be able to make better profit over time. The authors do not think that suppliers involvement in the development process is critical for a continued good working relation instead more of a way for the suppliers to show their interest in working with EMP. Neither the profit is something to put a lot of effort in, the suppliers cannot say to us that they are making a lot of money on our business if they do not want to see requests from us on lowering their prices.

6.6 Supplier Survey – EMP buyers[202]

Table 6-8, P&S buyers answers and ranking sorted by highest answer (left) and highest ranking (right).

Question	Average answer	STDEV	Average ranking	STDEV		Question	Average answer	STDEV	Average ranking	STDEV
2	1,25	0,50	1,50	0,00		1	0,75	0,50	1,50	0,00
6	1,00	0,58	1,25	0,50		2	1,25	0,50	1,50	0,00
1	0,75	0,50	1,50	0,00		3	0,75	0,50	1,25	0,50
3	0,75	0,50	1,25	0,50		4	-0,50	0,82	1,25	0,50
10	0,50	0,82	0,50	0,82		6	1,00	0,58	1,25	0,50
5	0,25	1,26	0,25	1,26		7	0,00	1,00	1,00	0,58
9	0,25	0,96	0,75	0,96		9	0,25	0,96	0,75	0,96
7	0,00	1,00	1,00	0,58		10	0,50	0,82	0,50	0,82
8	0,00	1,29	0,00	0,58		5	0,25	1,26	0,25	1,26
4	-0,50	0,82	1,25	0,50		8	0,00	1,29	0,00	0,58

Statement (Scale; 1,5 "I totally agree" to -1,5 "I totally disagree")

Area: Relation

1 The level of trust within the relation, between You and the suppliers, is satisfying.
2 Working relations, between You and the suppliers, is perceived as satisfying.
3 The communication, between You and the suppliers, is perceived as open and honest.
4 EMP communicates timely and adequate information to the suppliers.

Area: Operational

5 EMP place orders with shorter lead time than agreed.
8 Late order-changes after order is placed are frequently recurring.
9 Late order-changes after order is placed affect the suppliers' ability to deliver according to first

[202] Results also shown in appendix 12

confirmed delivery date.

10 Late order-changes after order is placed affect the suppliers' cost of manufacturing and delivery.

Area: Other

6 The suppliers are sufficiently involved in EMP's development process of new products.

7 EMP gives the suppliers the opportunity to make acceptable profit over long term.

Ranking (Scale; 1,5 "Very important" to -1,5 "Not important at all"

1-7 Rank the importance the statement.

8 How important do You think (or what You have heard from the suppliers) it is, from the suppliers' point of view, that the orders not are changed after the suppliers have received them.

9 How important do You think (or what You have heard from the suppliers) it is, from the suppliers' delivery precision perspective, that the orders are not changed after they have received it.

10 How important do You think (or what You have heard from the suppliers) it is, from the suppliers cost perspective, that the orders are not changed after they have received it.

6.6.1 Compared to ASIC suppliers

6.6.1.1 Relation

- Lower average answer from buyers than from suppliers on "communicating timely and adequate information" and "the level of trust within the relation"
    - The supplier think that EMP is better on these two statements that EMP themselves think
- More or less the same level of high agreement on "good working relations"
- The suppliers do not think that we communicate open and honest information. There is a big gap in the supplier's answers compared to the buyers' on this statement.
    - An explanation can be, as said in chapter 6.4.1, that things that have happened recently have affected the suppliers' way of answering. Therefore the suppliers' may not be given so much thought.

6.6.1.2 Operational

- Supplier think it is a less problem than the buyer that "orders are changed after they have been placed" and it does not seriously affect the delivery precision and the cost of manufacturing.
    - In order for EMP to improve its process and always place orders with correct lead time, this is a good perception to have. Still it is important to know that, even though the data shows that many orders are placed with shorter lead time than agreed, the suppliers are flexible in meeting our requests. It is still important to have in mind that late order changes probably will affect the delivery precision to some extent.
- The buyers and the suppliers have the same opinion if EMP places order with shorter lead time than agreed, they agree to some extent.

6.6.1.3 Other

- Suppliers think the possibility of making acceptable profit over long term is lower than the buyers think.
    - This answer was expected and probably nothing to put further effort in.
- The buyers think that the suppliers are sufficiently involved in the development process. The supplier would like to be more involved.

6.6.2 Conclusion

It is especially important for the buyers to have in mind that the suppliers put a great value in the relation dimension. Also that late order changes affect the cost. By increasing the process control and more strictly place orders in time, without changes, a positive trend of lowered costs may occur.
There is a differ in ranking on statement; 2, 6, 3 and 10. Buyers think that these are more important than the suppliers think they are. This misunderstanding might result in focusing on wrong areas and the resources are misled into less value adding activities. Therefore it is important to clarify what areas are important for both parties in a partnership.

6.6.3 Compared to class 2 suppliers

6.6.3.1 Relation

- Lower average answer from buyers than from suppliers on “communicating timely and adequate information” and “the level of trust within the relation”
    - The supplier think that EMP is better on these two statements that EMP themselves think
- Higher average from the suppliers on “open and honest communication”

- Likewise answers from buyers and the suppliers on ”satisfying working relations”

6.6.3.2 Operational

- The buyers think that orders are placed with shorter lead time than agreed more often than the suppliers do.
- The buyers think that late order changes are more frequently occurring than the suppliers do.
- Same opinion (agree) on that late changes affect “delivery precision” and “cost of manufacturing and delivery”

6.6.3.3 Other

- Supplies agree more than the buyers that there is a opportunity to make a acceptable profit over time
- Buyers think that the suppliers are sufficiently involved in the development process the suppliers want to be more involved.

6.6.4 Conclusion

Also for these suppliers it is important for the buyers to have in mind that the suppliers put a great value in the relation dimension. These suppliers are delivering less strategic components than the ASIC suppliers do, in some cases generic components. It therefore corresponds well with the relation theory in chapter 4.10 and 4.11 that the operational part of the relationship is important and that the adaptability and flexibility is lower here than for the ASIC suppliers. It is also important that the order lead time are agreed and followed in order to improve the delivery performance.

6.7 Supplier Classification

This chapter will give guidance for future work with the foundation for a supplier relationship program and how to classify the suppliers. Today the P&S spend the major part of their resources on the relation with class 1 and 2 suppliers. The new classification divides the suppliers in three parts, Class 1, 2a, and 2b. The new classification should be seen as a foundation for future improvements of how the relation should be designed.

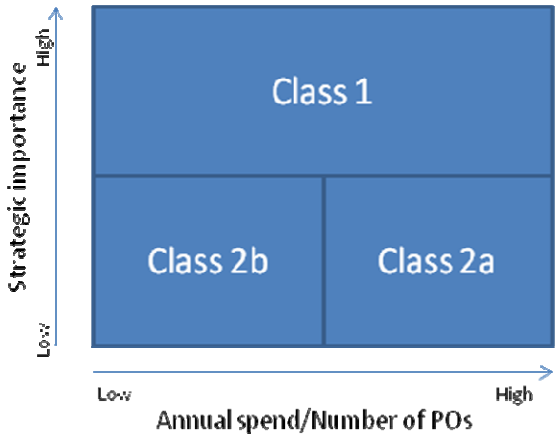

Figure 6-13, New supplier classification model.

Class 1

The new class 1 are identical with the existing class 1. This part includes all ASIC suppliers due to their great importance for EMP's business. There should be continuous improvements on the relationship and the suppliers should be measured as described in the analyse chapter.

Class 2a

The class 2a is based on today's class 2 classification. The supplier needs to achieve two threshold values; yearly spend over 300k SEK and/or more than 12 orders per year, to be a class 2a supplier (based on EMP internal spend/order data). The class 2a suppliers' stands for a significant importance through their annual spend or frequency of the deliveries for the reference design. Therefore the suppliers in this category are the next to be measured when P&S decide to measure on more suppliers.

Class 2b

The class 2b classification is also based on today's class 2 but with different threshold criteria. To be classified as a class 2b the suppler cannot have a yearly spend over 300k SEK and they need to have less than 12 deliveries per year. The relation with suppliers from this category should be similar to the one P&S have with the class 2 suppliers today.

6.8 Customer Satisfaction

The authors' main goal when starting with this thesis was to use a holistic view, from supplier's supplier to end customer, to look at factors affecting or being affected by the work at the P&S department. During the way and especially after talking to David Håkansson (CPM for Sharp and businesses within Japan) the authors realised that it would be too time consuming to do a thesis work with such a big scope. Another thing that affected the decision, to not contact EMP's end customer, was that the customers' knowledge of the P&S

department existence is probably low. There are no channels of contact between the two parties. If deliveries not reach the end customer in time, the end customer does not contact the P&S department who have shipped the goods. The customer rather contacts the CPM. Therefore it would not be of interest for the authors to speak with the end customer about the service (How P&S perform in the delivery perspective) because the end customer is not aware of the P&S existence.

7 Conclusion

In this chapter the conclusion will be described. The conclusion reflects on the collected empirical material, the analysis and the result of the analysis. Findings and recommendations that have been found in the study will be described

The purpose of the master thesis was to create a foundation regarding efficiency and effectiveness in the flow of goods, information and the way of work within the procurement process. The study clarified weaknesses / information gaps in the traceability of the order process. The traceability is important to increase the control of the process and recommendations are presented how to increase the process control and how to fill the information gaps. The authors have proposed changes to the existing measurements and added new measurements in order to fill the information gaps and to be able to give a better picture of the P&S's performance.

The identification of inconsistency in the documentation, especially in the root-cause work for failures of KPIs resulted in a new improvement tool / document. The study also resulted in guidance and recommendations of areas to be included in the P&S's next revision of the purchase system (PO LOG file) to increase the process control. Each area described above will be presented more detailed below

The information gaps
The authors identified three information gaps within the order process. This means that in some cases a specific order item cannot be traced throughout the whole order process. The order process is divided in two separate flows, one for components and one for PCBs. Between these flows there are no information interchanges. Within the PCB flow the ordered items can be traced through the whole process but in the component flow there are three independent measurement areas that are not connected to each other. Figure 7.1 shows the case described, poor information connection between the PCB and components order process and very poor information connection within the component process.

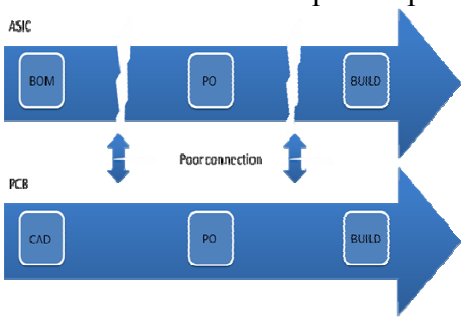

Figure 7-1, Information gaps in the order process

The authors' proposed changes (presented in chapter 6) will eliminate these information gaps, both between and within the processes. To fulfil the gaps; new measurements, documentation tools have been created, and guidance for the next revision of the purchasing system have been given. Further descriptions of these areas are presented below. The result of the recommendations is that the orders are fully traceable throughout the process. The connection between the processes will be established and performance analysis can be conducted much easier. Figure 7-2 illustrates the order process, with completed traceability.

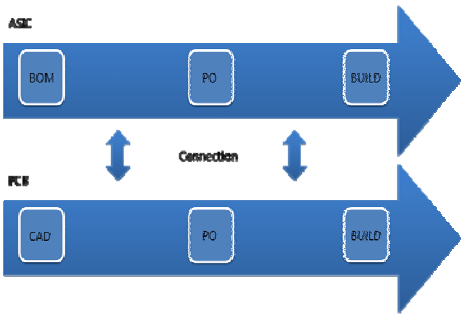

Figure 7-2, Outcome of the suggested improvements

The measurements

The authors changed some of the existing measurements and added new measurements to the performance measurement system. By doing so all important activities will be measured, which results in full traceability within and between the processes. All measurements that are proposed are presented thoroughly in chapter 6.1.

When the authors designed the new set up of measurement the purposes was that all measurements should be useable on both the component and the PCB flow. There are expectations; the two measurements on the BOM, the delivery precision versus the first confirmed date and the order acknowledgement are only used for the component flow. In the PCB case CAD on time is the only measurement that is not used on the components. Before this study took place the P&S had different measurements for PCBs and the components. The changed measurements have been changed to better reflect the performance of the process. The new ones are designed to measure important activities that are not measured today. The information gathered together will improve the process transparency and enable a better control of the process.

Except the measurements that are measuring the different process activities, two of the new measurements are reflecting the department's performance. One of the measurements, *overall supply index*, measures the department's overall performance. The overall performance includes the performance of crucial activities that is input to the department's process. The second one only measures the department's performance without taking external performances into account.

The performances of the today's measurements are reported monthly and does only show the components' performances, not the PCBs. The authors propose that the PCB measurements also need to be reported in the monthly report because of its importance for the build. If the PCB is not delivered before the build, the component can not be mounted on anything and the build can not be carried out.

Improvement tools / document

The study identified inconsistency in the operational work, especially in the reporting of root causes to failed KPIs. The authors therefore designed a tool / document to simplify the analysis work with root causes and to unify the department's way of working.

To simplify the root cause analysis work, P&S started to use the 5-why method to find the final root cause. P&S have established the first level of categorisation of the root cause analysis. By using the established six existing categories the authors have established sub-

categories to further simplify the analysis work. The standardisation of the category levels enables the employees to easily and quickly find the final root cause to the failure.

The document should be used to compile all failures per order item level and the document enables P&S to trace the item and in which areas it is failing. Today the department have different documents for different areas of failures and they follow up on monthly basis. The new document will include all measurements in one document and the documents will be used for a whole year at the time. The yearly basis increases the visibility because several of the order items are in progress for more than one month. The new document is divided into two parts; one for P&S and one for the suppliers. In the P&S part all information on the process's measurements, the root cause to failure and action point to avoid future issues are logged. The supplier document is sent if the occurred issue is caused by the supplier and the supplier fill in information about why the item failed and action point to prevent future issues. This document simplifies the analysis of root causes and enables P&S to easily find items that are failing in more than one area.

Guidance for next revision of purchasing system

To achieve the purpose with process control and to secure that full traceability can be achieved the authors established guidance for areas that needs to be included in the purchasing system. The system, called PO-LOG file, is where the buyers log all their purchase orders and also from where the measurements will be calculated. In this case several guidances of new and changed requirement specifications have been done to secure the measurement of the process. The study has also given guidance that the new root cause document needs to be used. All guidance is made to secure that the purposes with this study will be achieved.

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Informants

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Electronic Sources

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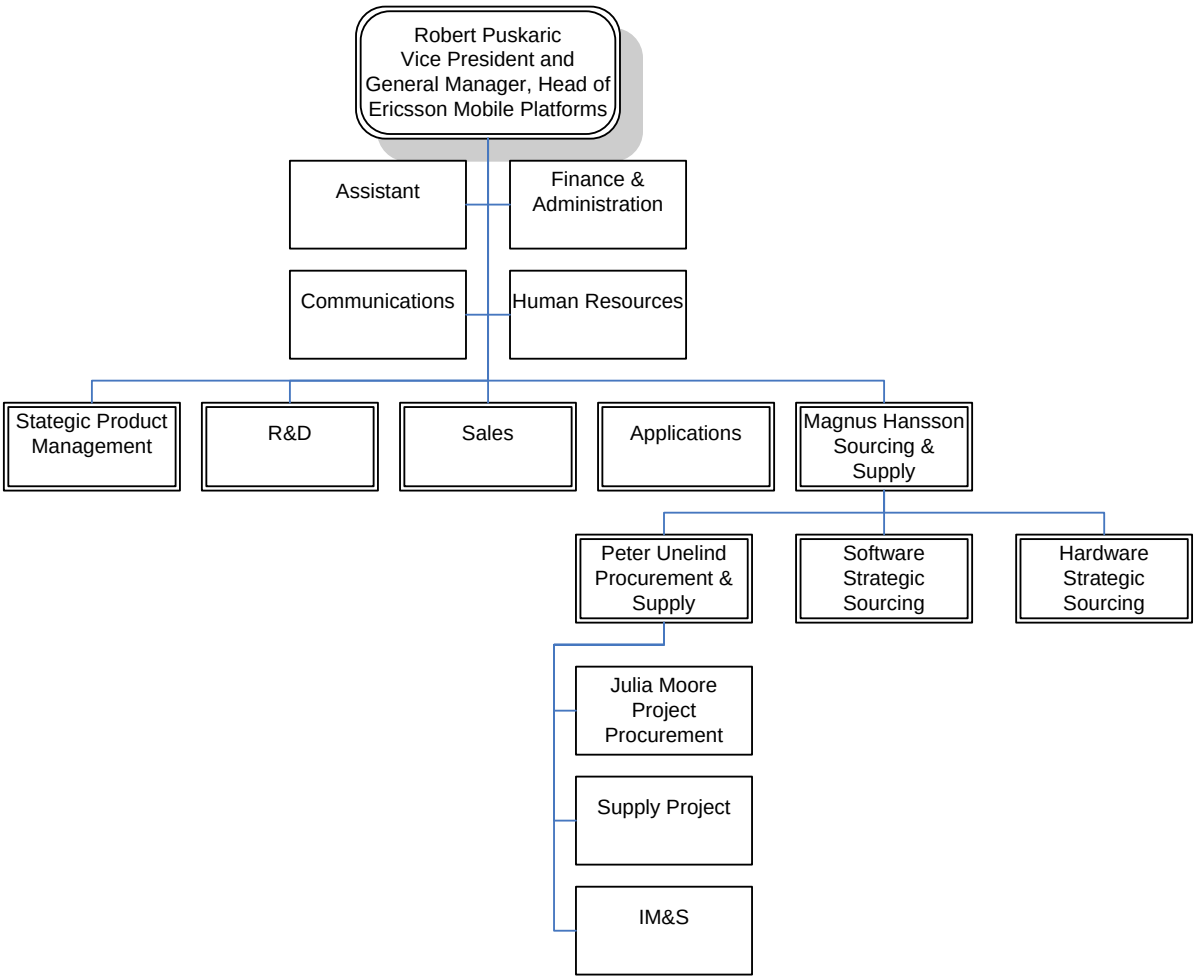
Appendix 1 Ericsson Mobile Platforms, organisation



Appendix 2 Measurement; Threshold value, Limitations and Owners

Threshold Value

Measurement		Threshold
Type	Description	(Target value)
PCB	Supplier On-time delivery	2 wd
PCB	CAD-drawing received on-time	20 wd
PCB	Confirmed order	Must confirm requested date
Class 1	Delivery precision first confirmed (A)	-
Class 1	Delivery precision requested (B)	-
Class 1	Order acknowledgement responsiveness (C)	Must be responded within 72 hours
Class 1	Agreed order lead time (D)	4 weeks order lead time
Class 1	No of days before receipt of BOM to build date	Received by P&S 12 weeks before build date
Class 1	Line stop (E)	9 am day before build date
Class 1	Last components received	-
Class 1	Overall supply index	[(5*E) + A + B + C + D + E]/10
Class 1	Delivery precision first confirmed per year	Average of DPFC per year, (Σ DPFC)/12
Class 1	EMP delivery precision towards customer vs. requested (F)	Delivery precision towards forecasted delivery d

Threshold limitations

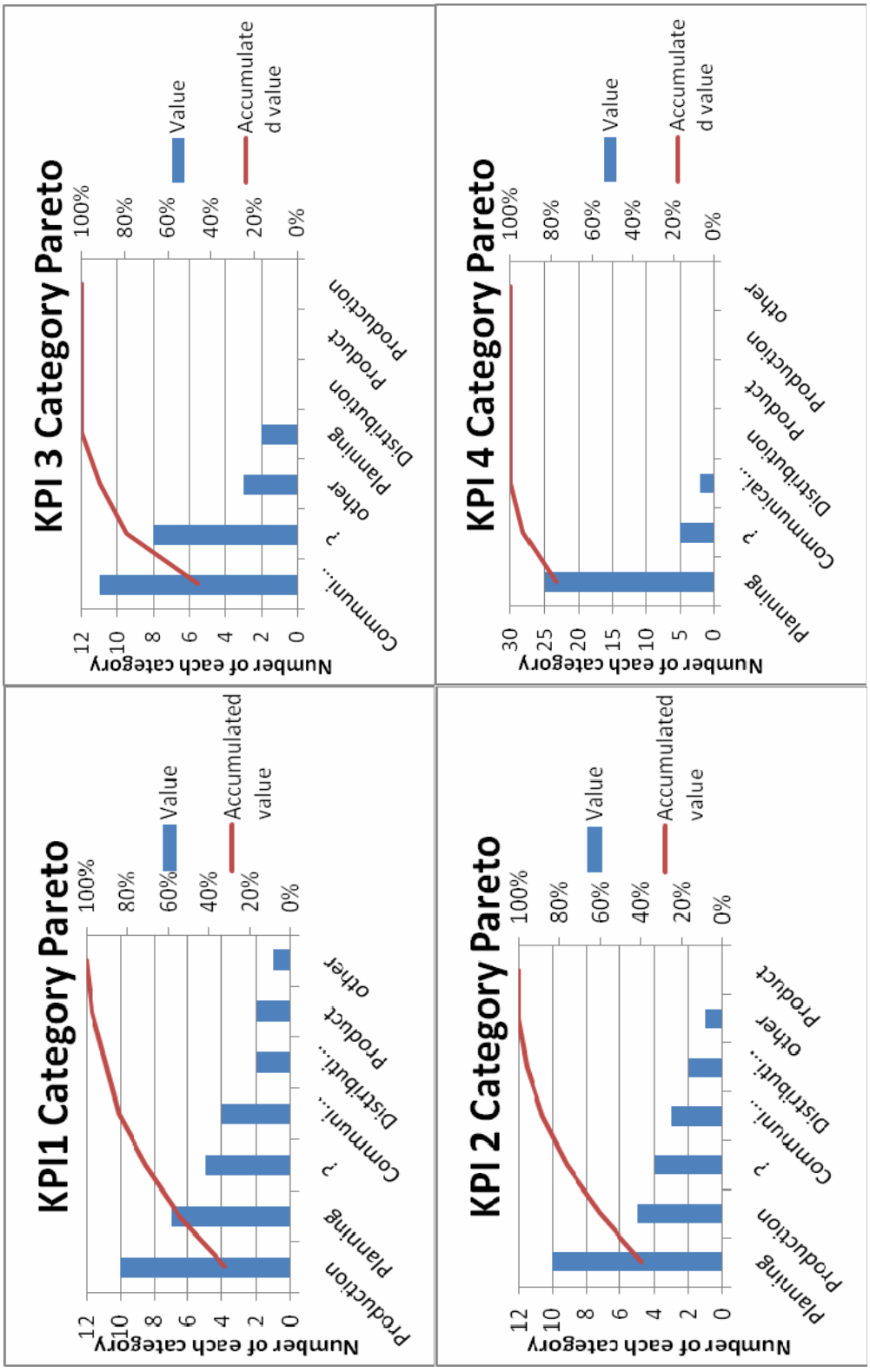
Measurements	Threshold limitations		
	Robust	Committed level	Stretch
Delivery precision first confirmed	75%	80%	85%
Delivery precision requested	50%	60%	70%
Order acknowledgement responsiveness	50%	70%	90%
Agreed order lead time	70%	80%	90%
No of days before receipt of BOM to build date	-	12 weeks	-
Line stop	10%	5%	3%
Last components received	-	10 work days	-
Over all supply index	70%	80%	90%
Accumulated Delivery precision first confirmed per year	75%	80%	85%
EMP delivery precision towards customer vs requested	85%	90%	95%

Measurement owners

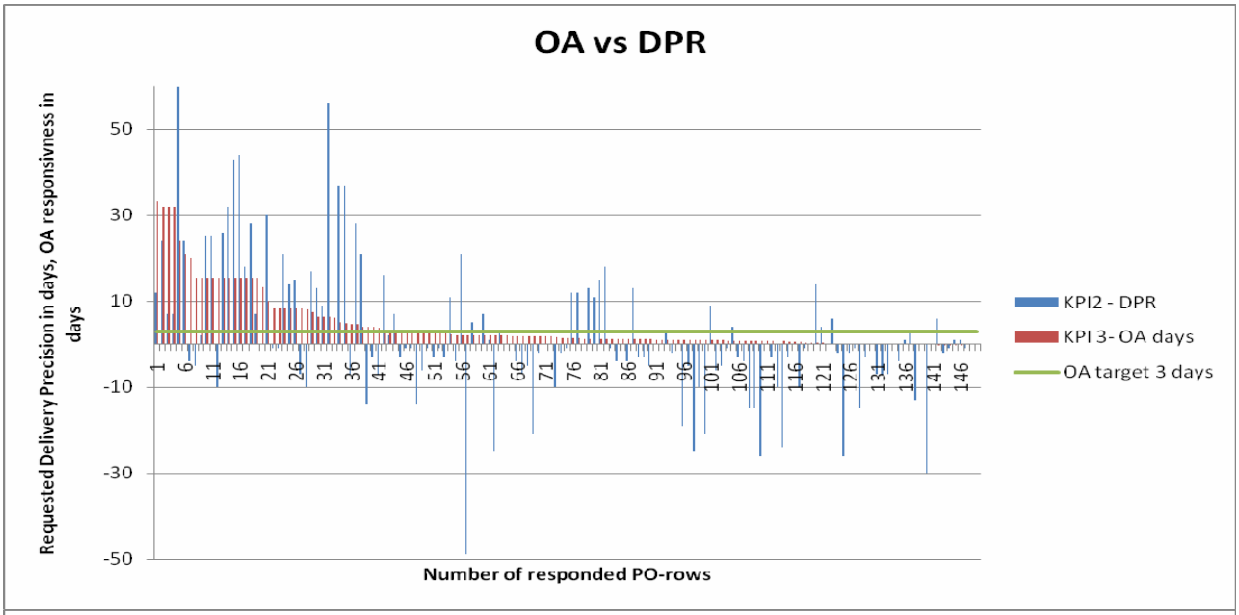
Measurements	Owner/responsible
Delivery precision first confirmed	KPI-responsible
Delivery precision requested	KPI-responsible
Order acknowledgement responsiveness	KPI-responsible
Agreed order lead time	KPI-responsible
No of days before receipt of BOM to build date	PSM
Line stop	PCB- responsible
Last components received	PCB- responsible
Over all supply index	KPI-responsible
Delivery precision first confirmed per year	KPI-responsible
EMP delivery precision towards customer vs. requested	PAS-responsible

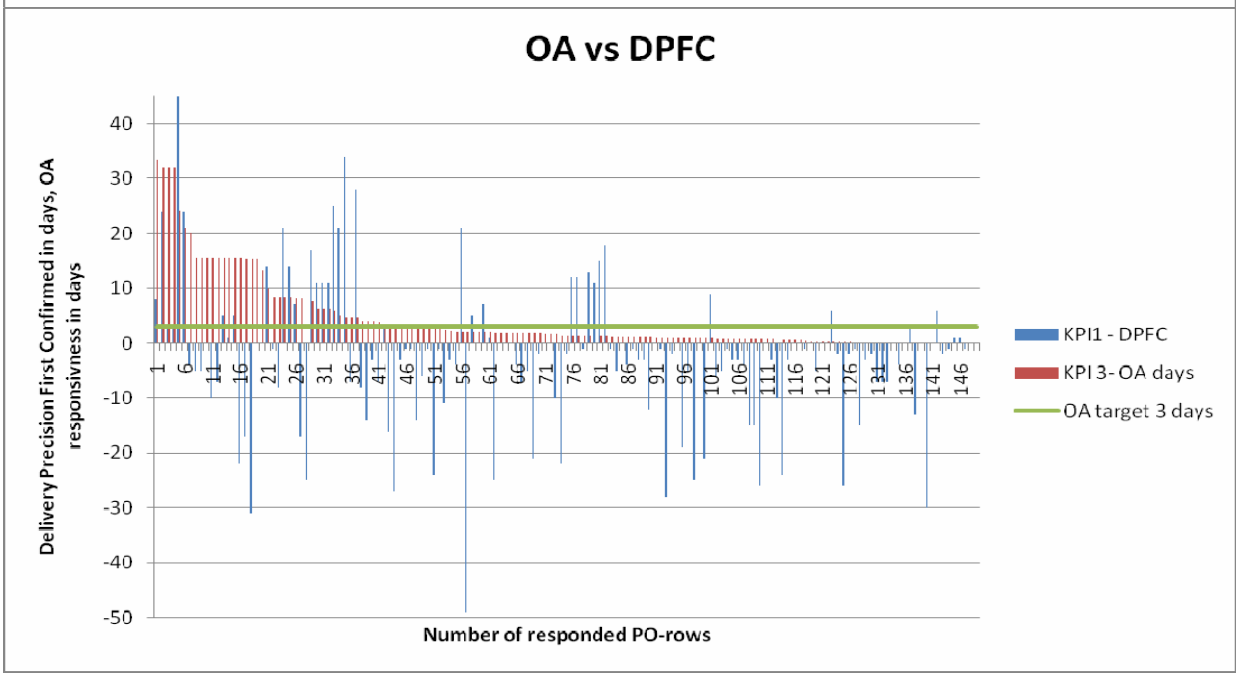
Appendix 3 Root cause categories

KPI 1 Delivery Precision First Confirmed
KPI 2 Delivery Precision Requested
KPI 3 Order Acknowledgement responsiveness
KPI 4 Agreed Order Lead Time



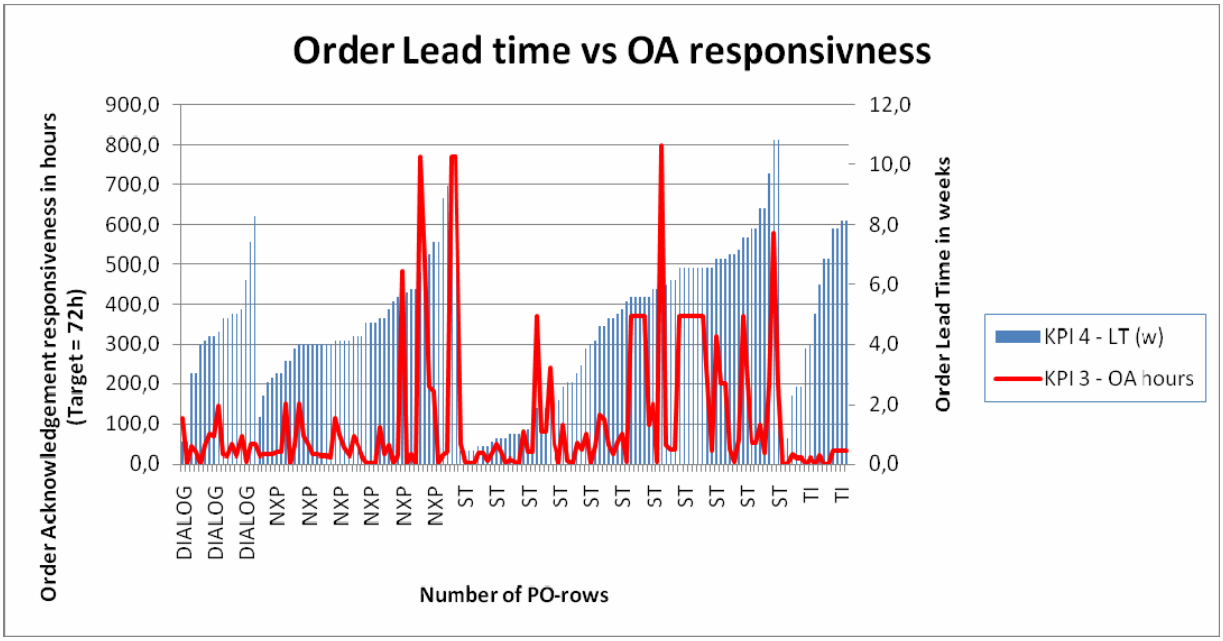
Appendix 4 Correlation between OA and delivery precision





Appendix 5 Order lead time vs order acknowledgement

The diagram shows the low correlation between the order lead time and the order acknowledgement responsiveness.



Appendix 6 Table of PCB process performance and delivery performance

PCB PO process analysis	
CAD data	
Not on time (later than 20 workdays before build start)	36%
Mean value of CAD data arrival (workdays before build start)	26
PO placed	
Mean value, from CAD arrives to order placed (workdays)	3,2
Supplier given lead time (From order being placed to target received date)	
Mean value (actual days)	23,8
Min value (actual days)	0
Max value (actual days)	115
Lead time shorter than 18 workdays	60%
Mean value on late orders (actual days	26,7
Delivery precision	
Late delivery according to first promised date	39%
*(-+) 1 workday from first promised delivery date	32%
Late deliveries – Correlations	
Late CAD data when order is late	27%
Supplier lead time shorter than 18 workdays when order is late	66%
Average lead time on the failed orders towards first promised date (workdays)	19,6
Possible build stop (Orders delivered the day before the build start or later)	
Percentage of all orders	24%
Actual number of registered build stops	6

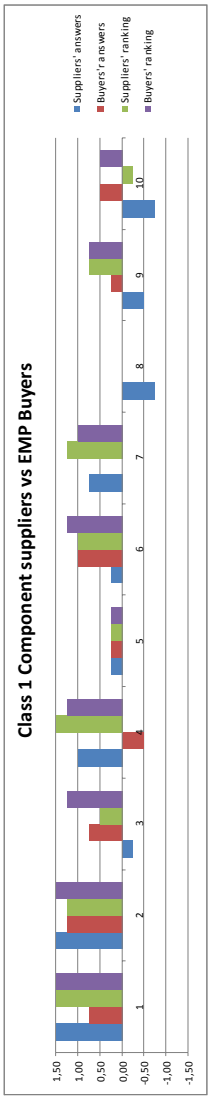
Appendix 7 Extract from PCB data spread sheet

	A	D	E	H	I	J	K
1	Build date	Target CAD date / OK	CAD date / OK'd	Target rec.	Order Date	First Promised delivery date	Date received
2	2008-02-18	2008-01-21	2008-01-31	2008-02-16	2008-01-31	2008-02-17	2008-02-15
8	2008-02-19	2008-01-22	2008-01-25	2008-02-17	2008-01-28	2008-02-19	2008-02-18
9	2008-02-27	2008-01-30	2008-02-01	2008-02-25	2008-02-06	2008-02-22	2008-02-20
10	2008-02-27	2008-01-30	2008-02-01	2008-02-25	2008-02-06	2008-02-22	2008-02-20
11	2008-02-27	2008-01-30	2008-01-31	2008-02-25	2008-01-31	2008-02-28	2008-02-27
12	2008-02-27	2008-01-30	2008-01-31	2008-02-25	2008-01-31	2008-02-25	2008-02-25
13	2008-02-20	2008-01-23	2008-02-04	2008-02-18	2008-02-06	2008-02-21	2008-02-18
15	2008-02-21	2008-01-24	2008-02-06	2008-02-19	2008-02-11	2008-02-22	2008-02-20
17	2008-03-12	2008-02-13	2008-02-18	2008-03-10	2008-02-21	2008-03-09	2008-03-08
19	2008-03-18	2008-02-19	2008-03-04	2008-03-16	2008-02-29	2008-03-16	2008-03-15
21	2008-03-31	2008-03-03	2008-03-04	2008-03-29	2008-03-06	2008-03-20	2008-03-31
24	2008-03-26	2008-02-27	2008-03-14	2008-03-24	2008-03-14	2008-03-25	2008-03-25
25	2008-04-18	2008-03-21	2008-03-25	2008-04-16	2008-03-25	2008-04-14	2008-04-15
		2008-03-26	2008-04-03	2008-04-21	2008-04-04	2008-04-21	2008-04-21
			2008-04-03	2008-04-22	2008-04-04	2008-04-21	2008-04-
					2008-04-26	2008-04-26	

Appendix 8 Survey Answers Class 1 component suppliers

Class 1 Component Supplier

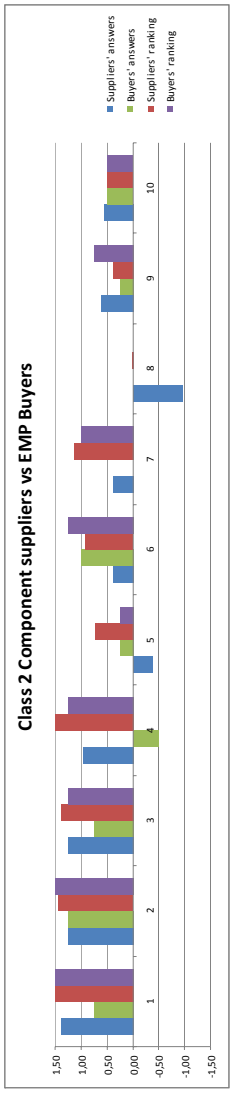
Question	Average answer supplier	STDEV	Average ranking supplier	STDEV	Average answer buyer	STDEV	Average ranking buyer	STDEV
1	1,50	0,00	1,50	0,00	0,75	0,50	1,50	0,00
2	1,50	0,00	1,25	0,50	1,25	0,50	1,50	0,00
3	-0,25	1,50	0,50	1,41	0,75	0,50	1,25	0,50
4	1,00	0,58	1,50	0,00	-0,50	0,82	1,25	0,50
5	0,25	0,96	0,25	0,50	0,25	1,26	0,25	1,26
6	0,25	0,96	1,00	0,58	1,00	0,58	1,25	0,50
7	0,75	0,96	1,25	0,50	0,00	1,00	1,00	0,58
8	-0,75	0,96	0,00	1,29	0,00	1,29	0,00	0,58
9	-0,50	1,41	0,75	0,50	0,25	0,96	0,75	0,96
10	-0,75	0,96	-0,25	0,96	0,50	0,82	0,50	0,82



Appendix 9 Survey answers Class 2 component suppliers

Class 2 Component Supplier

Question	Average answer supplier	STDEV	Average ranking supplier	STDEV	Average answer buyer	STDEV	Average ranking buyer	STDEV
1	1,38	0,33	1,50	0,00	0,75	0,50	1,50	0,00
2	1,26	0,44	1,44	0,24	1,25	0,50	1,50	0,00
3	1,26	0,56	1,38	0,33	0,75	0,50	1,25	0,50
4	0,97	0,80	1,50	0,00	-0,50	0,82	1,25	0,50
5	-0,38	1,05	0,74	0,90	0,25	1,26	0,25	1,26
6	0,38	0,93	0,91	0,94	1,00	0,58	1,25	0,50
7	0,38	1,05	1,15	0,79	0,00	1,00	1,00	0,58
8	-0,97	0,87	0,03	1,18	0,00	1,29	0,00	0,58
9	0,62	0,99	0,38	0,93	0,25	0,96	0,75	0,96
10	0,56	1,14	0,50	0,87	0,50	0,82	0,50	0,82



Appendix 10 Statements asked the suppliers in the survey

Statement (Scale; 1,5 "I totally agree" to -1,5 "I totally disagree")

Area: Relation

1 The level of trust within the relation, between EMP and You, is satisfying.
2 Working relations, between EMP and You, is perceived as satisfying.
3 The communication, between EMP and You, is perceived as open and honest.
4 EMP communicates timely and adequate information.

Area: Operational

5 EMP place orders with shorter lead time than agreed.
8 Late order-changes after order is placed are frequently recurring.
9 Late order-changes after order is placed affect Your ability to deliver according to first confirmed delivery date.
10 Late order-changes after order is placed affect the cost of manufacturing and delivery.

Area: Other

6 You are sufficiently involved in EMP's development process of new products.
7 EMP gives You the opportunity to make acceptable profit over long term.

Ranking (Scale; 1,5 "Very important" to -1,5 "Not important at all"

1 Rank the importance the statement 1.
2 Rank the importance the statement 2.
3 Rank the importance the statement 3.
4 Rank the importance the statement 4.
5 Rank the importance the statement 5.
6 Rank the importance the statement 6.
7 Rank the importance the statement 7.
8 How important is it that the orders not are changed after You have received them.
9 How important is it, from Your delivery precision perspective, that the orders are not changed after You have received it.
10 How important is it, from Your cost perspective, that the orders are not changed after You have received it.

Appendix 11 Statements asked the buyers in the survey

Statement (Scale; 1,5 "I totally agree" to -1,5 "I totally disagree")

Area: Relation

1 The level of trust within the relation, between You and the suppliers, is satisfying.
2 Working relations, between You and the suppliers, is perceived as satisfying.
3 The communication, between You and the suppliers, is perceived as open and honest.
4 EMP communicates timely and adequate information to the suppliers.

Area: Operational

5 EMP place orders with shorter lead time than agreed.
8 Late order-changes after order is placed are frequently recurring.
9 Late order-changes after order is placed affect the suppliers' ability to deliver according to first confirmed delivery date.
10 Late order-changes after order is placed affect the suppliers' cost of manufacturing and delivery.

Area: Other

6 The suppliers are sufficiently involved in EMP's development process of new products.
7 EMP gives the suppliers the opportunity to make acceptable profit over long term.

Ranking (Scale; 1,5 "Very important" to -1,5 "Not important at all"

1 Rank the importance the statement 1.
2 Rank the importance the statement 2.
3 Rank the importance the statement 3.
4 Rank the importance the statement 4.
5 Rank the importance the statement 5.
6 Rank the importance the statement 6.
7 Rank the importance the statement 7.
8 How important do You think (or what You have heard from the suppliers) it is, from the suppliers' point of view, that the orders not are changed after the suppliers have received them.
9 How important do You think (or what You have heard from the suppliers) it is, from the suppliers' delivery precision perspective, that the orders are not changed after they have received it.
10 How important do You think (or what You have heard from the suppliers) it is, from the suppliers cost perspective, that the orders are not changed after they have received it.

Appendix 12 Survey answers – Class 1 and 2 Component Suppliers

Class 1 (ASIC) Component Suppliers vs EMP Buyers

Question	Average answer supplier	STDEV	Diff. (supplier - buyer answe	Average ranking supplie	STDEV	Diff. (supplier - buyer rankin	Average answer buye	STDEV	Average ranking buye	STDEV
1	1,50	0,00	0,75	1,50	0,00	0,00	0,75	0,50	1,50	0,00
2	1,50	0,00	0,25	1,25	0,50	-0,25	1,25	0,50	1,50	0,00
3	-0,25	1,50	-1,00	0,50	1,41	-0,75	0,75	0,50	1,25	0,50
4	1,00	0,58	1,50	1,50	0,00	0,25	-0,50	0,82	1,25	0,50
5	0,25	0,96	0,00	0,25	0,50	0,00	0,25	1,26	0,25	1,26
6	0,25	0,96	-0,75	1,00	0,58	-0,25	1,00	0,58	1,25	0,50
7	0,75	0,96	0,75	1,25	0,50	0,25	0,00	1,00	1,00	0,58
8	-0,75	0,96	-0,75	0,00	1,29	0,00	0,00	1,29	0,00	0,58
9	-0,50	1,41	-0,75	0,75	0,50	0,00	0,25	0,96	0,75	0,96
10	-0,75	0,96	-1,25	-0,25	0,96	-0,75	0,50	0,82	0,50	0,82

Class 2 Component Suppliers vs EMP Buyers

Question	Average answer supplier	STDEV	Diff. (supplier - buyer answe	Average ranking supplie	STDEV	Diff. (supplier - buyer rankin	Average answer buye	STDEV	Average ranking buye	STDEV
1	1,38	0,33	0,63	1,50	0,00	0,00	0,75	0,50	1,50	0,00
2	1,26	0,44	0,01	1,44	0,24	-0,06	1,25	0,50	1,50	0,00
3	1,26	0,56	0,51	1,38	0,33	0,13	0,75	0,50	1,25	0,50
4	0,97	0,80	1,47	1,50	0,00	0,25	-0,50	0,82	1,25	0,50
5	-0,38	1,05	-0,63	0,74	0,90	0,49	0,25	1,26	0,25	1,26
6	0,38	0,93	-0,62	0,91	0,94	-0,34	1,00	0,58	1,25	0,50
7	0,38	1,05	0,38	1,15	0,79	0,15	0,00	1,00	1,00	0,58
8	-0,97	0,87	-0,97	0,03	1,18	0,03	0,00	1,29	0,00	0,58
9	0,62	0,99	0,37	0,38	0,93	-0,37	0,25	0,96	0,75	0,96
10	0,56	1,14	0,06	0,50	0,87	0,00	0,50	0,82	0,50	0,82

Appendix 13 Sub-categories

1. Communication

1.1 Internal / EMP. EMP have problem with internal communications. For example; Not enough information is transferred between internal departments.
1.2 EMP – Supplier. The communication between EMP and the Supplier has issues. For example; Adequate information is not transferred.
1.3 Internal /Supplier. The supplier has internal communication issues. For example; Not enough information is transferred between internal departments.
1.4 Supplier - their supplier. The communication between EMP's supplier and their supplier is not satisfied. The sub-category reminds on 1.1 Internal/EMP. For example; Adequate information is not transferred towards the supplier's supplier.
1.5 EMP – MIC. This Sub-Category will handle communication issues related to the MIC-factories. For example; Lack of information regarding future line stop caused by maintenance work.

2. Planning

2.1 EMP – rescheduling. Issues, caused by EMP, that result in rescheduling. For example; late changes in BOM lead to cancelled Purchase Order and New Purchase Order.
2.2 Supplier – Rescheduling. Issues, caused by the Supplier, that result in rescheduling. For example; late changes in production that
2.3 Build rescheduling. Issues that cause build rescheduling. The rescheduling can be caused by both EMP and Supplier
2.4 Supplier – Employees. Issues related to employees. For example; Not enough employees (or) at the right place within the suppliers company.
2.5 Risk minimisation. Risk minimising. For example way to handle bank holidays, vacations, and Supplier's supplier delivery delays etc.
2.5 Supplier - Upstream Supply Chain Issues. The supplier's upstream Supply Chain Issues. For example; The supplier's delivery of raw material was late.

3. Product

3.1 Technology – complexity. Issues related to the products Technology and complexity. For example;
3.2 Quality issues. Quality issues related to the product.
3.3 MIC-production. Quality issues related to the delivered product. For example; Defect product.

4. Production

4.1 Raw material. Issues related to / caused by the material in the manufacturing process. For example;
4.2 Equipment. Issues caused by the manufactory equipment. For example; Line stop caused by equipment brake down.
4.3 Quality issues. Issues related to quality issues. For example; Quality issues that leads to reproduction.
4.4 MIC-production. Issues related to the MIC-factories. For example: Assembly problem caused by staffing-problem or by the equipment.

5. Distribution

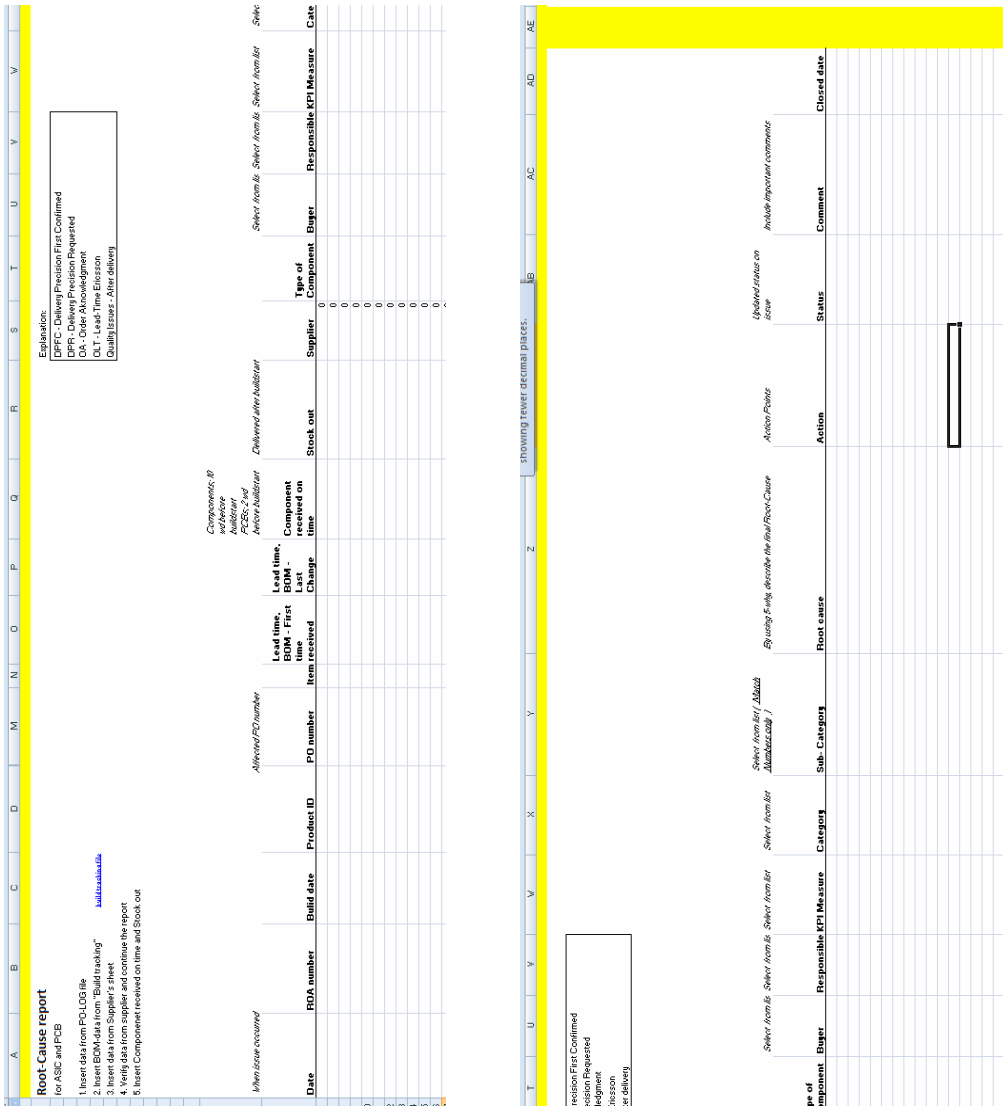
5.1 Delivery Pick Up. Issue related to Delivery Pick Up at the supplier. For example; Later Pick Up than agreed.
5.2 Delays. Issue related to delivery delays. For Example; Delays during transportation caused by traffic jam.
5.3 Delivery destination. Issue related to delivery destination. For example; Incorrect destination or addressee.

6. Other

There are no sub-categories. Other is only used in ordinary cases. For example; Issues occurred by flood or earthquakes.

Appendix 14 Root cause report

The compiled root cause report sheet. The suppliers' template is similar and will not be showed.



Merge the BOM-data with PO-row-data.

To secure that ROA number and all Builds have an independent number all ROA-number must be written in the same way. The new PO-LOG-system merges ROA-number, Revision of BOM and specific Build number. This way of writing should be pleased, therefore all documents that include information to the root cause document must write the ROA-number in this standard. All documents are not able to change into this standard and therefore a new column is created in those cases. The column will collect and merge (the ROA-number, Revision of BOM and specific Build number) and respond the ROA number as in the PO-LOG file

Appendix 15 AHP workshop

The results from the AHP workshop of the overall supply index and the supply index are showed below. The result from this AHP workshop is used to create the index document, showed in appendix 16.

Overall Supply Index

Pairwise comparison

	ASIC							
KPI	BOM f.r.	BOM l.c.	OLT	OA	DPR	DPFC	Build res.	Stock out
BOM f.r.	1,00	3,00	0,33	0,33	0,25	0,33	0,33	0,20
BOM l.c.	0,33	1,00	1,00	1,00	1,00	1,00	0,50	0,20
OLT	3,00	1,00	1,00	3,00	0,25	0,25	0,33	0,20
OA	3,00	1,00	0,33	1,00	0,25	0,25	0,25	0,20
DPR	4,00	1,00	4,00	4,00	1,00	0,33	0,33	0,20
DPFC	3,00	1,00	4,00	4,00	3,00	1,00	1,00	0,20
Build res.	3,00	2,00	3,00	4	3	1	1,00	0,20
Stock out	5,00	5,00	5,00	5,00	5,00	5,00	5,00	1,00
SUM	22,33	15,00	18,67	22,33	13,75	9,17	8,75	2,4

	PCB			
KPI	CAD on time	DPR	Build res.	Stock out
CAD on time	1,00	0,25	1,00	0,20
DPR	4,00	1,00	1,00	0,20
Build res.	1,00	1,00	1,00	0,20
Stock out	5,00	5,00	5,00	1,00
SUM	11,00	7,25	8,00	1,60

	ASIC vs PCB	
ASIC/PCB	ASIC	PCB
ASIC	1,00	1,00
PCB	1,00	1,00
SUM	2,00	2,00

Supply Index

Pairwise comparison

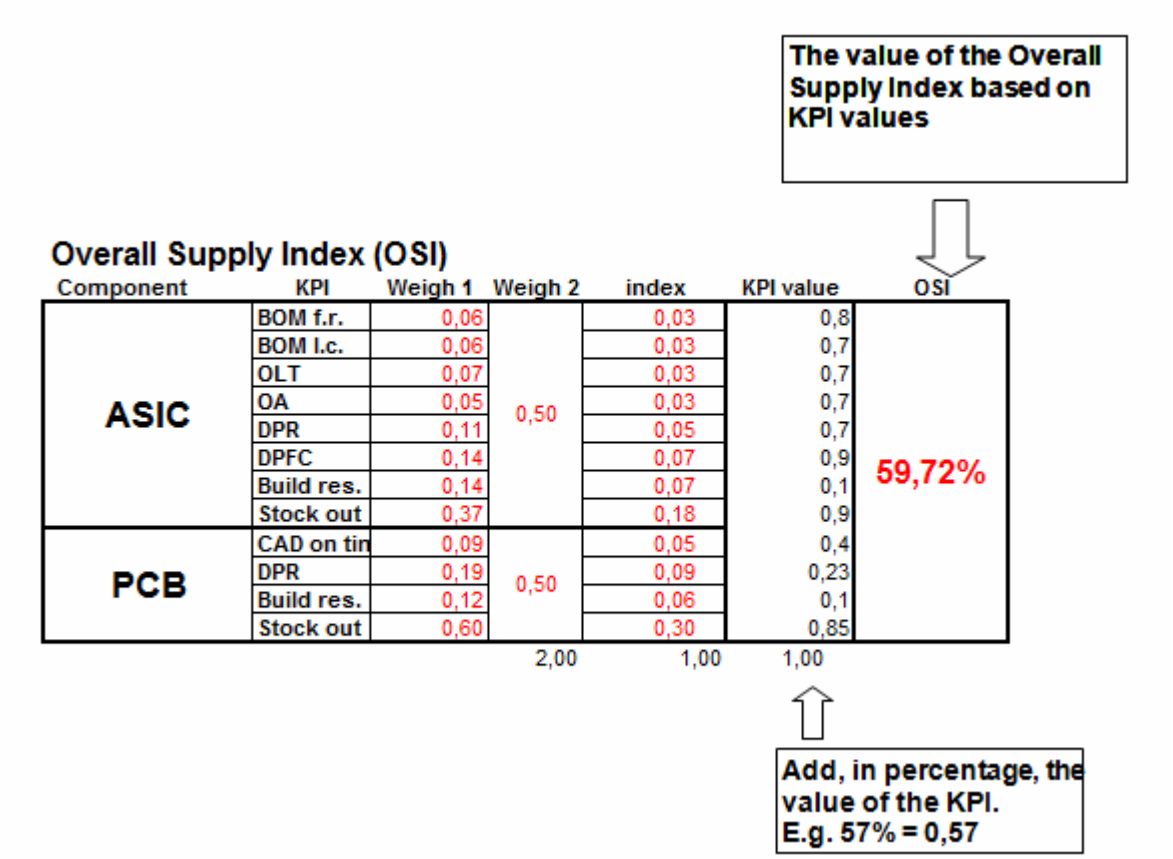
	ASIC					
KPI	OLT	OA	DPR	DPFC	Build res.	Stock out
OLT	1,00	3,00	0,25	0,25	0,33	0,20
OA	0,33	1,00	0,25	0,25	0,25	0,20
DPR	4,00	4,00	1,00	0,33	0,33	0,20
DPFC	4,00	4,00	3,00	1,00	1,00	0,20
Build res.	3,00	4	3	1	1,00	0,20
Stock out	5,00	5,00	5,00	5,00	5,00	1,00
SUM	17,33	21,00	12,50	7,83	7,91666667	2

	PCB		
KPI	DPR	Build res.	Stock out
DPR	1,00	1,00	0,20
Build res.	1,00	1,00	0,20
Stock out	5,00	5,00	1,00
SUM	7,00	7,00	1,40

	ASIC vs PCB	
ASIC/PCB	ASIC	PCB
ASIC	1,00	1,00
PCB	1,00	1,00
SUM	2,00	2,00

Appendix 16 Overall Supply Index document

A similar document is used for the supply index, but without BOM fr, BOM lc and CAD on time.



Appendix 17 Ishikawa diagram – Six Sigma Project

All possible root causes for late PCB deliveries