



**LUNDS UNIVERSITET**  
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*Division of Production Management*

# Maintaining and improving supplier relations with auditing

— A study at ABB Sweden and Singapore

Lund

26 August 2012

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## **Preface and acknowledgements**

This Master Thesis was written during the spring and summer of 2012 as the final part of our five year long master degree in Industrial Engineering and Management at Lund University, Faculty of Engineering.

We would like to express our gratitude to the initiator of the project, Mr Håkan Nytorp at ABB Singapore, for giving us the opportunity to write our Master Thesis with the company. We would also like to thank Mr Philippe Landré and Ms Cecilia Johansson at ABB Sweden for helping us throughout the work with the Master Thesis. Moreover, we would like to thank our project supervisor in Singapore, Ms SweeSuan Koh, for valuable comments and ideas, and Mr Paul Dennis at ABB Singapore for his support. We have received a lot of help, support, feedback and data from other employees at ABB and would like to thank all of you as well.

To our supervisor at Lund University, Faculty of Engineering, Mr Bertil Nilsson, we would like to express our gratitude for all the support and appreciated feedback throughout the whole process of this Master Thesis.

Finally, we would like to take the opportunity to thank our family and friends who have helped and supported us during these five years of hard studies and fun at Lund University.

Lund, August 2012

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## Abstract

- Title: Maintaining and improving supplier relations with auditing  
– A study at ABB Sweden and Singapore
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Production Management
- Background: In today's globalized world, many producing companies depend on large supplier networks. Supplier relations require maintenance and a tool for that is supplier auditing. ABB is a leader in power and automation technologies that enable industrial customers to improve performance while lowering environmental impact. ABB business division Process Automation (PA) and business unit Control Technologies (CT), abbreviated as PACT, has established close partnerships with many of their suppliers. This emphasizes the importance of conducting audits, since a supplier partnership means mutual dependence between the parties. ABB PACT has to be able to rely on the contracted supplier's performance, while the supplier has to be able to rely on ABB as a strong and long-term customer. Key actors within auditing at ABB PACT express that there is room for improvement within the audit processes.
- Purpose: The purpose of this Master Thesis is divided into two parts. The first part is to find out whether there is improvement potential of the audit processes and the use of audits at ABB PACT both in Sweden and Singapore. The second part is to find out how the audit processes could be improved.
- Research questions: By introducing generic research questions that do not focus on a specific case, this Master Thesis has potential to contribute with findings for the academy in general as well.
- This study will answer the following research questions in order to achieve the purpose:
- Frequency*
- What is an appropriate frequency for conducting supplier audits in order to maintain and develop supplier relations?
- Measurement*
- What is an appropriate design for a measurement system that facilitates and motivates for supplier performance improvements?

*Consistency*

- What is an appropriate way of administrating and documenting audits in a consequent manner in order to facilitate information sharing and communication between auditors?

*Competence*

- What is an appropriate level of competence for auditors in order to conduct efficient audits and how can it be achieved?

Method:

A mixture of the systems approach and the actors approach are used in this Master Thesis. The systems approach includes both qualitative and quantitative data collection and the actors approach is used since many personal opinions have played an important role in the study. Furthermore, an abductive research strategy is used, since the study results are derived from critically evaluating a combination of obvious values and observed processes. Mostly qualitative data from interviews and a survey is used. The survey and old audit material also contribute with some quantitative data. The data collection methods are a literature study, interviews, a survey, and a case study.

Findings:

This study proves that there is improvement potential regarding the policy for when to conduct audits, the measurement system in the audit templates, the consistency in the audit process and the level of competence among the auditors.

A prerequisite for the following recommendations to be useful is a clear supplier audit organization. The following suggestions are the authors' recommendations to ABB for how more consistent, efficient and probably better audits will be achieved:

- There should be clear instructions regarding the annual supplier KPI update and the result of it should show clearly if an audit has to be conducted or not.
- All audit templates should use the same scoring system with a passing level at 50% and each graded question should be commented and motivated.
- Each audit guide should contain a Gantt chart clearly showing the activities in the audit process and the documents used in each step of the process.
- The responsibilities pre, during and post audit should be clearly stated and communicated.
- Classroom training of internal audit procedures should be offered

The following conclusions apply to the research questions.

An appropriate *frequency* for when to conduct an audit was not found. Instead, the findings show that the importance lies within having a well implemented and communicated policy for deciding whether a supplier has to be audited or not. If such a policy is not already implemented, it should be done and communicated clearly.

An appropriate design for a *measurement* system was found. The same scoring system should apply for all audits, it should contain an appropriate scoring scale that notices and motivates potential improvements and it should require the auditor to comment and motivate the given scores.

An appropriate way of administrating and documenting audits in a *consequent* way was found. The audits should contain a clear schedule for the different steps, tasks and documents used in an audit. The audit responsibilities should also be clearly communicated. The documentation of an audit should be administrated through a global database.

A competent auditor should have both process and audit knowledge. However, an appropriate level of *competence* is hard to decide on. In the ABB case, the general opinion is that the auditors' process knowledge is big but that the auditors lack in specific audit competence. By providing internal audit training for the auditors, the appropriate level of holistic competence could be achieved.

Keywords: Supplier auditing, supplier relations, supply chain, risk

## Sammanfattning

- Titel:** Att bibehålla och förbättra leverantörsrelationer med leverantörsbedömningar  
– En studie på ABB Sverige och Singapore
- Författare:** Elisabet Ericsson och Elisabet Wahlstedt
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- Bakgrund:** I dagens globaliserade värld är många företag beroende av stora leverantörsnätverk. Goda leverantörsrelationer kräver underhåll och ett verktyg för detta är att utföra leverantörsbedömningar. ABB är ledande inom kraft- och automationsteknologier och hjälper industriella kunder att öka sin prestanda och samtidigt minska sin miljöpåverkan. ABBs affärsdivision Process Automation (PA) och affärsenhet Control Technologies (CT), tillsammans förkortat som PACT, har etablerat nära relationer med många av sina leverantörer. Detta betonar vikten av att utföra leverantörsbedömningar, eftersom en leverantörsrelation innebär ömsesidigt beroende mellan parterna. ABB PACT måste kunna lita på en kontrakterad leverantörs prestanda, medan leverantören måste kunna lita på ABB som en stark och långsiktig kund. Nyckelspelare inom leverantörsbedömningar på ABB PACT uttrycker att det finns utrymme för förbättring av leverantörsbedömningsprocessen.
- Syfte:** Syftet med detta examensarbete är uppdelat i två delar. Första delen är att undersöka om det finns potential för förbättring av ABBs leverantörsbedömningar både i Sverige och Singapore. Den andra delen är att ta reda på hur processerna för leverantörsbedömningarna skulle kunna förbättras.
- Genom att introducera generella problemformuleringar som inte fokuserar på specifika fall, kan resultaten i detta examensarbete även bidra till akademien.
- Problemformulering:** Studien kommer att svara på följande frågor för att nå syftet:
- Frekvens*
- Vad är en lämplig *frekvens* av leverantörsbedömningar för att bibehålla och utveckla leverantörsrelationer?
- Mått*
- Vad är en lämplig design av ett *mätssystem* som förenklar och motiverar förbättringar hos leverantörer?



### *Konsekvens*

- Vad är ett lämpligt sätt att administrera och dokumentera revisioner på ett *konsekvent* sätt för att förenkla informationsutbyte och kommunikation mellan revisorer?

### *Kompetens*

- Vad är en lämplig *kompetensnivå* för revisorer så att de kan utföra effektiva leverantörsbedömningar och hur kan en sådan kompetensnivå uppnås?

**Metod:** I detta examensarbete används en blandning av ett system- och aktörsangreppsätt. Systemangreppsättet innehåller både kvalitativ och kvantitativ data och aktörsangreppsättet används eftersom många personliga åsikter har haft stor betydelse i den här studien. Vidare används en abduktiv forskningsmetod, eftersom resultaten är härledda från en kritisk granskning av värden och observerade processer. Främst kvalitativ data från intervjuer och en enkät används i studien. Enkäten och ifyllt audit-material bidrar även med kvantitativ data. Datainsamlingen består av en litteraturstudie, intervjuer, en enkät och en fallstudie.

**Slutsats:** Första delen av syftet är att undersöka om det finns potential för förbättringar av ABBs leverantörsbedömningar i Sverige och Singapore. Denna studie visar att sådan förbättringspotential finns vad gäller en policy för när en leverantörsbedömning ska göras, betygssättningen i leverantörsbedömningsmallarna, standardiseringen av leverantörsbedömningsprocessen och kompetensnivån bland revisorerna.

Den andra delen är att ta reda på hur processerna för leverantörsbedömningarna skulle kunna förbättras. En förutsättning för att förbättringsförslagen ska vara användbara är att det finns en tydlig organisation som ansvarar för leverantörsbedömningarna. Följande förslag är författarnas rekommendationer för hur mer konsekventa, effektiva och förmodligen bättre leverantörsbedömningar kan erhållas:

- Det bör finnas tydliga instruktioner att årligen uppdatera leverantörs-KPIer samt att resultatet av uppdateringen visar tydligt om en leverantörsbedömning behöver göras det kommande året eller ej.
- Alla leverantörsbedömningsmallar bör använda samma betygssystem med en godkändgräns i betygsskalan vid 50% och varje betygssatt fråga bör kommenteras och motiveras.
- Varje leverantörsbedömningsguide bör innehålla en så kallad Gantt chart som tydligt visar vilka aktiviteter som ingår i leverantörsbedömningen och vilka dokument som ska användas i de olika stegen.

- Det bör alltid vara tydligt bestämt vem som bär ansvaret för aktiviteterna före, under och efter leverantörsbedömningen.
- Alla leverantörsbedömare bör erbjudas auditutbildning.

Följande resultat återkopplar till problemformulering.

Slutsatsen dras att en lämplig *frekvens* av leverantörsbedömningar inte kunde hittas. Istället visar resultaten att det är viktigt att implementera och tydligt kommunicera en policy som säger att en leverantör behöver bedömas eller inte. Om inte en sådan policy är implementerad ännu, bör det ske och kommuniceras tydligt.

Slutsatsen dras att en lämplig utformning av ett *mätssystem* kunde hittas. Samma betygssystem bör gälla för alla leverantörsbedömningsmallar och bör bestå av en lämplig betygsskala som visar förbättringspotential. Mätningssystemet bör även kräva att leverantörsbedömaren förklarar och motiverar givna betyg.

Slutsatsen dras att ett lämpligt sätt att administrera och dokumentera revisioner på ett *konsekvent* sätt kunde hittas. Leverantörsbedömningsmallarna bör innehålla ett tydligt schema för vad som ska göras när och vilka dokument som ska användas. Ansvarat för de olika uppgifterna bör vara tydligt kommunicerat och dokumentationen av leverantörsbedömningarna bör ske med hjälp av en global databas.

Det är tydligt att en *kompetent* leverantörsbedömare bör ha både processkunskap och specifik revisionskunskap. Genom att erbjuda revisorerna utbildning inom leverantörsbedömning bör en lämplig kompetensnivå kunna nås.

Nyckelord: Supplier auditing, supplier relations, supply chain, risk

## **Abbreviations**

AML: Approved Manufacturer List

BD: Business Division

BOM: Bill of Material

BU: Business Unit

CAP: Corrective Action Plan

CEN: European Committee for Standardization

CoPQ: Cost of Poor Quality

CT: Control Technologies

DCS: Distributed Control System

EHS: Environment Health and Safety Assessment

EMS: Electronic Manufacturing Services

EPC: Engineering Procurement Constructions

ISO: International Organization for Standardization

KPI: Key Performance Index

LBU: Local Business Unit

MTO: Made to Order

MTS: Made to Stock

N/A: Not applicable

OHS: Occupational Health and Safety

OTD: On-time Delivery

PA: Process Automation

PACT: Process Automation Control Technologies

PAQ: Process Audit Questionnaire

PCBA: Printed Circuit Board Assembly

PLC: Programmable Logic Controller

PPM: Parts Per Million

R&D: Research & Development

SC: Supply Chain

SCM: Supply Chain Management

SIS: Swedish Standard Institute

SQP: Supplier Qualification Process

TQM: Total Quality Management



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# 1 Introduction

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*The aim of this chapter is to explain the background and purpose of this Master Thesis. Also, a short introduction to ABB is given, including the business division, business unit and product that the authors have been working with. Furthermore, the research questions that the Master Thesis is built upon are presented as well as the approach of the study.*

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## 1.1 Background

This Master Thesis started with discussions with ABB Sweden and Singapore regarding risk in their supply chain. Soon, the issue of single source components and what risk those imply was brought up.

ABBs power and automation portfolio is divided into five business divisions: Power Products, Power Systems, Discrete Automation and Motion, Low Voltage Products and Process Automation. Of interest in this Master Thesis is the division of Process Automation (PA), which includes the business unit Control Technologies (CT). The business division PA and the business unit CT are abbreviated as PACT.

The ABB business unit CT currently has around 500 single source components, meaning that there is only one supplier who manufactures the component. Due to the risks that single source components can imply, it is of high importance to ABB that their suppliers are reliable in terms of different aspects, such as quality, on-time delivery, etc.

The discussion of risk in the supply chain soon changed focus from the risk of single source components in general to supplier relationships and how well functioning supplier relations could be created and maintained in particular. One way of preventing interruptions in the supply chain, maintaining a high-performing supplier relationship and improving the performance is to evaluate the supplier by conducting audits.

ABB PACT has around 450 suppliers and with many of those, they have established close and long partnerships. This emphasizes the importance of conducting audits, since a supplier partnership imposes mutual dependence between the parties. ABB has to be able to rely on the contracted supplier's performance, while the supplier has to be able to rely on ABB as a strong and long-term customer.

Even though ABB has centrally developed audit questionnaires and emphasizes the importance of performing supplier audits, different actors within PA Sweden express that there is a need to improve this part of the supply chain organization.

Based on that, the authors decided to focus the study of the audits and the audit processes at ABB, business division Process Automation (PA) and business unit Control Technologies (CT), to identify the improvement potentials.

With the traditional responsibility for the supply chain lying in Sweden, supplier audits have up until this moment been performed in Sweden. However, the distribution center of the control system Freelance has changed its location from Västerås in Sweden to Singapore. Singapore was chosen due to

the location's advantages regarding the closeness to the Asian market, the stable political situation and the logistical hub that Singapore is. As a result of the reorganization of the distribution of Freelance, the responsibility for the different parts of the supply chain naturally changes. This means that conducting supplier audits is a new task for ABB PACT Singapore. By highlighting the experiences and issues that ABB Sweden has faced in the past when conducting audits, ABB Singapore could learn from experienced auditors and avoid facing the same issues and that way, get a "jump start" when initiating the audit work. (ABB 1, 2012) (K.1, 2012) (S., 2012)

The findings in this Master Thesis therefore have potential to help both ABB Sweden and Singapore in managing and maintaining their supplier relations.

## **1.2 Company background, ABB**

"ABB is a leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact." ABB stands for "Power and productivity for a better world". (ABB 1, 2012)

ABB PA is one of the largest suppliers of solutions to the process industries. (ABB 1, 2012)

### **1.2.1 ABB Control Technologies**

Process Automation is a business division helping customers from a variety of sectors to make their processes more efficient. Within the division PA, there are nine business units. Control Technologies (CT) is the biggest business unit. CT is in charge of the design, supply and distribution of products offering the appropriate level of control and safety for process and power automation needs in all types of industries. The products offer a unique possibility to hold and connect the data from the production processes with other information systems within the company and make the information available in real time. (S., 2012)

As displayed in figure 1 below, 800xA, Advant, and Freelance are the three control systems that have the largest shares of the turnover of the products within the business unit CT.

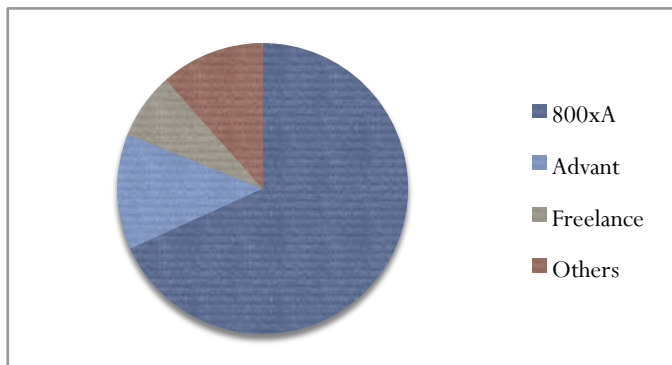


Figure 1: ABB PACT products and turnover (I., 2012)

Product line	KUSD
800xA	180,841
Advant	34,151
Freelance	19,395
Others	30,731

800xA is the most powerful of the control systems. Advant is an older model and Freelance is a model not as powerful as 800xA but suitable for smaller industry applications. (ABB 2, 2012) (C.1, 2012) (I., 2012)

### 1.2.2 Freelance

Freelance is a control system for process automation that combines a distributed control system (DCS) with a programmable logic controller (PLC). It enables easy operation and diagnostics of engineering, commissioning, maintenance and fieldbus management, used for connecting automation equipment and PLC. Characteristically for Freelance is its cost-efficiency in combination with its simplicity in use while providing powerful automation. (ABB 3, 2012) (ABB 4, 2012)

## 1.3 Purpose

The purpose of this Master Thesis is:

- To find out whether there is improvement potential of the audit processes at ABB PACT both in Sweden and Singapore;
- To find out how the audit processes could be improved.

By introducing generic research questions that do not focus on a specific case, this Master Thesis has potential to contribute with findings for the academy in general as well.

## 1.4 Research questions

In order to find out the improvement potentials of the audit processes at ABB PACT, the following four research questions will be answered:

### *Frequency*

- What is an appropriate frequency for conducting supplier audits in order to maintain and develop supplier relations?

### *Measurement*

- What is an appropriate design for a measurement system that facilitates and motivates for improvements?

### *Consistency*

- What is an appropriate way of administrating and documenting audits in a consequent manner in order to facilitate information sharing and communication between auditors?

### *Competence*

- What is an appropriate level of competence for auditors in order to conduct efficient audits and how can it be achieved?

## **1.5 Delimitations**

This Master Thesis focuses on the ABB business unit Process Automation and the business division Control Technologies and the control system Freelance, and these are therefore the main delimitations of this study.

In the Freelance product family, there are many different parts and components. When conducting the supply chain mapping, it was chosen to look at the heart of the Freelance system, which is the controller AC 800F. This delimitation is both necessary and relevant since the scope would be too big otherwise. Also, since the controller AC 800F can be configured in a large number of different varieties, the supply chain mapping displays the simplest control system that can be built. Within a future project, the supply chain mapping performed in this Master Thesis could be enlarged to integrate further modules and varieties of the control system.

Also, it was chosen only to investigate ABBs four audit templates and processes even if other process varieties might exist. Those four processes were chosen because they were presented to the authors as the four most important and most frequently used audit processes.

## **1.6 Limitations**

The time frame of 20 weeks for completing this Master Thesis posed a time limitation for the scope of the study. Furthermore, it was sometimes difficult to schedule interviews and telephone conferences with ABB employees due to their other working tasks. Of course, the authors understand the situation, but it has nevertheless put a limitation on the data collection in this Master Thesis. It also proved to be difficult to receive old audit material; different ABB personnel were asked and reminded regarding the data. In the end, it was possible to get two complete audit cases, as is further explained in the chapter Empirical phase II.

## 1.7 Target group

This Master Thesis is primarily aimed to be relevant for people involved in the supply chain organization working with supplier audits at ABB PACT in Sweden and Singapore. The findings in this Master Thesis can be applied to the work of experienced supplier auditors, as well as beginners within the area.

With the generic research questions presented in chapter 1.4 above, this Master Thesis will also investigate supplier auditing from a general perspective. This will make the study relevant for students within the area as well. Another potential target group of this Master Thesis is organizations from the same sector as ABB as well as other industries that perform supplier audits.

## 1.8 Approach

The approach in this Master Thesis can be explained with figure 2 below. The basis of the study was built at ABB Sweden. With the information on how the audit work is performed in Sweden, the authors investigated the situation in Singapore. That, combined with the theory, gave the basis for finding the improvement potentials in the audit process and also what those improvements could be. That resulted in recommendations for a kind of “best practice” process for auditing.

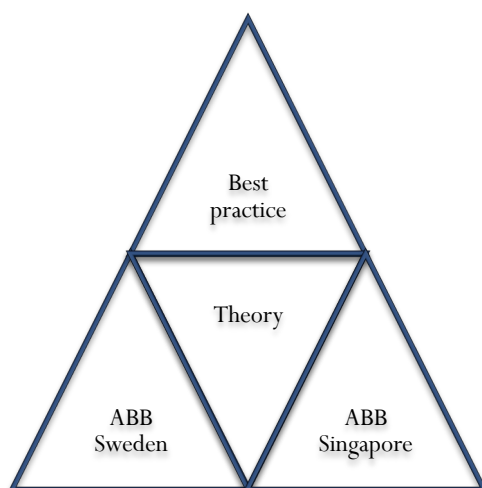


Figure 2: The approach of the study

The work was divided in the following way:

- *Empirical phase I*  
After having formulated the problem, purpose and objective with the Master Thesis, interviews were held and information gathered at ABB Sweden.
- *Analysis phase I*  
With the information gathered during Empirical phase I, it was possible to perform a first analysis resulting in four feedback areas, derived from the research questions presented above. These areas were used as the more detailed research questions in the remaining steps.

- *Empirical phase II*  
At ABB Singapore, the second empirical round took place. The data collection was focused on finding material that proved or disproved the feedback areas from Analysis phase I. The data collection mainly consisted of material from filled-in audit cases, audit templates as well as the feedback on a survey sent out to people involved in the supplier audits at ABB.
- *Analysis phase II*  
With the data gathered from the Empirical phase II, the four feedback areas could be proved or disproved. The second analysis also resulted in recommendations for how ABB PACT can improve the audit process.

The approach in this Master Thesis is visualized in figure 3 below.

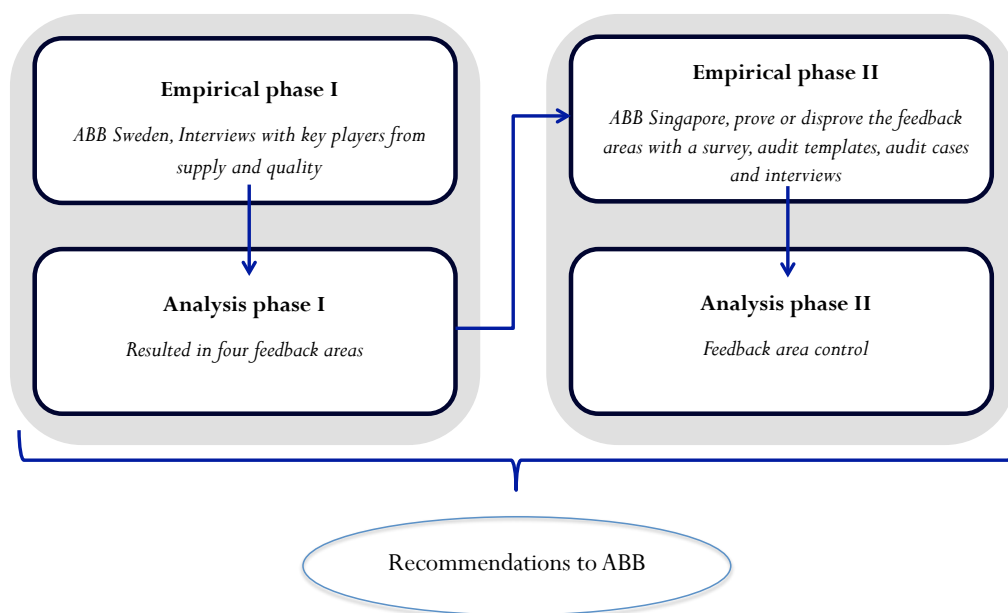


Figure 3: The approach in this Master Thesis

The authors have cooperated in all parts of this Master Thesis.

## 1.9 Reading instructions

The instructions are supposed to help the reader of this Master Thesis to find the parts that are most relevant to him/her.

The reader who wants to get the *academic background* of the study should, prior to the other chapters, read:

- *Chapter 1 Introduction*  
The background for this Master Thesis is presented, as well as the research questions and purpose of the study.
- *Chapter 2 Methodology*  
The methodology used for the study is explained.
- *Chapter 3 Theoretical framework*



The theory that composes the basis for the study is presented; risk, supply chain mapping, quality, purchasing, single sourcing, supplier partnership management, and auditing.

- *Chapter 9 Conclusion*

The concluding chapter reconnects to the research questions, comments on the credibility of the study as well as suggests further study and academic contribution.

The reader who is more interested in the *ABB case* should focus on reading:

- *Chapter 4 Empirical phase I*

The first empirical chapter presents the findings from the study performed at ABB PACT Sweden. Basic facts about the supply chain organization at ABB PACT are presented, as well as the processes used for the supplier audits.

- *Chapter 5 Analysis phase I*

The first analysis chapter presents the four feedback areas, which are the result from analyzing the empirical study performed at ABB PACT Sweden.

- *Chapter 6 Empirical phase II*

The second empirical chapter presents the findings from the study performed at ABB PACT Singapore. Here, data is gathered in order to prove or disprove the feedback areas. This chapter consists of feedback from a survey regarding auditing and a review of old audit material and the audit templates.

- *Chapter 7 Analysis phase II*

The second analysis chapter presents a thorough analysis of the four feedback areas. Each feedback area results in suggested recommendations for how to improve the audit processes. The recommendations are prioritized using a recommendation implementation matrix.

- *Chapter 8 General reconnection to ABB Business*

The Master Thesis is here reconnected to the ABB case regarding the PA SCM corner stones and the ABB SCM vision.

The *hurried reader* who is interested in the *findings and recommendations* should read:

- *Chapter 4.6 Summary of Empirical phase I*

Empirical phase I is the first empirical study performed at ABB PACT Sweden. Here, the main points from the chapter are listed, including facts about the supply chain organization at ABB PACT as well as the feedback on the processes used for the supplier audits.

- *Chapter 6.3 Summary of Empirical phase II*

Empirical phase II is the second empirical study performed at ABB PACT Singapore. Here, the main data and response on each feedback area are listed.

- *Chapter 7 Analysis phase II*

The second analysis chapter presents a thorough analysis of the four feedback areas. Each feedback area results in suggested recommendations for how to improve the audit processes. The recommendations are prioritized using a recommendation implementation matrix.

- *Chapter 9 Conclusion*

The concluding chapter reconnects to the research questions, lists the recommendations proposed to ABB PACT, comments on the credibility of the study as well as suggests further study and academic contribution.

## 2 Methodology

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*In this chapter, the methodology of how to perform a research study is explained. Also, the methodology chosen for this Master Thesis is presented.*

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### 2.1 Scientific approach

The way of gathering knowledge from a scientific perspective could be explained as a characteristic of *how* the knowledge process is performed. The difference between scientific knowledge and non-scientific knowledge lies within the structuring and systemization that take place when gathering data and developing knowledge with a scientific approach. However, the method itself does not guarantee that the work is scientific. The scientific criterion depends on how well the deeper parts of reality are revealed. (Holme & Solvang, 1996)

Every researcher has his/her own approach on how to study the reality and to perform research. However, there are general classifications to be found regarding the theme. Arbnor and Bjerke present three different research approaches; the analytical approach, the systems approach and the actors approach. (Arbnor & Bjerke, 1994)

#### 2.1.1 Analytical approach

The analytical approach to the knowledge gathering is based on a logical and mathematical outlook. The approach finds the results from an analytical analysis to be universal and valid and that they do not change. All other results are supposed to be subjective according to the analytical approach.

The analytical approach is based on models, which can be explained to be an image of the objective reality. These models are often based on quantitative elements. The approach is based on the view that true knowledge can only be obtained from observing the reality.

A problem can be divided into sub-problems. With the analytical approach, the different sub-problems all sum up to the total of the whole problem, symbolically showed in figure 4 below. The analytical approach can simplified be explained as the techniques that the knowledge owner would use. (Arbnor & Bjerke, 1994)

A supplier audit team could be described illustratively when using the analytical approach. According to this approach, the audit team would consist of the most experienced quality manager, the most experienced supplier manager, the most experienced production manager etc. without considering how well they work as a team.

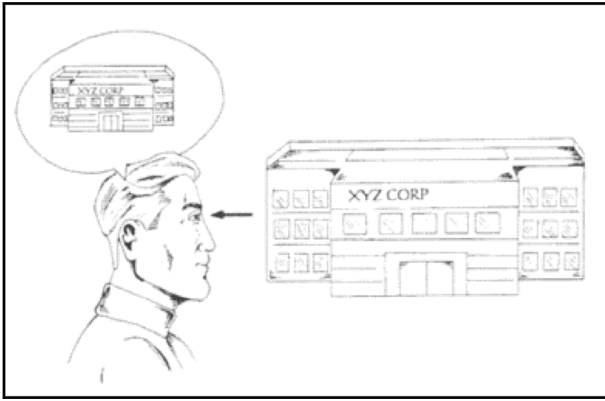


Figure 4: A symbolic description of the analytical approach (Arbnor & Bjerke, 1994)

### 2.1.2 Systems approach

A systems approach to a problem, as a scientist would describe it, can be outlined with five considerations on a basic level:

1. The objectives of the total system, and the whole system's performance measures;
2. The fixed constraints in the system's environment;
3. The system's resources;
4. The system's components, activities, goals and performance measures;
5. The system's management.

The main objective of having an overall systems view is that it will construct a logic place where to begin. Many mistakes have been made when thinking in a subsequent way about a system and once the true objectives of a whole have been ignored, the final result will never have a total systems perspective.

A system, where there are independencies between parameters, calls for a research method that considers the interrelations. The systems approach considers synergy and assumes that the sum of its parts not necessarily is equal with the whole, as is visualized in figure 5 below.

The systems approach typically uses linking and mapping methods for analysis and uses models, recommendations and case studies as a basis for the theoretical and empirical studies. Both qualitative and quantitative research methods are commonly used. The systems approach has a holistic view and the links between the different parts are considered equally important as the parts themselves. (West Churchman, 1968)

With the systems approach, synergies are considered. A problem can be divided into sub-problems where different parts can sum up to a total greater than the individual problem itself. (Arbnor & Bjerke, 1994)

Returning to the audit team. With a systems approach, the focus is now on the relationship between the team members and how well the team works as a whole rather than their individual skills. The supplier who is the auditee, the audit procedure and other external factors are taken into consideration as well.

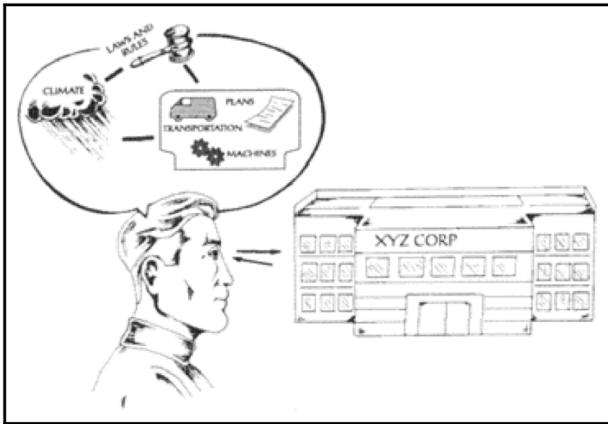


Figure 5: A symbolic description of the systems approach (Arbnor & Bjerke, 1994)

### 2.1.3 Actors approach

The actors approach, unlike the analytical approach and the systems approach, is based on the view that things change with the individual; terms and definitions are ambiguous and reinterpreted continuously. The approach finds that the basis for true knowledge is the subject signification and the ambiguous view is therefore essential as well as desirable.

The actors approach can simplified be explained as the determination of the signification, meanwhile the other two approaches are based on definitions.

The approach's focus on the actor as an individual being intentional is important. The importance is within understanding the individual as the acting, reflecting and creating person he/she is, and not induced by external factors where he/she is usually explained as a component with systematic attributes. This is why the approach focuses on *actions* rather than *behaviors*. An illustrative visualization of the actors approach can be found in figure 6 below. The actions focus gives the actor an active role, and the behavior focus gives the actor a passive role. (Arbnor & Bjerke, 1994)

The actors approach would imply that the selection of the audit team would focus on finding team members with the desirable auditing skills and team spirit. The leader of the team also plays an important role; the team changes depending on the leader.

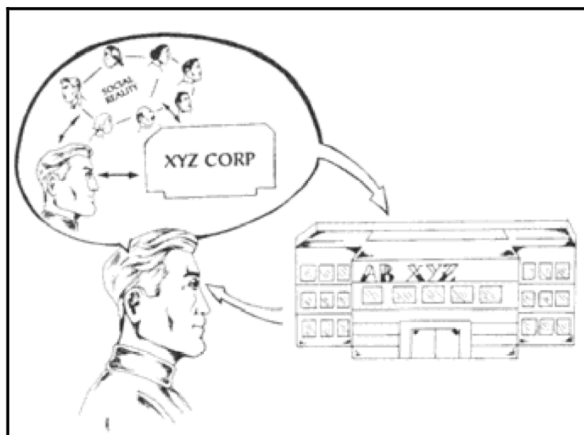


Figure 6: A symbolic description of the actors approach (Arbnor & Bjerke, 1994)

## 2.2 Research strategies

The data collection method can be divided into two general groups evaluated closer in the chapters below. Which method to choose or a combination of both lays the foundation for the data collection approach and how to draw conclusions from that data.

### 2.2.1 Inductive, deductive, abductive methods

Qualitative and experimental research strategies are based on two forms of human thinking; deductive and inductive.

The deductive method is based on accepted, general principles and ideas. Those are then used to explain a specific action or phenomenon.

The inductive method is usually applied when using a qualitative research approach. This method is based on general rules growing or evolving while observing single events or phenomena.

Figure 7 below shows the procedure from fact to theory through the inductive method, followed by the procedure from theory to predictions through the deductive method.

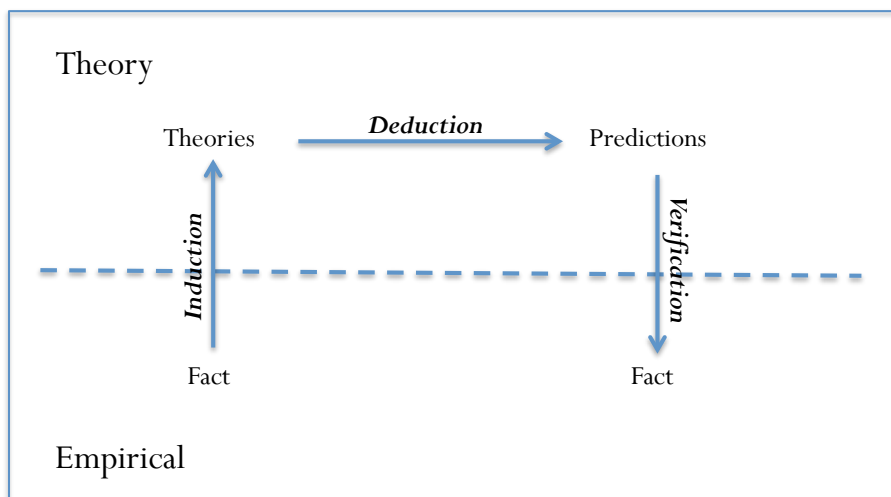


Figure 7: From fact, to theory and predictions back to fact (Arbnor & Bjerke, 1994)

In figure 7, the horizontal line separates the empirical world, which is full of facts from the theoretical world, which is quantitatively built up. The world below the line symbolizes the knowledge, which we gain through testing, observation and interviews. The world above the line symbolizes mathematical formulas, systematically gathered data and logical sequences. Three steps are differentiated in the figure. The first step is induction where general rules are derived from single events, meaning that a theory is built based on factual knowledge. Thereafter the researcher has to ask him/herself the question whether the theory actually covers what was supposed to be found. That is done by returning to the empirical world to control the theory. In order to control a general theory, specific cases have to be considered. The researcher also has to ask himself/herself what the general theory says about the future development. That step is called deduction, which is a scientific method where it is investigated what the general theory can say about single events in the future. Thereafter it is possible for the

researcher to return to the theory to investigate whether he/she was right in his/her predictions, which is the final step called verification. (Arbnor & Bjerke, 1994) (DePoy & Gitlin, 1999)

Logic consists of two parts; formal logic and informal logic. The formal logic is the symbolical logic and the informal logic is the critical thinking. In the abductive approach, a pattern in a phenomenon is found and based on that, a hypothesis is suggested. That way, abduction is a way of thinking critically, thus a form of informal logic. This means that through the abductive approach, one hypothesis among several others can be suggested and explained to be the correct one, even though the formal logic might suggest something else. With this approach, predicted values are compared with received or observed values and the most plausible value is selected. (Yu, 1994)

### 2.2.2 Quantitative and qualitative and methods

Collected data can be divided into quantitative and qualitative data. Quantitative data can be counted or classified in units such as number, share, weight, colour etc. and is of high formalization and structure. Statistical analyses are performed to process the received data. Qualitative data has a low degree of formalization and is expressed in words and descriptions, which are analysed based on the researcher's perception and interpretation.

When studying a chosen field of interest, often a complex and diverse reality is faced. Therefore it is important to choose different kinds of data collection methods, expressed by Holme and Solvang as "Not only what can be counted counts." It can therefore be advantageous to use a combination of qualitative and quantitative methods, since they can complement each other. (Holme & Solvang, 1997)

The similarity of the two methods is that they have the same purpose. Both methods aim at delivering a greater understanding of our society and how different aspects in it influence each other. Table 1 below displays some characteristics of qualitative and quantitative methods. (Holme & Solvang, 1997) (Höst et. al., 2006)

Quantitative methods	Qualitative methods
1. Little information about many research units; broad approach.	1. Much information about few research units; deep approach.
2. Systematically and structured observations, such as surveys with fixed answering alternatives.	2. Unstructured and non-systematic observations, such as interviews without fixed answering alternatives.
3. Interest in the common, average or representative.	3. Interest in the unique or divergent.
4. Interest in single variables.	4. Interest in connections and structures.

Table 1: Quantitative and qualitative methods (Holme & Solvang, 1997) (Höst et. al., 2006)

As can be seen in the table, the quantitative and qualitative methods differ in many ways. In general, the quantitative methods are suitable for big data collections with structured and systemized information. The qualitative methods are suitable for smaller data collections with unstructured and non-systemized information.

## 2.3 Data collection

To perform a comprehensive data collection is essential in order to get a good research basis. The theoretical framework covers relevant theories within the area. Interviews and case studies can provide more details on particular issues on a more company specific level.

### 2.3.1 Literature study

A literature study from a research point of view is a process of investigating how important the own field of study is, how it matches with the already existing research and how it could contribute with further findings. The literature study helps the researcher to develop his thoughts and bring the process forward towards a delimitation of the problem, such as a specific issue or question.

The literature study is important for four main reasons:

1. To determine what prior research that has been performed regarding the subject;
2. To determine the level of the knowledge and theory development within the area;
3. To determine the relevance of the existing knowledge basis within the area;
4. To determine a logical basis for the choice of research strategy.

(DePoy & Gitlin, 1999)

### 2.3.2 Interviews

“The danger of too much flexibility is just as obvious as the truth in the argument that to give to everybody shoes of size 8 is to give the same thing to everybody, yet with different effect”. (Galtung, 1967)

The quote above states the difficulties there are with both quantitative and qualitative interviews. Quantitative interviews are like giving everybody shoes of size 41, meaning that everyone gets the same instructions. However, the big flexibility there is when performing qualitative interviews can also be a problem. In a qualitative interview, the communication between the interviewer and the interviewee is much like a normal conversation, with the interviewer only deciding the theme for the conversation. During qualitative interviews, there is not a standardized questionnaire being followed. The aim of such an interview is for the interviewer to pan for relevant information without steering the interviewee. With qualitative interviews the interviewees can mention and bring up many different aspects of the same issue or area. Performing qualitative interviews is a time-consuming way of gathering data. Each interview lasts between one and three hours, and depending on the situation the number of interviewees differ. This gives the interviewers a delicate problem when handling the information and bringing it together.

Before selecting who will be invited to an interview, a thorough review of *what* the interview should reveal and contribute with is essential. This is a so-called *pre-theory*; a plan for what to do and how to do it, with flexibility in mind – things will change during the interviews. The purpose of the qualitative interviews is to increase the information value and construct a foundation for deeper understanding and more complete perceptions of the phenomena that is being investigated. The selection of whom to include in the investigation must not be performed randomly, but systematically from predefined criteria. Strategically this could mean to select the *extreme* cases in order to get a wider range of variation of the material.



With the flexibility that comes with this method of data collection, the possibility of returning to the interviewees with more questions and requests for clarification is great. Interviews are therefore normally included in the information phase as well as the analysis phase of a project. (Holme & Solvang, 1997)

### **2.3.3 Case study**

The case study is a detailed and deepened description of a specific unit, individual or incident. The data is then gathered during a longer time period. Historically, the case study was treated as inferior to other methods regarding knowledge generating. However, during the last 20 years, the case study has gotten its revenge and is now a respected data collection method.

The most known *case* is an individual. However, there are many other potential cases to study; organizations, events, societal environments, or specific groups. The case study is a useful tool when:

- One is interested in investigating a phenomena in its natural environment;
- One wants to support and develop theory;
- One wants to get deeper understanding of a case, individual or event, which is atypical, different, or impossible to study otherwise.

When using the case study, the main focus is not to generalize but to draft or support a theory with empirics.

In a single case study, the individual, group or event is studied only once. In multiple case studies, several cases are studied more than once. In the multiple holistic case study, a global unit is studied more than once and for different parts within the unit.

The selection between a single case study and a multiple case study depends on what the result is supposed to be. If the purpose is repetition, the multiple case study is the most suitable. If a single case is of extra interest, the single case study is the most suitable. (DePoy & Gitlin, 1999)

### **2.3.4 Survey**

The survey is an efficient form of gathering information from a big sample of people using the same method. The survey is suitable when a specific behaviour or information is to be investigated or described. A survey is a structured list of questions and assigned space for answering them. Surveys can be performed both by oral and written answers. The oral survey is conducted like an interview when the person in charge of the survey asks the interviewee the questions listed on the survey, and also the answer alternatives. The main advantages with the oral survey, is that the survey can be clarified as the question-and-answer session proceeds. Also, it is less likely that the interviewee finishes before all questions are answered. However, conducting oral surveys require more time from the person in charge of the survey than sending out a written answer-survey.

Surveys can include both pre-defined answer alternatives to choose from and open answers. When asking for quantitative data, pre-defined answer alternatives can be used. Questions including “how much”, “how often”, “how long” are suitable for a pre-defined scale or answer alternatives. Less precise

questions are more suitable for open answers. This qualitative data collection can be administrated in two ways. Either by leaving space for comments on the questions or by asking the questions formulated as statements and asking the interviewee to grade them according to how well the statements correspond to his/her own opinion.

When sending out a survey, it is important that the sample of people is selected with care. If the group of people, potential for the survey, is small, the best selection is to ask everyone to complete the survey. If the group is big, representatives have to be selected. This selected group of representatives to whom the survey is sent is called sample group. Gathering the answers from the sample group, conclusions can be drawn about the whole group of people.

The selection of the sample group can be made in different ways. *A random sample* is chosen with the help of a random-number generator, generating a sample group that is a subset of the whole group. *A systematic sample* chooses every N individual or unit to be a part of the sample group. *A stratified sample* first defines a number of categories or *strata* and thereafter selects a sample group from these categories. If the sample group includes all individuals or units, it is *a complete sample*.

The survey is a data collection of *fixed design*. It is not appropriate to change, add, remove or reformulate questions after the survey has already been sent out. Therefore, it is important that the survey is well prepared and tried on a reference group before it is sent out to the real sample group. The results from the reference group must not be included in the data collection, but the comments on the formulation of the questions should be taken into consideration.

If the survey originates from a hypothesis, the answers from the survey can help in the work of performing a hypothesis testing. This includes testing a hypothesis in relation to an alternative hypothesis in order to be able to reject one of the hypotheses. (Höst et.al., 2006)

## **2.4 Credibility**

Credibility is a combination of reliability, validity, and representativeness, and expresses to what extent the research can be trusted, is valid and can be generalized.

### **2.4.1 Reliability**

Reliability expresses to what extent the study's results can be trusted. If the same result is achieved with every repetition of a specific measuring with the same variables and circumstances, the results are of high reliability. It can be of great importance to determine the reliability of an instrument that is used for measuring in order to be sure that variations in the test results come from real changes and not the measuring instrument. (DePoy & Gitlin, 1999)

The data collection and analysis of it has to be performed thoroughly in order to achieve high reliability. This can be done by constantly reporting how the work has proceeded. Feedback from interviewees on consolidated data can ensure that the data has been understood correctly. Statistic methods are central in the analysis of qualitative data. Another important factor is the selection of the data source, i.e. the selection of interviewees. (Höst et. al., 2006)

### **2.4.2 Validity**

Validity addresses the connection between the object to be investigated and what is actually measured. Triangulation can be used to raise the validity, meaning that different methods, types of data or people can be used in order to broaden the studies.

Validity is a measure of systematic, non-random errors, while reliability is a measure of random errors in the measuring. Validity can be related to three different aspects – content, criteria and term. (Höst et. al., 2006)

Content validity addresses the degree to which an instrument seems to reflect the main content in the field or phenomena of interest. This type of validity, which is seen as the most basic validity, is sometimes also referred to as face validity. In order to achieve high face validity the following should be included in the study:

- Thorough literature study should give a specification of the complete scope of a used term.
- Specific items should deliver an adequate representation of all aspects of a used term.

A selection of items that reflects each aspect can be performed if all aspects of a term are known to the researcher.

Content validity faces two common problems. Firstly, a possible lack of clear and complete term definitions. Secondly, the lack of a generally accepted objective method for defining to what extent a test has reached an acceptable level of validity. Letting a panel of experts review the items that have been constructed can be a possibility to ensure a higher degree of validity.

Criteria validity expresses the correlation between a standard or an instrument that have proven to be exact and reliable, and the test of interest. The two types of criteria validity that are differentiated are simultaneous and predictive validity. Simultaneous validity is characterized by the existence of a known, standardized test that measures the term of interest. If the purpose of using an instrument is to predict or to determine the existence of an event or action, predictive validity is used.

Term validity is used when the researcher has developed a theoretical basis of an instrument. To get supporting evidence for the connection between the instrument and related variables, the researcher approaches different steps, which consist of the different types of validation, i.e. content and simultaneous, as stated above. Term validation is the most extensive and complex type of validation. (DePoy & Gitlin, 1999)

### **2.4.3 Representativeness**

Representativeness expresses to what extent the results can be generalized. It is highly dependent on the selection of data sources. Strictly seen, it is only possible to generalize results to the population that have delivered the basis of the selection of data. Ensuring that pre-selected data is received can raise the representativeness. If the context that is to be generalized very much reminds of the context of the performed study, the probability that the object of interest would behave similarly in the new context increases. Increased representativeness can be achieved by a thorough description of the examined context. (Höst et. al., 2006)

## **2.5 The methodology in this Master Thesis**

### **2.5.1 The scientific approach in this Master Thesis**

Due to the systematic nature of logistics and supply chains, the systems approach is popular for studies within the field of logistics and supply chain management. Supply chains, as they are set up today in a global world, consist of many different actors, locations and relationships that are linked together. Even though it is possible to divide a supply chain into different parts to study individually, it is essential to keep the holistic view at all times. The systems approach includes both qualitative and quantitative data collection and is a natural choice of scientific approach for this Master Thesis.

When using the systems approach, it is important that the system has a clear limitation. Therefore, a sharp definition of the studied areas is essential, which is explained in chapter 1.5 Delimitations.

Besides the systems approach, also the actors approach is used, since many personal opinions have played an important role in the study.

### **2.5.2 The research method in this Master Thesis**

The study performed in this Master Thesis is based on both received data and observed patterns and procedures. The natural choice of research method for this study is therefore the abductive method, see chapter 2.2.1. The study results are derived from critically evaluating a combination of obvious values and observed processes, which is the most efficient way of performing a research study of this type.

Mostly qualitative data from interviews and a survey is used. The survey and old audit material also contribute with some quantitative data. Therefore, a combination of qualitative and quantitative methods is used.

### **2.5.3 The data collection in this Master Thesis**

The data collection methods in this Master Thesis are a literature study, interviews, a survey, and a case study.

### 3 Theoretical framework

*In this chapter, the theory that is the basis of this study is presented. First, an overview of the concept risk management is presented. Thereafter, the risk discussion is narrowed down to focus on the theory behind supplier auditing.*

#### 3.1 Risk

A company is exposed to many different kinds of risks. Within the supply chain, being dependent on suppliers for the supply of goods is one of them. By identifying the risks and also learning how to manage them, the risks can be reduced or even mitigated. A company's supply chain is often large and involves many different actors and activities. In order to find where the risks are located within the supply chain, supply chain mapping is a useful tool. Single source components and other types of risky relationships with suppliers can be visualized by mapping the supply chain.

Within the purchasing process, supplier relationships are developed. In order to evaluate a supplier relationship and its performance, supplier auditing is another useful tool. By having a proactive approach towards the supplier relationship, many risks can be eliminated just by reacting on weak signals. Auditing can be performed with a proactive attitude, making it a natural part of the supplier relationship. There are different ways of performing supplier audits. The International Organization for Standardization (ISO) has checklists for how an audit should be performed according to their standard.

##### 3.1.1 Risk management

“Risk Management – the variety of activities undertaken by an organization to control and minimize threats to the continuing efficiency, profitability, and success of its operations.” (Coyle et al, 2010)

The process of managing risk consists of four major steps: risk identification, risk analysis, risk control, and risk reporting. In figure 8, the Deming wheel is illustrated describing the theory of risk management as a cycle of planning the risk identification, analysing the risk based on the findings from the risk identification, checking and controlling the impact of the risk, and finally acting by reporting and monitoring the established risk control. (Coyle et al, 2010) (Kliem & Ludin, 1997)

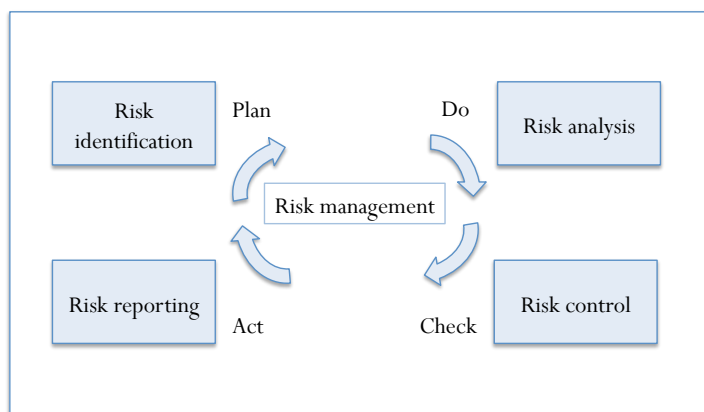


Figure 8: The Deming wheel, risk management process (Kliem & Ludin, 1997)

The risk management process includes the following aims:

- Define the scope and the key objectives of the risk management process.

- Identify risk issues by gathering data, performing brainstorming sessions and interviews.
- For each identified risk, allocate responsibilities to provide further details on background, consequence, and management information.
- Grade each risk on a *likelihood* and *potential impact* scale.
- Compare the risks in order to prioritize them from urgent *management attention* to *less important*.
- Develop an implementation framework for action plans and responses for each risk and monitor the effectiveness of the actions.
- Construct a process map, allowing for re-evaluations of the risks and new risk identification activities.

By implementing the above-mentioned objectives in the risk assessment work, the risk management process has the potential of structuring the work and constructing a high-performing process. (Kliem & Ludin, 1997)

### **3.1.1.1 Risk strategies**

There are different risk strategies that an organization could use in order to handle risk. There are four main risk strategies:

- *Risk avoidance*  
In order to avoid a risk, the activity causing it could be avoided. This strategy provides absolute avoidance of the risk but it also excludes the potentials that the activity might bring to the organization.
- *Risk mitigation*  
Some risks cannot be avoided, since the activities causing them are essential for the organization to function. However, the likelihood of the risk can be reduced. When reducing a risk, it might be at the expense of a cost increase due to changes in the risk management.
- *Risk transference*  
Some risks are too complicated for an organization to mitigate on its own. In such situations, the organization can seek external assistance and transfer the whole risk or parts of it on a third party. The third party is paid or in other forms compensated for sharing or taking the risk.
- *Risk acceptance*  
One of the options for risk treatment is to accept the risk. For a risk of low probability and small impact if occurring, an organization can therefore choose to retain it. Other risks might need more attention.

Depending on what risk the organization is exposed to, the suitable risk strategy should be chosen. (Coyle et al, 2010)

### **3.1.1.2 Risk categorization**

There are different types of risk. A risk can be everything from non-acceptable non-manageable risk to long-term positive risk. In order to understand what and how a detected risk will affect the business, it is important to understand the risk itself. There are many ways of categorizing risk:

- *Positive risk vs. negative risk*

Positive risk has a positive impact on the situation, more known as *opportunity*. Positive risk is a risk that should be increased as much as possible.

Negative risk has a negative impact on the situation. Negative risk is a risk that should be eliminated or at least reduced as much as possible.

- *Acceptable risk vs. non-acceptable risk*

Acceptable risk is a risk that does not harm an organization and its business significantly, e.g. something that affects the tasks that are not on the critical path. Non-acceptable risk has a significant impact on the project or organization, stopping or harming the business, e.g. something that affects the tasks that are on the critical path.

- *Manageable risk vs. non-manageable risk*

The process or project owner, whom the risk is affecting directly, might be able to turn the risk into a manageable risk. A non-manageable risk is a risk that the process/project owner cannot handle on his/her own, for example a cut in budget from a higher level in the organization.

- *Short-term vs. long-term risk*

Short-term risk, as it is self-explained, is a risk on a short-term basis. Long-term risk is a risk on long-term basis.

- *Internal vs. external risk*

Internal risk is unique to a process or project, and is caused by something inside the process/project boundaries. External risk is a risk, which the internal organization/project/process does not control.

When the category of the risk is determined, it is also useful to know the root cause of the risk. The root cause investigates the source of the risk and the main risk factors. Generally, project risks arise from three sources:

1. *Factors that are under project control*

For example management systems, contractors' performance, design.

2. *External controllable factors that are under the control of decision makers elsewhere*

For example government policy, political will, institutional governance.

3. *External uncontrollable factors*

For example natural disasters, technology changes, political instability, inflation, changes in price structure.

### **3.1.1.3 Risk assessment**

An organization is affected differently by a risk depending on what type of risk it is and what source it has. Performing risk planning is essential in order to control the situation, independent of the type and source.

When assessing the risk, there is normally a common approach that is used, as can be seen in figure 9 below.

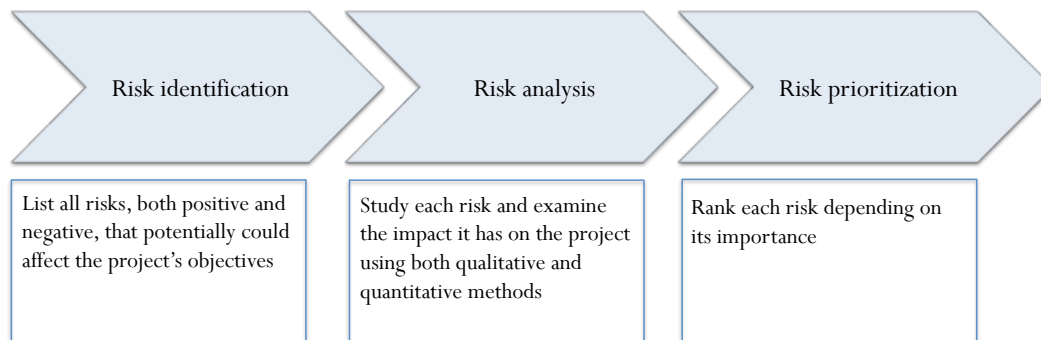


Figure 9: Risk assessment (Gardiner, 2012)

Risk identification is the activity of identifying all risks that potentially could have an impact on a case, project etc. It is also important that the documentation of the risks is understandable for all parties and performed in a structured way. Risk is often identified in areas of business impact and benefits, project management, organizational impact, technical risks and complexity, logistics, production and testing.

A useful way of identifying risks is to gather a group of key people who brainstorm and take notes on all risks that the specific case or project could be exposed to and thereafter classify them as *low impact risk*, *medium impact risk* or *high impact risk*.

The aim of prioritizing the identified and analysed risks is to emphasize where further actions are needed and which risks to mitigate; negative risks, and which risks to enhance; positive risks.

#### 3.1.1.4 Risk exposure

The comparison between the different risks is important in order to distribute the resources effectively. The prioritization list should provide a proactive and holistic perspective and should include the following six elements:

- *Likelihood of the risk occurring* – low, medium or high;
- *Impact of the risk* – impact on cost, performance, benefits, schedule;
- *Frequency of the risk*;
- *The importance of the risk in relation to other risks*;
- *Exposure* – probability and impact;
- *Cost and resources required to modify the risk*.

Once the probability of the risk and the impact of the risk have been determined, the risk exposure factor can be calculated:

*Risk exposure = probability of risk \* impact of risk*, also displayed in figure 10 below.



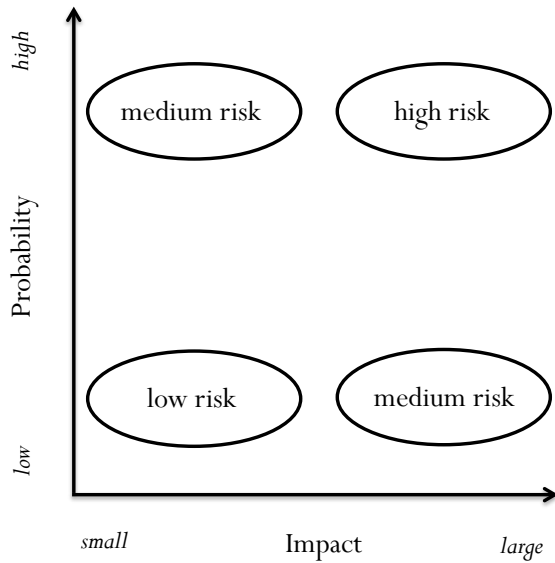


Figure 10: The risk exposure matrix (Gardiner, 2012)

The risk exposure matrix illustrates an overview of the risk depending on its probability and impact. If the risk is considered to occur with low probability and, if occurring, would have a small impact, the risk is considered low, which is showed in the lower left corner. If the risk has low probability of occurring but with large impact, the risk is considered medium as can be seen in the lower right corner. With a high probability of occurring and a small impact, the risk is also considered medium, see the upper left corner. If a risk has high probability of occurring and has a large impact if occurring, the risk is considered to be high, which can be seen in the upper right corner.

*Risk appetite* can be explained as the organization’s policy on how to handle the risks. If the risk appetite is high, the organization is willing to accept a bigger risk. If the risk appetite is low, the organization focuses on minimizing the risk as much as possible. The objective with the risk analysis is not to eliminate all risks, but to find a balance between risk exposure and risk appetite, each organization being a unique case. (Gardiner, 2012)

### 3.2 Supply chain mapping

A tool for understanding how and where a process is exposed to risk and other factors is to conduct a process mapping. When mapping a manufacturing or service process, the process is broken down into a series of basic steps. Each step in the process has its own name, and is described by the equipment, staff, resources, information flow and the time allocated to it.

In a supply chain, there are many actors and activities involved. To conduct a supply chain mapping is therefore a complex task. However, to visualize the chain’s processes can help in understanding where the organization is exposed to risk and other dangers, and where changes would result in the biggest improvements. A supply chain mapping gives an overview that can simplify the handling of difficulties within the supply chain organization. Quality is such a matter. The map provides a chance to trace errors backwards in the chain, which for example facilitates the procedure for managing deviations in quality performance.

The supply chain mapping concept can also be used for other, simplified, types of mapping. The concept is a helpful tool for visualizing a process in order to make it clearer and easier to understand how and where different activities occur in a process. (McLane & Wood, 2009)

### **3.3 Quality**

Supply chain risk can be derived from different factors. One is the risk of quality discrepancies.

Quality is a complex concept. Not even experts agree on about how to achieve quality. To some, quality is a technical matter, strongly linked to engineering. To others, it is a statistical measure to achieve process control. A third view is that quality depends on motivation and management engagement in creating that motivation. Quality cannot be expressed in a single one of these terms, but has a combination of technical, statistical, motivational and managerial characteristics. An interaction between all four quality aspects is needed in order to perform sufficient quality management.

One way of explaining quality is the degree to which material conforms to specifications. The company can claim that the product quality is high if the conformance is high. It is though still possible that a product that has been designed strictly according to specifications can have poor functionality. This means that it is possible for a product to be objectively of high quality but subjectively of low quality.

This imposes that high quality products need to:

- Conform closely to specifications;
- Satisfy consumer expectations, needs and requirements.

This also indicates that a product's quality can be too high. Meaning that the conformance and performance is very high but the customer does not demand a product of such high quality as being offered. This also means that two customers appraising the quality of the same item can have very different opinions about it.

Naturally, the specification of the purchased material depends on the kind of material ordered, such as raw material or parts. Purchased parts include semi-finished items that will be processed further and finished materials that will become components of finished items. Usually, purchased parts are specified with graphic descriptions, such as engineering drawings, including dimensions, finishes, hardness etc. Something that opens the door to misinterpretation, due to the lack of specification, is when the supplier is given a prototype with a request to finish a product as similar as possible to it. (W.C. Benton, 2007)

#### **3.3.1 Total quality management and purchasing**

Total Quality Management (TQM) is a continuous improvement process and requires the integration of production, planning, marketing, engineering, distribution and field service. Through involving the whole organization, it reaches much wider than the traditional quality view. It is an innovative way of thinking and implementing requiring the following:

- Defining the mission;
- Identifying systems output;
- Identifying customers;
- Negotiating customer requirements;
- Developing a “supplier specification” that simplifies the details regarding customer requirements and expectations;
- Determining the necessary activities required to fulfil those requirements and expectations.

Firms are recently moving towards establishing long-term strategic relationships with their suppliers. In order to compete in today’s competitive markets, the suppliers have to be involved in an early stage of the firms product design and development and they need to be provided with performance feedback and suggestions. Reduced transaction cost can be achieved by a long-term relationship between suppliers and manufacturers. A problem with establishing long-term relationships can be that the supplier may gain increasing power in the supply chain. A reaction to this can be to have one key supplier and other backup suppliers. Usually, the firm works closely with the key suppliers and they are involved in the manufacturer’s product development and get large volume orders. While backup suppliers get a small volume of business and have a rather loose relationship with the manufacturer, the key suppliers have a bigger volume of business and a close relationship with the manufacturer.

The quality assurance system of the supplier must match the in-house quality requirements of the customer. Naturally, the stated expectations of the customer must meet the supplier’s minimum level of performance. Should the target expectations not be achieved, the system must be programmed to rapidly respond such that it can return to the agreed quality targets. (W.C. Benton, 2007)

### **3.3.2 Quality target commitment**

It is necessary to specify the agreed-upon quality targets. The following issues should at the minimum be addressed before signing a purchasing contract.

1. *Parts per million (PPM) target agreement*  
The PPM value is determined by the number of rejected parts, divided by the parts delivered, multiplied by 1 000 000.
2. *Field failure and reliability requirements*  
It can be difficult to precisely quantify field failure. Therefore there should be no defects in the field.
3. *Warranty agreement*  
In case of a field failure, there should be a warranty agreement covering all the costs caused by the field failure, such as parts, repair and handling cost.
4. *Urgency to solve problems*  
It is vital to have a quick solution to any quality variance. Usually, customer satisfaction is directly related to the speed with which the solution is achieved.

It is the design and purchasing departments in an organization that make the first decision on what quality performance the product that reaches the end customer will have. The raw material, components or semi-finished products that the supply department provides the rest of the organization

with, set a certain quality standard. In the contracts with the suppliers, it is therefore essential that clear quality target commitments are stated. To follow up that the supplier's quality performance is as high as expected is also an important task. (W.C. Benton, 2007)

### 3.3.3 Quality surveillance

To some people, inspection means to sort out the good from the bad. What it really should be is an active process for preventing errors, defects and deviations by using a proactive approach.

Having a system, which is based on the detection of bad quality and erroneous processes and products using a post-production detection method, is a costly and inefficient way of handling the quality control. The key is prevention. The strategy should include a "how-am-I-doing"-attitude, with a focus on controlling the process continuously. This type of inspection should therefore be performed by the operative personnel and not a separate "quality police force" focusing on detecting the problems afterwards. It is essential that the quality improvement measurements, are accepted by the involved personnel and that the results are never used for illustrating how bad one individual or team performs. The emphasis when performing inspections and measurements is to be on how it can help to correct potential problems and improve the processes.

An important part of the inspection is to measure inputs, outputs and the actual processes. A system that is not measured is hard to know anything about. On the contrary, a process that is measured is also possible to control. In order to control a system or process, the first step is therefore to measure it. Measuring all activities, equipment, materials etc. will make it possible to define target values and to focus on reaching those.

When designing a measurement system, it is important to understand whom the measures are supposed to reach and how this can be achieved. Results from a measurement dedicated to the senior management of an organization are differently focused than results dedicated to the production manager of the same organization. For these decisions, it is therefore important to remember to focus on the information that is most helpful to the recipient and that can direct the recipient to the actions that are required in each specific situation. (Oakland, 1990)

There are different types of supplier assessments that companies perform. Three examples of such inspections are as follows:

- *Supplier certification/qualification programs*  
Involving long-term visits and evaluations, with a focus on evaluations.
- *Supplier development programs*  
Involving long-term visits and evaluations, with a focus on long-term training helping the supplier to improve.
- *Supplier audit*  
Supplier audits are similar to supplier qualification programs, with additional visits performed by auditor teams. The results from the audits are provided to the suppliers, with the target of helping the suppliers to ensure and improve product quality and process objectives. The development focus is emphasized.

(Foster, 2010)

### 3.4 Purchasing

A company delivering physical products to the end customer normally has to purchase the different parts of the final product from external suppliers, making the purchasing division both financially and operationally crucial for the whole business.

#### 3.4.1 Purchasing process

The purchasing function is, within the procurement activity, in charge of delivering the components to the internal customers from well-selected and high-performing suppliers. The purchasing process, as displayed in figure 11 below, visually explains how the procurement is conducted in the company.

As can be seen in figure 11, the purchasing process is divided into two sub-functions; tactical purchasing and order function. The strategic part of the purchasing process - tactical purchasing, includes the specification determination, supplier selection and contracting. The operational part of the purchasing process - order function, includes ordering, expediting and evaluation, as well as follow-up and evaluation. The transition between contracting and ordering is what divides sourcing and supply.

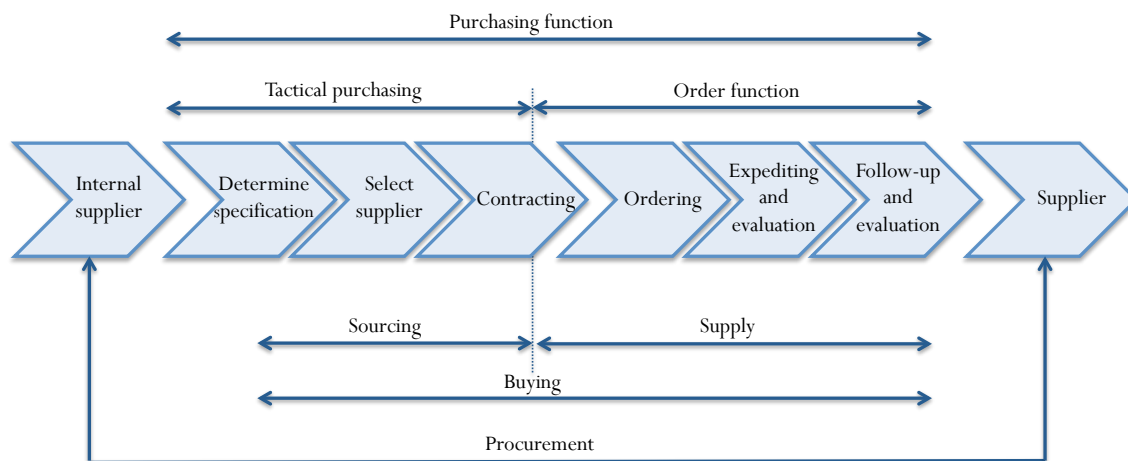


Figure 11: The purchasing process model (van Weele, 2012)

Purchasing actions have to be consistent with the company's competitive strategy. When formulating the purchasing strategy, the organization's competitive priorities, the organization's strengths and weaknesses and the competitive environment must be considered. (van Weele, 2010)

### 3.5 Single sourcing

In many organizations, it is common to have at least two approved suppliers for each purchased material, component or service. However, in some cases it is not possible, and single sourcing is the only option. Single sourcing can also be argued to create greater commitment and a partnership between the supplier and the organization that is hard to find for multi-sourced purchased goods. A single sourced component, with a close relationship with this specific supplier, requires careful management and more work in order to manage the good relationship. To work with only one supplier and build a solid basis and understanding between the two parties regarding requirements, capabilities and how to handle deviations can be argued to be much more efficient than to hop from one supplier to another.

A single source component, only sourced from one supplier, poses a greater risk in comparison with dual- or multi sourced components that spread the risk on several suppliers, see chapter 3.1. The risk exposure also measures the impact that an incident contributes with. A single source component naturally contributes with a larger impact from a risk perspective than a dual- or multi sourced component. If the supply of a complex and critical component, often single sourced, would be interrupted or stopped somewhere in the supply chain, it could have a large impact on the business.

What makes a single source component risky is mainly high complexity. That in turn leads to difficulty in finding a different supplier who can quickly produce a substitute, which is a similar but not necessarily identical product that can replace the existing product. A complex component is usually developed in co-operation with the supplier and this is often both costly and time-consuming. Therefore, such components are single-sourced to a higher extent than other components. If the design of the product is specifically invented by or for a company, it can be hard to switch from one supplier to another without a long start-up phase. Another aspect of the issue is if the production of the component requires the supplier to adjust the production processes in order to produce the specific component. Introducing a new supplier to the same complex component most likely means that changes in the processes at the supplier’s facility are necessary. That is a difficult and time-consuming process. For these reasons, single sourcing is sometimes the only option for some components. (Oakland, 1990)

### 3.6 Supplier partnership management

It is not possible for the individual members of the supply chain to function without the economic, quality and service performance of the other actors in the supply chain. Over recent decades, many businesses have begun to realize the advantages of sharing technology, information and planning with other firms. Through sharing information and planning efforts, the firms reduce uncertainty and increase control. Critical elements of a supply partnership in comparison to traditional supply relationships are listed in table 2 below.

<b>Traditional supply relationships</b>	<b>Supply chain partners</b>
Price emphasis for supplier selection	Multiple criteria for supplier selection
Short-term contracts for suppliers	Long-term contracts for suppliers
Bid evaluation	Intensive evaluation of supplier value-added
Large supplier base	Small supplier base
Proprietary information	Shared information
Power-driven problem solving	Mutual problem solving
<ul style="list-style-type: none"> <li>• Improvement</li> <li>• Success sharing</li> </ul>	<ul style="list-style-type: none"> <li>• Improvement</li> <li>• Success sharing</li> </ul>

Table 2: Comparison of the elements of two SC relationships (W.C. Benton)

In general, traditional supply relationships consist of a large supplier base with shorter contracts and a large focus on price. In the supply chain partner relations, the suppliers are selected on a wider criteria

base. The contracting is normally on a long-term basis; the supplier base for such relations is therefore smaller.

Some argue that partnerships can provide similar benefits as vertical integration through acquisition, to harness supplier expertise. Five major potential benefits of supplier partnerships are listed in figure 12 below. Below each benefit, the areas to which the benefit applies are listed.

Reduced uncertainty for buyer in:	Reduced uncertainty for suppliers in:	Cost savings in:	Time management	Shared risks and rewards
<ul style="list-style-type: none"> <li>• Material costs</li> <li>• Quality</li> <li>• Timing</li> <li>• Smaller supplier base</li> </ul>	<ul style="list-style-type: none"> <li>• Market</li> <li>• Understanding customer needs</li> <li>• Product specifications</li> </ul>	<ul style="list-style-type: none"> <li>• Economies of scale in ordering, production and transaction</li> <li>• Decreased administrative costs</li> <li>• Fewer switching costs</li> </ul>	<ul style="list-style-type: none"> <li>• Faster product development</li> <li>• Faster to market for new products</li> <li>• Improved cycle time</li> </ul>	<ul style="list-style-type: none"> <li>• Joint investments</li> <li>• Joint research and development</li> <li>• Market shifts</li> <li>• Increased profitability</li> </ul>

Figure 12: Potential benefits of supplier partnerships (W.C. Benton, 2007)

On the other hand, supply chain partnerships can retain inherent risks. The largest one being that heavy reliance on one partner can have large negative consequences if the partner does not meet the expectations. Furthermore, decreased competitiveness may result from loss of partnership control, complacency and overspecialization with an affirmed partner. Also, overestimating partnership benefits while ignoring potential shortcomings poses a common risk. (W.C. Benton, 2007)

### 3.6.1 Supplier partnership implementation and critical success factors

The partnership implementation process can be long and complicated but has to be performed thoroughly in order to ensure a successful supplier relation. The change from a traditional supply arrangement to a supplier partnership involves both an attitude and structural change.

The figure 13 below shows a guide to the implementation process.



Figure 13: Supplier partnership implementation steps (W.C. Benton, 2007)

In the first step of the partnership implementation process, the firm has to evaluate potential risks and benefits of a partnership in comparison with traditional supplier relations, in order to identify the need of a partnership. Thereafter, the criteria for the partners have to be defined, candidates are assessed and partners are selected. Then, the complete sense of awareness about the needs and participation of all involved parties has to be established, which is a very critical step in the process. Finally, once the partnership has been established, it has to be maintained to either enhance its development or bring about its dissolution.

The entire supplier partnership implementation process includes several critical success factors, the most rudiment being top management advocacy.

A list of critical success factors, connected to the different implementation steps can be found in figure 14 below.

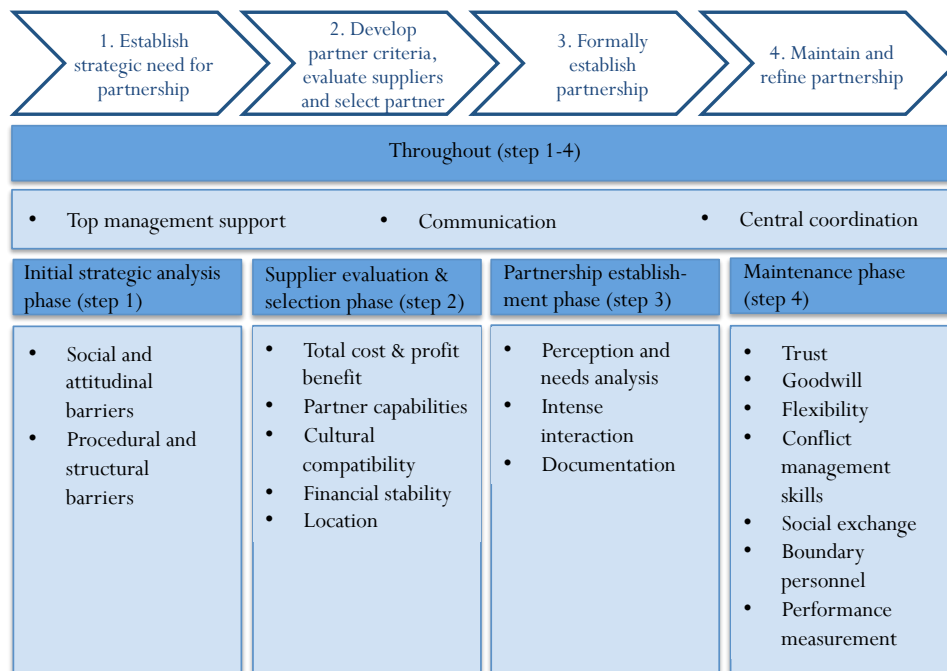


Figure 14: Supplier partnership success factors (W.C. Benton, 2007)

The most important attitudinal factors in a successful supplier partnership involve cooperation, trust, goodwill and the ability to handle conflicts while being flexible. Also, shared goals, attitude, communication and effective performance measurement are described as success factors.

If the firms are unable to work successfully, the partnership may have to be dissolved. If a firm has abandoned partners in the past, it might make future partners difficult to attract. It is therefore of high importance to investigate whether a partnership has sufficient potential prior to engaging in such a relationship.

The selection of suppliers is very important. A well-implemented supplier selection process within the supply/purchasing department increases the chances for well-functioning supplier relations. However, even after the selection phase, it is important to manage and develop the supplier relations in order to have high performing relationships between the different actors within the supply chain. (Oakland, 1990)

### 3.6.2 Supplier development

Supplier development is a process in which the buyer is involved in activities focusing on improving a supplier's performance. Examples of such activities are:

- Supplier evaluation;
- Supplier training;
- Consultation;
- Sharing data;
- Sharing processes.



When cooperating with a supplier and providing training and consultation and sharing processes and data, the chances of the supplier development to be efficient and rewarding increase.

The supplier development process consists of seven steps, as can be seen in the figure 15 below.



**Figure 15: Supplier development process (Foster, 2010)**

The first step in the supplier development process is to identify critical products and components. Normally such products or components are difficult to obtain, of high cost and/or of high volume, not seldom so-called strategic products. In the second step, critical suppliers are identified; suppliers delivering strategic products and components but not meeting quality/reliability objectives or scheduled deadlines. In the third step, cross-functional teams are formed in order to work with the supplier, starting with the fourth step of meeting with the top management at the supplier. The fifth step includes selecting key projects for the supplier to work with. The projects are chosen based on issues where there is a need for improvement and then selected depending on criteria such as ROI, impact, feasibility and required investment. The sixth step defines the project, in terms of cost and benefit sharing, commitment of resources, how to measure the improvements, accountability and deliverables. The seventh and last step focuses on monitoring the status of the development work. It is essential to monitor progress in order to revise strategies if necessary during the development process.

Many companies equalize supplier evaluation with supplier development. However, there is a significant difference; in the supplier development processes there are resources allocated for the development and improvement of the supplier, which is not the case for the supplier evaluation. Depending on how the targets are set, the benefits are also allocated differently to the parties. For example, if a buyer contributes to a 10% cost reduction at the supplier, the buyer may ask for a 5% price reduction and provide the other 5% cost reduction to the supplier as a benefit. Suppliers with successful development programs are often designated as preferred suppliers, this due to their commitment to the customer needs. (Foster, 2010)

### **3.7 Auditing**

Auditing is a tool for approving suppliers as well as ensuring continuous high performance and improvement in products, processes and systems. Audits can be performed both internally and externally and both of proactive and reactive reasons. Supplier audits are external audits performed in co-operation with the supplier who is the auditee. (van Weele, 2010)

### 3.7.1 Supplier auditing

Supplier audits are reviews of a supplier's systems and processes. Such audits are normally conducted before a supplier is fully approved but should also be used as a tool to maintain high continuous supplier relationship performance. Audits can be performed in form of:

- Visits to sites and premises;
- Questionnaires;
- Interviews with staff;
- Calculations on received data.

A combination of all four ways of conducting an audit gives a full and holistic audit result.

“The planning of the audit and review system is vital to successful cooperation with suppliers.”  
(Oakland, 1990)

It is important that both parties view audits as a contribution to a well-functioning relationship between two organizations. Also, both parties should desire to share information and be involved in the full process.

Sometimes the auditor's approach towards the supplier is more of a “policeman's” than a professional auditor. Unannounced visits and focusing on finding all problems possible at the plant will probably result in a supplier trying to hide all potential discrepancies more than be open to constructive feedback for continuous improvement, which should be the target of auditing.

A professional supplier-auditor relationship has a focus on understanding and helping each other, by for example:

- Looking at the organization with a pair of fresh eyes;
- Helping to identify system problems;
- Providing clear indication of desirable goals;
- Suggesting improvement strategies and advising on continuous performance improvement.

The on-site visit should pinpoint potential areas of improvement. The audit should also result in suggestions and advice that help rather than withdraw business if improvements are necessary. This type of partnership has potential to grow to a strong and solid relationship with smaller risks of interference.

The supplier quality audit should assess the quality and reliability of the supplier. This is most easily done by performing audits in the full producing system. The target should be to improve the four Cs:

- Communication;
- Capability;
- Confidence;
- Control.

The four Cs are a summary of the content in a supplier-contracting business relationship. By focusing on these when conducting the audits, sustainable improvements can be made. (Oakland, 1990)

Naturally, different companies use different audit processes. Even different departments within the same company use different processes. Despite this, the following ISO-auditing guideline shows how an audit is performed by the book.

### 3.7.2 ISO Guidelines for auditing according to the Swedish Standards Institute

The Swedish Standards Institute (SIS) is a member of both the European Committee for Standardization (CEN) and the International Organization for Standardization (ISO). The European Standard for guidelines for quality and/or environmental management systems auditing (ISO 19011:2002) was approved by CEN on September 9, 2002. The International Standard is a guidance tool for the management of audit programs, for the competence and evaluation of auditors and for conducting internal or external audits of quality and/or environment management systems. The standard is intended to apply to a broad range of users, while being flexible, making it possible to adapt the standard to a company's specific needs. (Swedish Standards Institute, 2002)

#### 3.7.2.1 Managing an audit program

Figure 16 below illustrates the process flow for the management of an audit program.

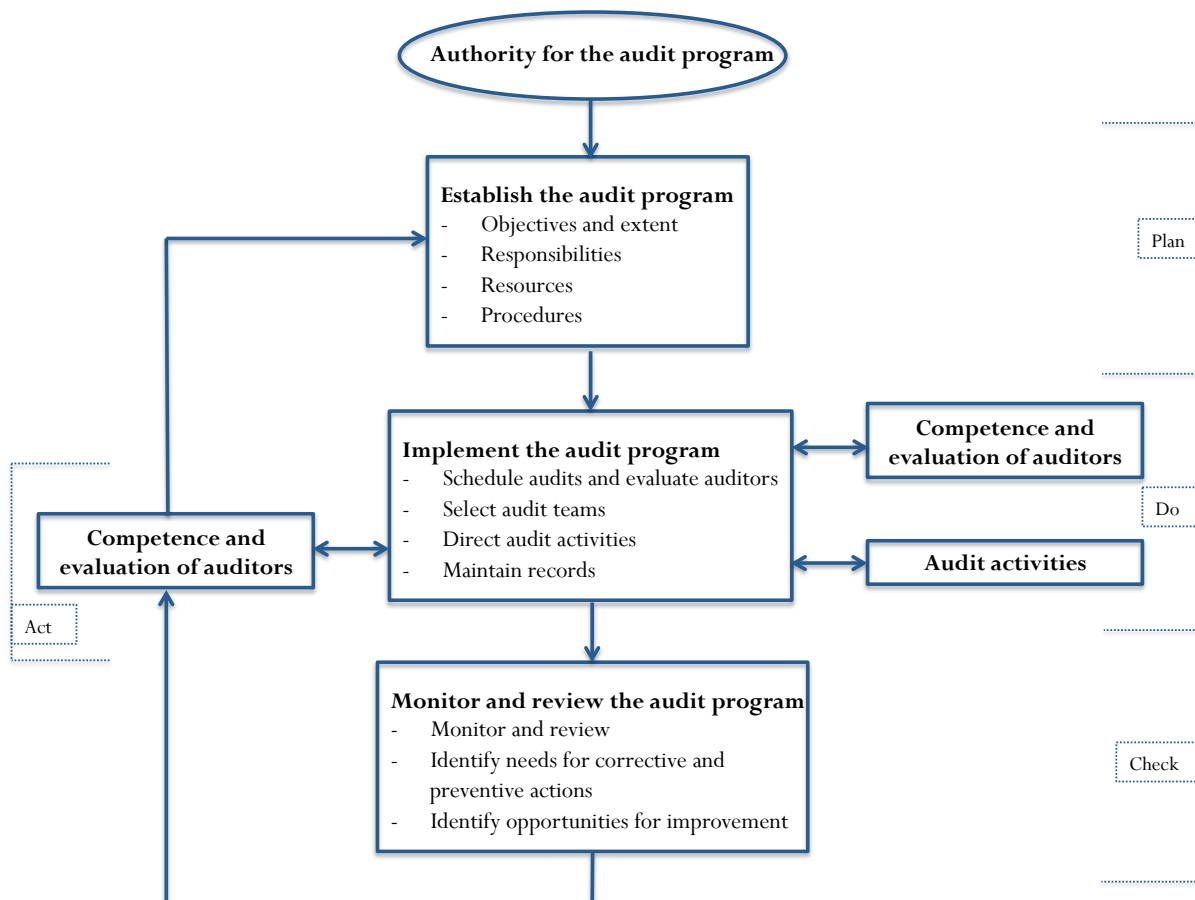


Figure 16: The process flow for the management of an audit program (Swedish Standards Institute, 2002)

The objectives of audit programs can include the following:

- To meet the requirements for certification to a management system standard;
- To verify conformance with contractual requirements;
- To obtain and maintain confidence in the capability of a supplier;
- To contribute to the improvement of the management system.

One or more individuals should be given the responsibility for managing the audit program. Those individuals should have management skills and technical and business understanding relevant to the activities to be audited as well as general understanding of audit principles.

The ones managing the audit program are responsible for establishing the objectives and extent of the audit program, establishing the responsibilities and procedures as well as ensuring that the resources are provided. The auditors should also ensure the implementation of the audit program, guaranteeing that the appropriate audit program records are maintained as well as monitoring, reviewing and improving the audit program.

The following should be addressed in the audit program:

- Planning and scheduling of audits;
- Assuring the competence of auditors and audit team leaders;
- Selecting appropriate audit teams and assigning their roles and responsibilities;
- Conducting audits;
- Conducting audit follow-up;
- Maintaining audit program records;
- Monitoring the performance and effectiveness of the audit program;
- Ensuring audit follow-up;
- Reporting to top management on the overall achievements of the audit program.

An audit process that clearly communicates the essential contents is more easily administrated and used by the auditors.

It is important to determine the feasibility of the audit, which should take into consideration:

- Sufficient and appropriate information for planning the audit;
- Adequate cooperation between auditor and auditee;
- Adequate time and resources.

Once the audit has been declared feasible, an audit team should be selected, taking the competence requirements into account. Also, by informing the supplier about the upcoming audit, he/she has a chance to prepare in advance. The audit team should send necessary documents to the supplier, as well as the questionnaires and other documents that the supplier is supposed to fill in prior to the audit. When the supplier has returned the above mentioned documents, the audit team should review the information prior to the on-site activities.

When preparing for the on-site audit, the audit team should formulate an audit plan to provide the basis for the visit.

The audit plan should cover:

- The audit objectives;
- The audit criteria and any reference documents;
- The audit scope, including identification of the organizational and functional units and processes to be audited;
- The dates and places where to perform on-site audit activities, including meetings with the auditee's management and audit team meetings;
- The roles and responsibilities of the audit team members and accompanying persons;
- The allocation of appropriate resources to critical areas of the audit.

The plan should then be reviewed and accepted by the audit team and presented to the auditee, prior to the on-site audit.

When arriving at the facility on the day of the audit, an opening meeting should be held with the auditee's management or those responsible for the functions or processes to be audited.

During the opening meeting, the audit plan is confirmed, a short summary of how the audit activities will be undertaken is provided, the communication channels are confirmed and the auditee is given the possibility to ask questions.

During the audit, the areas in the audit plan should be covered. At the end of the on-site audit, a short summary should be provided to the auditee, covering the main improvement potentials. Post audit, the audit team should review the findings from the on-site assessment and formulate a correction plan that will be sent to the supplier. The follow-up activities, including a follow-up audit to ensure that the improvement actions are implemented, are an essential part of the complete audit process and should not be neglected. (Swedish Standards Institute, 2002)

### **3.7.2.2 Audit methods**

When performing an on-site audit, there are different methods for how to collect the information that is needed. Examples of such include:

- Interviews;
- Observation of activities;
- Review of documents;
- Quantitative measures, for example evaluating failure rates, on-time deliveries, financial data or other statistics.

When interviews are conducted, there are some important factors to keep in mind. First of all, the interview should be held with persons from appropriate levels and functions performing activities or tasks within the scope of the audit. Also, the interviews should be held during regular working hours

and at the regular workplace. It is important to explain the reason for the interview and notes should be taken. Furthermore, questions that bias the answers should be avoided and the results should be summarized and reviewed with the interviewed person.

Any nonconformity with the audit criteria should be recorded and communicated to the supplier. The nonconformities should be reviewed with the auditee to obtain acknowledgement that nonconformities are understood and accurate. Any diverging opinions concerning the audit evidence or finding should be avoided and if they still remain, they should be recorded. (Swedish Standards Institute, 2002)

## 4 Empirical phase I: Supply chain organization and auditing

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*In this chapter, the ABB case is explained starting with a short description of the ABB organization. The chapter contains a supply chain mapping of a simple system within the CT product portfolio followed by an AS-IS description of the supplier audit templates at ABB. Thereafter, the opinions and experiences regarding auditing of key players within the supply and quality departments are presented.*

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### 4.1 ABB PA SCM corner stones

The objective of the supply chain management at the PA division is to secure and protect the division's sources of supply while also achieving the most favourable total cost/revenue balance as well as on-time deliveries of satisfactory quality components and products.

There are five corner stone approaches that the PA division follows:

1. Full implementation of *strategic sourcing* principles and processes;
2. Deploy *SCM policies, processes, tools and resourcing* effectively;
3. Active *supplier development*/cost of poor quality (CoPQ) reduction and sustainability deployment;
4. Active *collaboration*, commodity teams, R&D and technical community for lowest total product/project cost;
5. *SCM people development* improving knowledge, skills and behaviours.

Based on these five approaches, the work within the supply chain management is aimed towards the same goals. (ABB 7, 2012)

Supplier auditing at ABB PA addresses each of the five corner stone approaches in the following way.

1. Conducting audits is part of *strategic sourcing*, since important supplier relationships need to be managed.
2. The *policies, processes and tools* of the supplier audit should be performed as efficiently as possible.
3. The audit aims at *developing the supplier* through highlighting areas of improvement.
4. When conducting audits, the *collaboration* between both the supplier and ABB as well as between different auditors, should be improved and encouraged.
5. Finally, conducting audits encourages *people development* through audit training and experience.

Hence, supplier auditing is a necessary tool in PAs supply chain management approach and it is of high importance that supplier audits are conducted and followed up in a satisfactory manner. (B.5, 2012) (K.2, 2012)

### 4.2 The ABB PACT supply chain management vision

In 2012, ABB PACT implemented a three-year vision for the supply chain management. The vision consists of nine areas. Three of those are addressed in this Master Thesis since they are connected to supply chain risk from a sourcing and supplier relationship management perspective.

Firstly, the vision states that the CT supplier audit team should be in place, ensuring that the supplier development focusing on productivity, flexibility and quality is followed. Also, the audit team should focus on preventive quality assurance. In addition, the supplier performance should be improved by the audit team. Also, this area addresses the need to enhance the focus on environment, work environment, performance, quality and cost when conducting audits.

Secondly, the vision states that 70% of the sourcing should take place in emerging markets, which includes the development of the relations with the suppliers in emerging markets.

Thirdly, the vision states that more components should be dual sourced in order to minimize sourcing disturbances and to avoid currency exposure. (ABB 6, 2012) (E., 2012) (G., 2012)

#### 4.2.1 On-time deliveries

One way of measuring performance within the supply chain at ABB is by calculating the on-time delivery (OTD), which shows if a promised delivery time is met. The OTD measurement for PACT globally during 2011 shows that the supplier OTD was just above 81%. Meaning that the suppliers were able to deliver 81% of their products to ABB PACT on time. The OTD from PACT to their customers was 91%. (F., 2012)

More information about the ABB PACT organization can be found in Appendix A.

### 4.3 Supply chain mapping of ABB PA

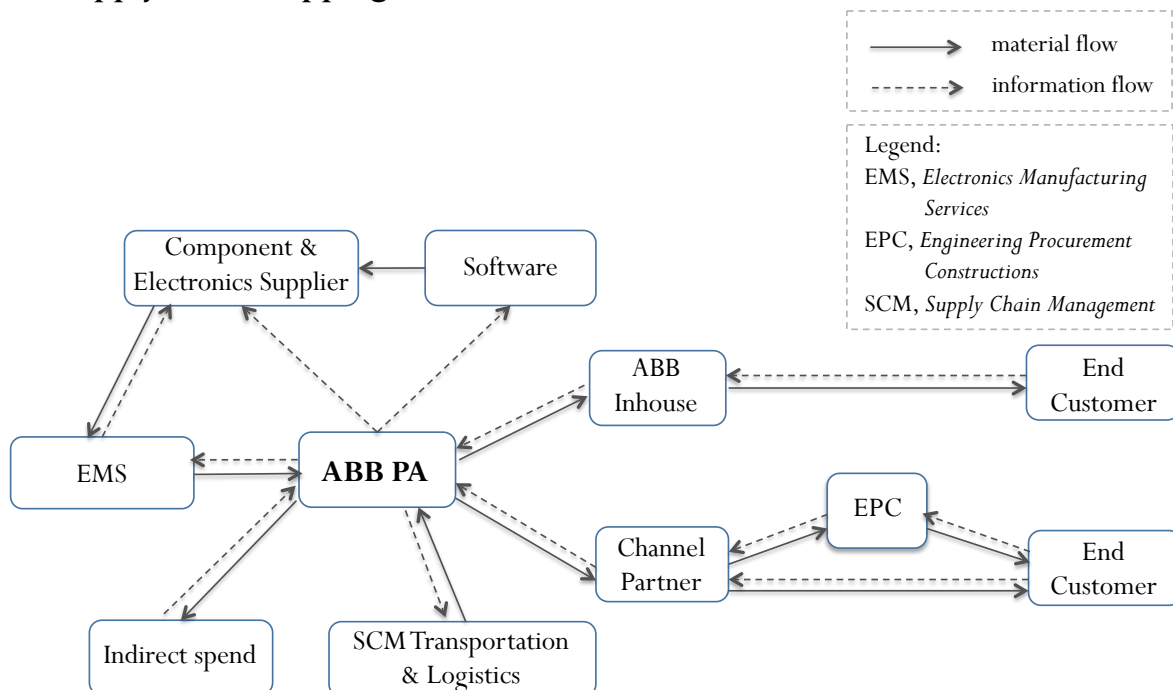


Figure 17: The supply chain of ABB PA

Figure 17 above shows the supply chain of ABB PA in terms of information and material flows between the suppliers, ABB and the customers.



ABB PAs main tier one suppliers are so called Electronics Manufacturing Services, short EMS. EMS deliver complete electronic systems to ABB, such as printed circuit boards. There is an information flow between ABB and the software, component and electronics suppliers. These suppliers deliver material to the EMS who finally supply ABB with complete electronic systems. Naturally, there is also a steady information flow between the EMS and ABB PA.

Indirect material, such as office material and transportation and logistics services are managed directly by ABB PA.

Most of ABB PAs products are bought by internal customers, i.e. other ABB divisions, and are thereafter sold to the end customer. Other products or systems are sold to channel partners who either sell the systems directly to the end customer or via so called Engineering Procurement Constructions (EPC) as visualized in the figure above. (S., 2012) (K.1, 2012)

#### 4.3.1 The supply chain mapping of the controller AC 800F

Due to the time limitation of this Master Thesis, it is not possible to perform a supply chain mapping of the entire supply chain of the control system Freelance. The SC mapping performed here could in a future project be extended to include the whole control system Freelance. It is the aim to demonstrate the supply chain of the simplest variant of AC 800F possible.

Figure 18 below displays where in the supply chain AC 800F is positioned, marked in red in the figure. In the following mapping, the control system is further investigated.

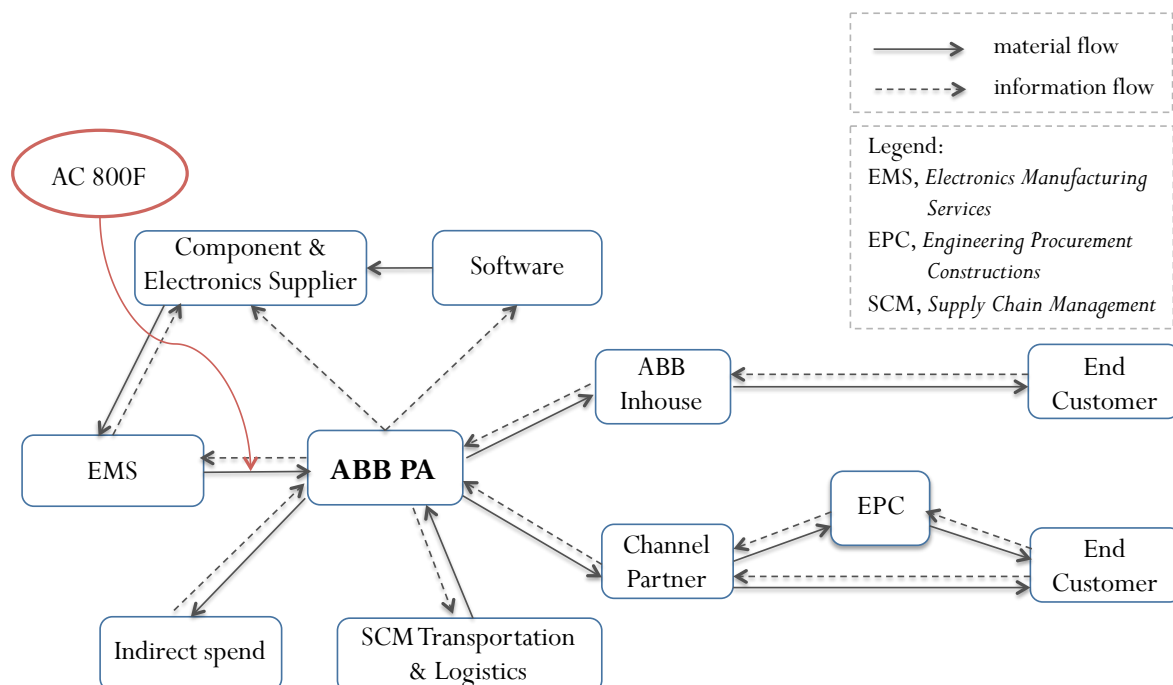


Figure 18: The supply chain mapping of ABB PA including AC 800F

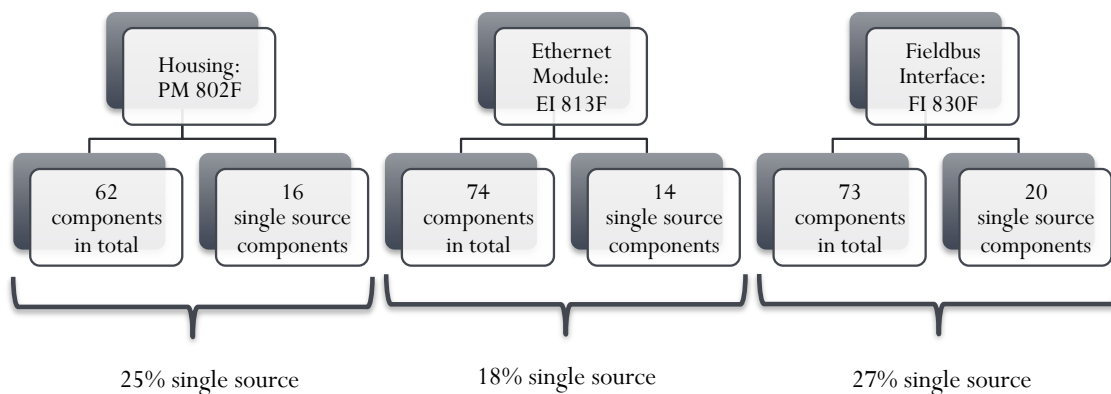
##### 4.3.1.1 Single source components of AC 800F

AC 800F is a controller that distributes process and diagnostic data. A description of the controller can be found in Appendix B.

The chosen delimitations for the mapping are explained in Appendix C.

The controller's main components Housing PM 802F, Ethernet module EI 813F and Fieldbus interface FI 830F were chosen to be included in the supply chain mapping. The bill of material, short BOM, for those three main components was investigated. From the BOM of AC 800F, it was possible to see for each component how many suppliers it has. That way it could be seen how many components that are single sourced or multiple sourced.

Figure 19 below shows the three main components and how many single source components those consist of. (B.3, 2012)



**Figure 19: The number of single source components of the Housing, Ethernet and Fieldbus**

As can be seen in the figure above, the following statistics of the main components are found:

- The Housing PM 802F has 62 components, whereof 16 are single sourced.
- The Ethernet module EI 813F has 74 components, whereof 14 are single sourced.
- The Fieldbus interface FI 830F has 73 components, whereof 20 are single sourced.

In summary, an average of 23% of the components of the controller AC 800F are single sourced.

A single source component does not automatically imply a large risk in the supply chain. In order to see the risks that the different single source components pose, a risk analysis has to be done. This Master Thesis will not cover a risk analysis and risk ranking of the different components. It will instead provide an idea of how such a ranking could be performed in the future, giving ABB the opportunity to further extend this study. This risk analysis is presented in chapter 7, Analysis phase II.

#### 4.4 Supplier audits at ABB PACT

One tool that ABB uses for measuring a supplier's performance is conducting supplier audits. Before a new supplier is contracted, an audit is conducted to ensure that the supplier's quality and capacity/capability are both in line with ABB's requirements, so called *supplier qualification audit*. Also,

by regularly performing audits, the purchasing team can ensure that the quality continuously meets ABBs standards, and handle potential issues if occurring. (K.1, 2012)

ABB uses different processes and associated templates when conducting audits, depending on the aim of the investigation. The following chapters present how an audit is conducted at ABB PACT and the four different audit templates being used today.

#### **4.4.1 The audit processes at ABB according to the audit guidelines**

The audit processes explained below is how the audit work should be performed according to ABBs audit guidelines.

Deciding when and why to perform an audit today can depend on the supplier's performance according to the Key Performance Indicators (KPIs). KPIs reflect the critical success factors of an organization. The key suppliers of PA are graded depending on their performance according to the KPIs stated below. The list ranks the suppliers and an active decision is made if and when to audit a certain supplier. The *Supplier Performance Rating* within the PA division depends on the following criteria/KPIs:

- Failure rate (DPPM, defected parts per million);
- Delivery performance (OTD, on-time delivery);
- Lead-time (measured in comparison with market lead-time);
- Cost reduction (annually measured in comparison with the prior cost);
- Cooperation (easy to do business with – commercially and technically).

The decision regarding if an audit should be conducted or not at a specific supplier should be made every year as well. The time interval from last time an audit was conducted or if there has been an incident or specific issue that needs to be evaluated can also trigger an audit. When each supplier has been evaluated based on the KPIs, it is decided whether the supplier has to be audited within the coming year. This should be done annually. (ABB 8, 2012) (B.5, 2012) (K.1, 2012) (S., 2012)

Before each audit, the focus area of the assessment has to be decided; materials handling, performance, quality, cost, social issues, code of conduct, environmental issues etc. The supplier is contacted and a date for the audit is decided. The supplier should also be informed about the focus area, what documents he/she will receive and how the supplier's performance will be graded.

The overall procedure when conducting an audit is as follows. The supplier answers a number of questions about the business in the so-called self-assessment questionnaire and grades himself/herself resulting in a self-assessment scoring. During an on-site audit, ABB answers the same list of questions that the supplier answered. The ABB questionnaire is called the qualification questionnaire, resulting in a score that reflects ABBs opinion regarding the supplier's performance. The score from the self-assessment and the score provided by ABB are compared and potential deviations are highlighted. Those deviations are addressed through giving the supplier a list of necessary improvements in form of a corrective action plan. The supplier evaluates the suggested improvements and breaks them down into a follow-up plan including improvement activities. Finally, a follow-up audit should be performed to

make sure that the deviations have been addressed and the corrective actions have been implemented. (B.5, 2012)

There are four different templates that ABB PA uses today when performing audits. ABB follows different audit processes depending on what type of audit that is to be conducted. Whether the focus is on qualifying a new supplier, investigating the environmental, health and safety issues at a contracted supplier or understanding the production processes, the audit processes are both similar and distinguished. The aim of the chapters below is to show what the four different audit processes that are used at ABB today look like. The four audit processes are *Supplier Qualification Process*, *Supplier Process Audit*, *Environment Health and Safety Assessment*, and *Sustainability Audit*.

#### **4.4.2 Template 1: Supplier Qualification Process**

The *Supplier Qualification Process (SQP)* is the process for qualifying new suppliers. It applies to all divisions, business units and local business units at ABB. It aims at ensuring that the supplier of interest satisfies ABBs requirements. The objective of the *Qualification Process* is to qualify and contract suppliers who perform on-time, on-quality and on-cost deliveries of products and services to ABB. There are a number of benefits that both the supplier and ABB can experience if the SQP is used appropriately. First of all, wasting time and other resources with suppliers who are incapable of meeting ABBs requirements can be avoided if understanding this early in the contracting process. Also, the understanding for the supplier and its capabilities can be improved as well as the cooperation between ABB and the supplier. Furthermore, by making the supplier's information available to other ABB units, the risk of an audit or other supplier evaluation activities being performed more than once can be eliminated.

A visualization of the SQP can be seen in figure 20 below. The steps in the process visualized below are the ones ABB auditors are instructed to follow when conducting an audit following the SQP.

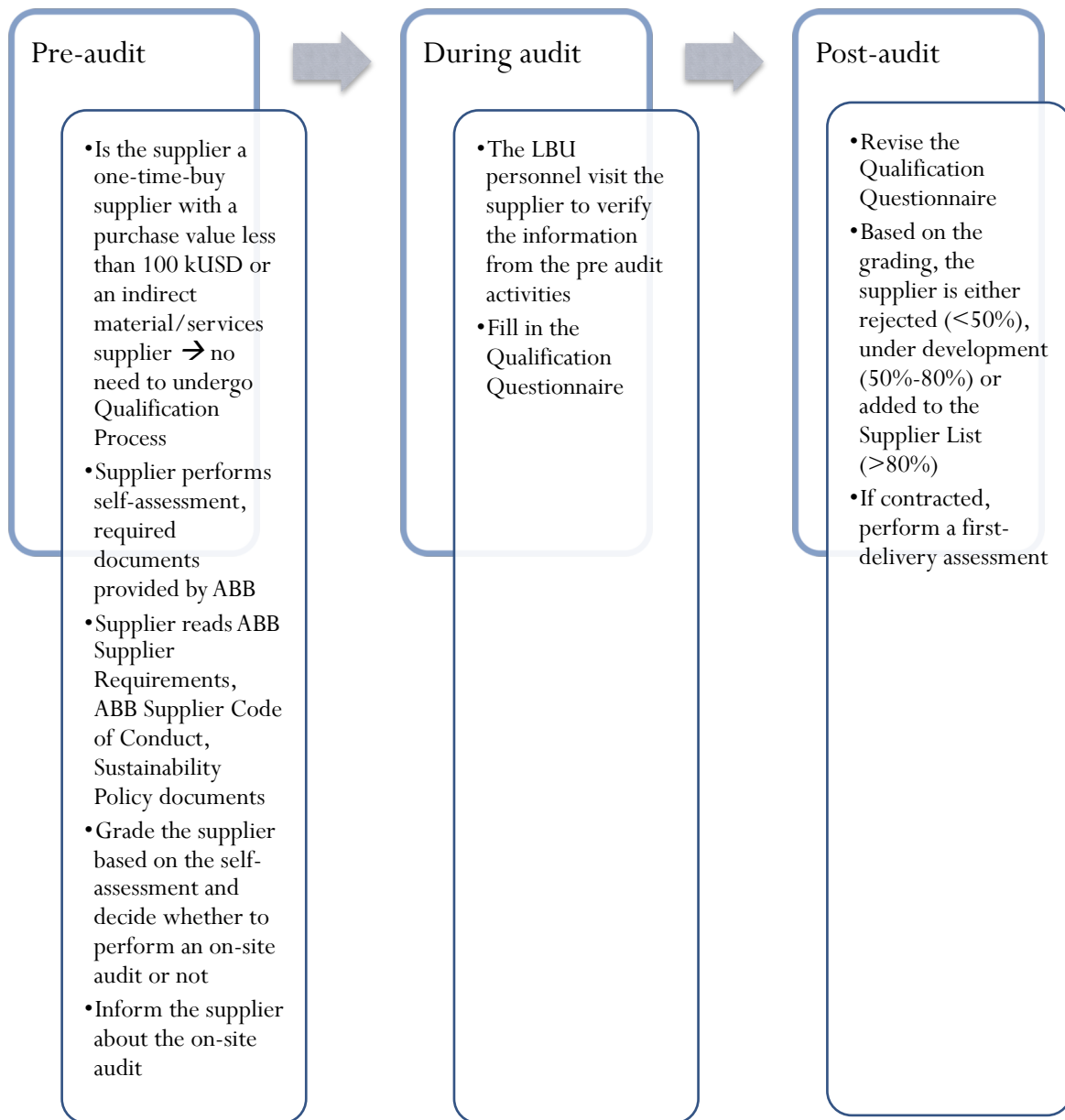


Figure 20: ABB SQP process (ABB 9, 2011)

Apart from two exceptions, all new ABB suppliers have to undergo the *Qualification Process*. The exceptions are:

- One-time-buy suppliers with a purchase value less than 100 kUSD;
- Indirect material and indirect service suppliers.

(ABB 10, 2012)

#### 4.4.2.1 SQP Audit criteria

The audit questionnaire includes the following areas:

- Company management;

- Sustainability;
- Products/Process design;
- Operational excellence;
- Continuous improvement;
- Costs.

Each area consists of questions that are graded according to the scoring guidelines explained below. (ABB 9, 2011)

#### 4.4.2.2 Scoring

In the *Supplier Qualification Questionnaire*, the supplier is asked to answer the different questions with either *yes*, *partial* or *no*. Depending on the supplier’s answers, the tool in the template calculates the score automatically. If all the answers are *yes*, the tool generates a 100% score. If all the answers are *partial*, the tool generates a 50% score. If all the answers are *no*, the tool generates a 0% score.

In case the supplier’s self-assessment score is below 50%, the supplier is rejected (step 6a). If the supplier’s score is between 50 and 80%, then the supplier is under development and will be added to the Supplier List if a continuous improvement plan is in place to reach 80% within one year. If the supplier’s score is over 80%, the supplier is added to the LBU Supplier List. (ABB 9, 2011)

#### 4.4.3 Template 2: Process Audit Questionnaire

The *Process Audit Questionnaire (PAQ)* has the purpose of verifying that the contracted supplier’s processes satisfy ABBs requirements. The PAQ is a list of questions used during the on-site audit. It is accompanied by a user guide called *Supplier Process Audit Questionnaire – User Guide*, in which each question of the PAQ is explained with remarks on *intent*, *evidence*, and *comments*.

Summarizing, the steps that ABB follows during the PAQ are visualized as in figure 21 below.

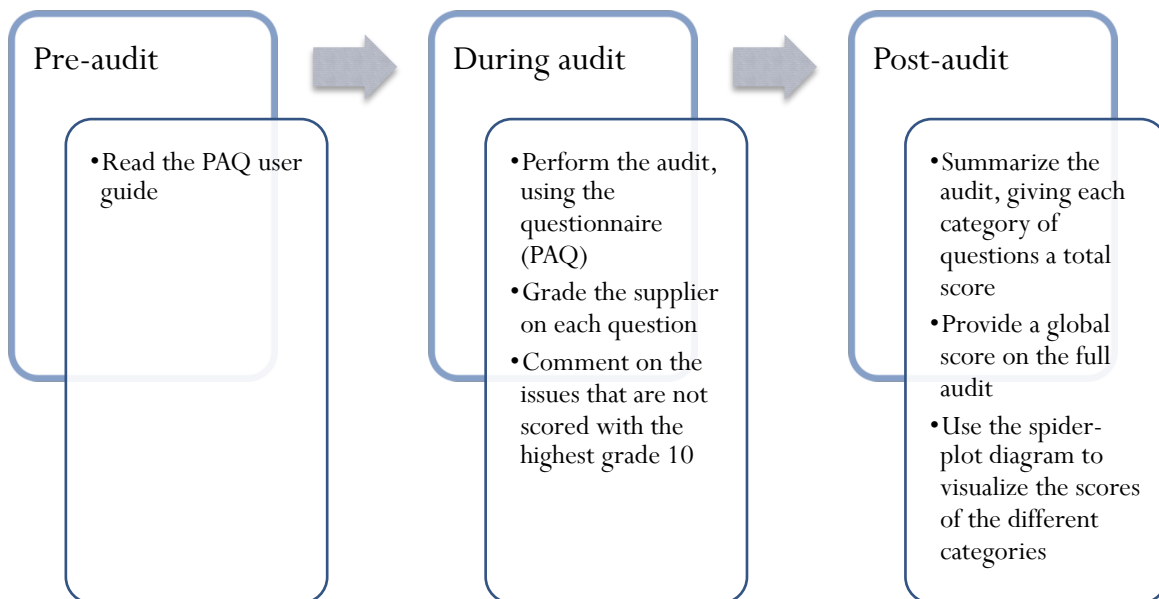


Figure 21: ABB PAQ process (ABB 11, 2012)

#### 4.4.3.1 PAQ audit criteria

The questions that are included in the audit questionnaire belong to five different areas:

- Pre-production;
- Sub-supplier management;
- Production/service execution;
- Logistics;
- General.

Each area consists of approximately 10 questions. The supplier is graded on all specific questions individually. Finally, a summary of the audit results, with the scores plotted in a spider-web diagram, is made, as shown in figure 22 below.

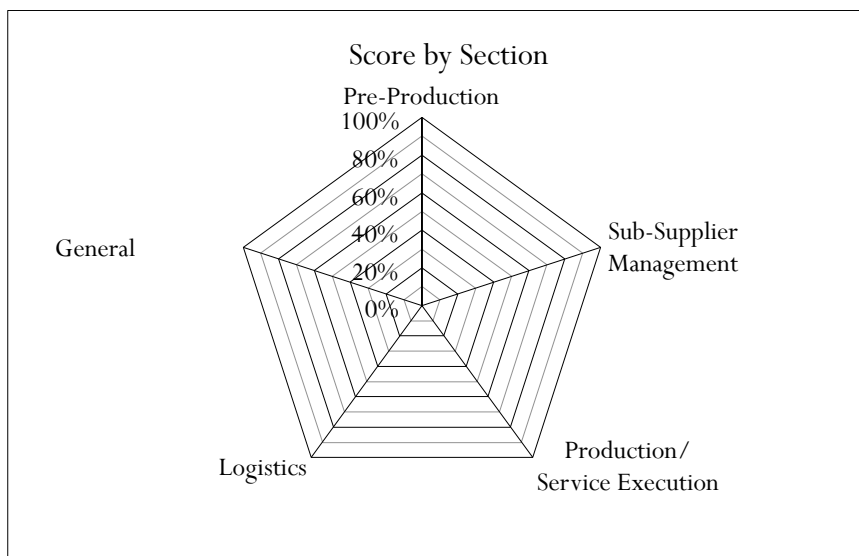


Figure 22: The spider-web diagram, from the PAQ template (ABB 11, 2012)

The audit team then explains, which the top five opportunities for improvement are. This listing should take the whole audit into consideration. By addressing the five top priorities, the supplier gets the possibility to address the issues of highest importance first. If there are additional issues that need to be addressed, that is to be communicated by the audit team as well. It is important to also highlight positive behaviors/processes since this can be motivating for the supplier and simplify future cooperation and performance during audit processes. (ABB 11, 2012)

#### 4.4.3.2 Scoring

Each question is scored by the person conducting the audit on a scale from 0 to 10, 10 being the highest score and 0 being the lowest. The grading is as follows:

- 10, the supplier fully meets the requirements;
- 8, most required elements of the requirements are present;
- 5, the supplier partially meets the requirements;
- 2, there is some evidence of requirements present;
- 0, there is no evidence to support the requirements.

Each category contains approximately ten questions, and each question is scored individually. The scores of all questions within one category are averaged, giving an overall score for the category. The overall score is stated in percentage. A global score for the audit is then achieved by calculating the average of the five category scores, giving the supplier a global score also in percentage.

If a question does not apply to a supplier, it is left out and explained why it does not apply, and marked as *not applicable, N/A*. All questions have the same equal weighting and therefore impact the overall score equally.

Only the score 10 describes the supplier as *fully meets the requirements* on the specific question. Any other score lower than 10 has to be motivated by the auditor. This is done by a comment in the space provided for this, next to each question. By commenting what is lacking in order to score a 10, the supplier is given the possibility to improve the specific issue. Naturally, the lower the score provided by the auditor, the more actions are needed by the supplier to achieve *fully meets the requirements*. (ABB 11, 2012)

#### **4.4.4 Template 3: Environment, Health and Safety Assessment**

The *Environment, Health and Safety Assessment*, abbreviated as EHS, is in line with ABBs Sustainability strategy. The strategy states the necessity that ABB engages its customers, employees, suppliers, business partners and communities to create innovative solutions to some of the world's challenges. (ABB 12, 2012)

The commitment of working with sustainability means that ABB needs to cooperate with its suppliers in the area of environment, occupational health and safety (OHS), business ethics and social policy.

In line with this, ABBs expectations are stated in the *ABB Supplier Assessment Protocol Audit Guide 1 Environment, Health and Safety*, saying that “the supplier provides a safe and healthy working environment at all sites and facilities and takes adequate steps to prevent accidents and injuries by minimizing, so far as is reasonably practicable, the causes of hazards.” Also, ABBs minimum requirements regarding OHS have been defined, which include, among others, that the supplier should have up-to-date OHS risk assessment reports, a responsible manager for OHS and evidence of workplace inspections. (ABB 13, 2011)



Summarizing, the steps that ABB follows during the *Environment, Health and Safety Assessment*, are visualized in figure 23 below.

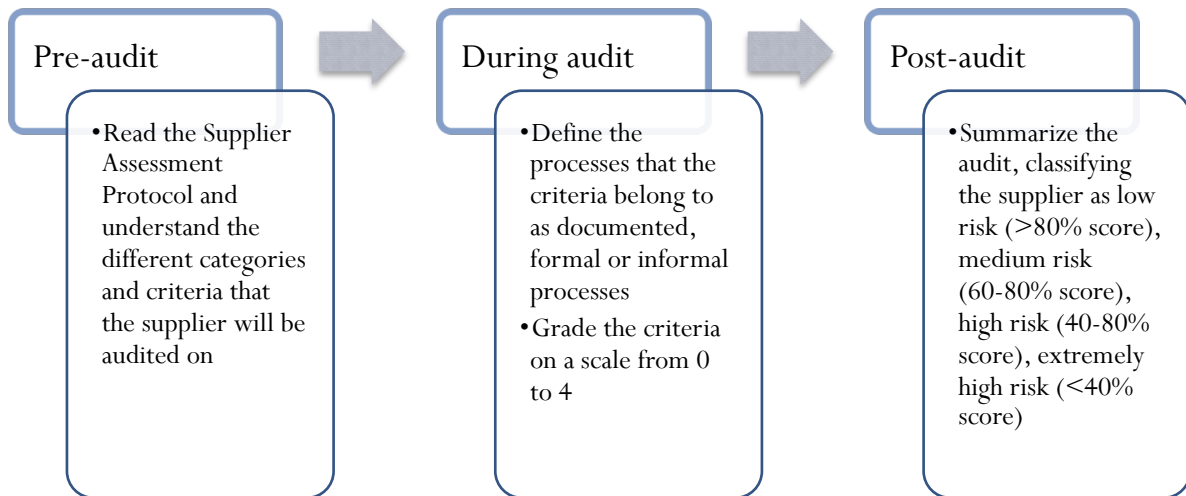


Figure 23: ABB EHS audit process (ABB 13, 2011)

#### 4.4.4.1 EHS audit criteria

The *EHS Audit* consists of a checklist, divided into three categories:

- General Management;
- Health and Safety;
- Environmental.

(ABB 14, 2012)

#### 4.4.4.2 Scoring and risk classification

Each criterion is scored based on how well it meets the ABB requirements. First, the criterion needs to be defined as belonging to a documented process, formal process or informal process. The following definitions are found in the Audit Guide.

A *documented process* is defined as a “written, auditable policy or procedure and typically deployed at the work level via standard work, work instructions or routing instructions”.

A *formal process* is defined as a process that is “driven by management and supported by the use of data, forms and/or documents, but is not necessarily supported by a written, auditable policy or procedure. A formal process may or may not use work instructions or equal”.

An *informal process* is defined as a process, “which is locally devised to address the management of a specific task or set of tasks. The process, which is typically created by, and shared with, the employee(s) responsible to perform the task(s), may or may not be known by management, may or may not be process connected to other process tasks and may or may not include the use of documents”.

When the type of process has been defined, the scoring depends on that. The grading is on a scale from 0 to 4, and the grades are outlined as follows:

- 4, Documented process is fully implemented and is likely to have undergone process improvement;

- 3, Formal process is fully implemented;
- 2, Informal process or formal process with limited structure;
- 1, Small evidence of an informal process, with little evidence of repeatability;
- 0, No evidence of a process, or false, unreliable procedures provided;
- N/A, Not applicable is a grade that is used when the issue is not relevant for the specific supplier.

Regarding the categories and subcategories stated above, the supplier is evaluated in terms of risk. The risk classification is as follows.

- *Low risk*
  - The supplier has been graded an overall score of 80% or above based on the criteria listed in the EHS protocol.
  - The supplier has partnership value to ABB.
- *Medium risk*
  - The supplier has been graded an overall score of between 60% and 80% based on the criteria listed in the EHS protocol.
  - The supplier is recommended to implement improvement actions.
- *High risk*
  - The supplier has been graded an overall score of between 40% and 60%.
  - The supplier is recommended to implement corrective actions.
- *Extremely high risk*
  - The supplier has been graded an overall score of less than 40% based on the criteria listed in the EHS protocol.
  - The supplier is recommended to immediately implement corrective actions, and should be considered for disqualification.

To summarize, the scoring is divided in three steps. Firstly, the type of process is determined. Secondly, the process gets scored according to the scale above and thirdly, the supplier is classified as a low, medium, high or extremely high risk supplier. (ABB 13, 2011)

#### 4.4.5 Template 4: Sustainability Audit

In line with *ABBs Supply Chain Management Sustainability Programme*, ABB should perform audits focusing on sustainability. A visualization of the steps in the *Sustainability audit* can be seen in figure 24 below.

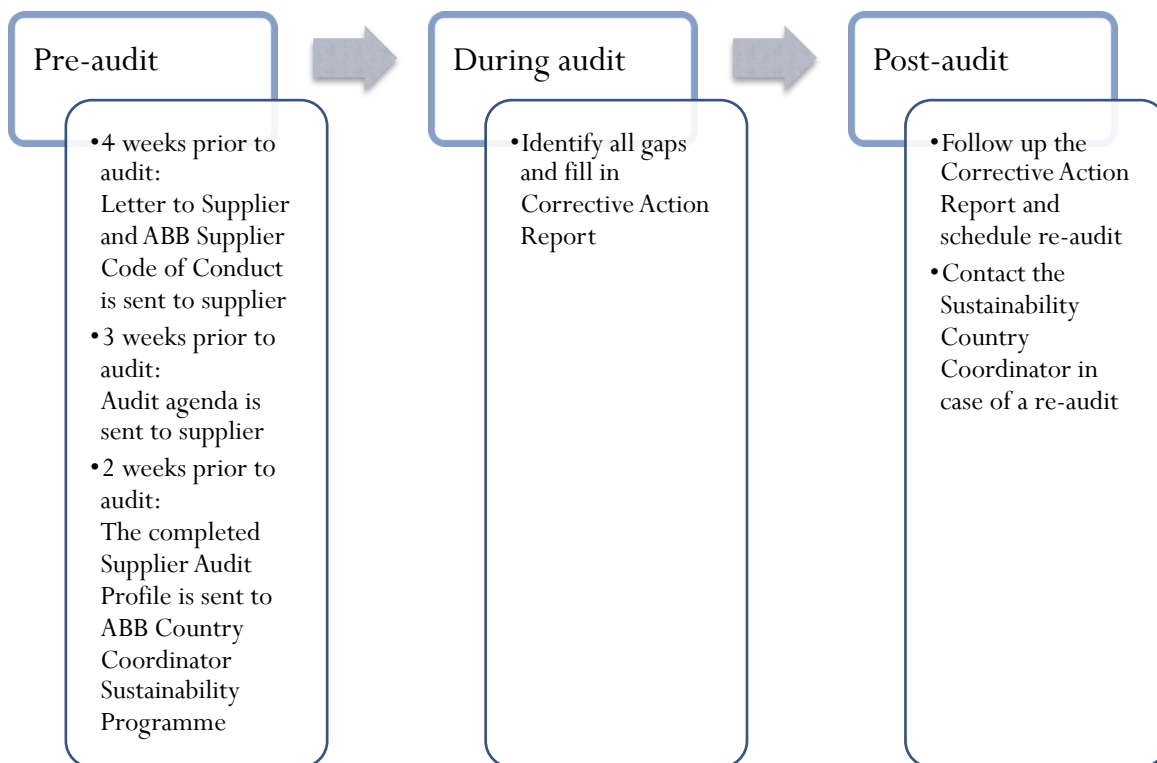


Figure 24: ABB Sustainability audit process (ABB 10, 2012)

First of all, an audit owner needs to be chosen, i.e. the person who is responsible for performing the audit. Thereafter, the steps described below should be conducted within the pre-defined time span.

As shown in figure 24 above, the auditor sends the Letter to Supplier, ABB Supplier Code of Conduct, and Audit Agenda to the supplier prior to the audit. Then the actual on site audit is conducted. If needed, the auditor makes a Corrective Action Plan and sends it to the supplier. The supplier then has to address the corrective actions in the CAP and the auditor controls that the actions are followed through. (ABB 10, 2012)

##### 4.4.5.1 Sustainability audit criteria

The audit protocol is divided into six sections, each with between four and 12 areas to assess, resulting in 41 areas/questions in total. The sections are as follows:

- General management;
- Working hours;
- Remuneration;
- Social benefit;
- Health and safety;
- Environmental protection.

(ABB 15, 2012)

#### **4.4.5.2 Scoring**

Each question is scored with a number from the same scoring scale used in the EHS audit; 0, 1, 2, 3, 4.

With a calculated total score, it is then divided by the total score possible and a score percentage is reached. For example, if the supplier's total score is 140 and the total score possible is 164 (41 questions\*score 4 = 164), the reached percentage is 85%.

Based on the percentage, the supplier is considered to be of low, medium, high or extremely high risk, using the same classification as the EHS audit. (R., 2012) (ABB 10, 2012)

### **4.5 Feedback on audit work at ABB**

After understanding the supply chain and its organization and going through the audit templates that are used, the authors talk to key actors within the supply and quality departments to get their feedback on the existing audit processes that are used and the audit work that is performed at ABB PA. The following chapters present different opinions given by these people regarding audit decision policy and time allocation, scoring, documentation, consistency, responsibility, and competence and training.

#### **4.5.1 Audit decision policy and time allocation**

ABB PACT does not have a set rule on how many audits that should be performed during a certain period of time. Some key players within auditing say that the KPIs, presented in chapter 4.4.1, are used when deciding to audit a supplier. However, whether that is a stated policy is not clear. The closest to a guideline that the authors have come across in this research is another ABB division, Power Products (PP), having a policy of conducting two audits per strategic purchaser per year. A strategic purchaser at the division has between 30 and 250 suppliers, whom he or she is responsible for. Unfortunately, soon after introducing the goal it was neglected since there was a lack in time for completing the tasks. (B.4, 2012) (B.5, 2012) (K.1, 2012)

An auditor should have knowledge in the production process as well as specific audit skills. Therefore, a competent auditor is normally a person with a full-time job within supply, sourcing or similar with, or at least who should have, knowledge in the auditing process as well. To find the time for these people to also perform audits in addition to their every day work is a challenge. If audit education and training is needed as well, the time allocation issue is obvious. (B.1, 2012)

Generally, an audit takes two days on-site to perform, out of which the last afternoon is dedicated for a quick on-site summary, including a short-list of the most important recommendations as well as scheduling a follow-up audit. After the audit, all deviations from the ABB requirements that are found during the on-site assessment have to be addressed, including a thorough follow-up analysis with well-motivated grading and recommendations. This is an essential part of the audit and often more work intensive than the actual on-site audit itself. The follow-up work has to be performed by the supplier.

As a key actor within the supply organization says: "Before the audit, ABB works 150%. After the audit, the supplier works 150% with the actual activities". However, the ABB audit team needs to be involved in the whole process in order to deliver a complete audit. (B.5, 2012) (B.2, 2012)

#### **4.5.2 Measurement**

As stated earlier, each supplier is scored when an audit is conducted. The scoring is performed on individual questions in different audit areas and an overall scoring of the whole assessment is given as well. An opinion that has been expressed is that it seems to be quite easy for the suppliers to get high grades and that those are generously distributed by the ABB auditors. The scoring consists of grades and comments explaining the grades given by the auditor. The commenting on the grades is sometimes neglected.

(B.5, 2012)

#### **4.5.3 Documentation**

When conducting audits, it is not only important to have the right competence but also to document the audits in a proper way.

ABBs audit documentation solutions have been different depending on the geographical location of the audit team, internal business unit and department, etc. Some of the audit documentation has been stored on local hard drives, making it hard for co-workers to access the information. Common tools have been used sporadically and there are complaints on the lack of user friendliness and the navigation function. An example of that is the C2 tool, which is a case management system used by the PA division in Sweden. C2 is an intranet-based tool connected to the ABB email system facilitating the updating and reporting within the tool. There are also other electronic tools that are being used for documentation of audit material that are not globally accessible. (ABB 16, 2012) (B.1, 2012)

Personnel involved in the audit process state that the documentation of the audits is of high importance. ProSupply is a global tool planned to be launched during the year of 2012. The tool will be used for controlling and sharing information about suppliers and audits. The new documentation tool is supposed to create one common platform for documentation. A users guide will inform all involved parties how the tool is to be used. (B.1, 2012)

#### **4.5.4 Consistency**

Local business units used to have their own way of working and thinking regarding audits, and therefore different audit processes were created. Today, the work is more standardized, which simplifies it and makes it easier to control and follow up. (B.1, 2012)

At the same time, the audit process is continuously under development in cooperation with the quality department. The reasons for this being that with each new product family that is introduced, new processes are also implemented. This means that ABB is aiming towards having a common audit process, but since there are many local audit processes behind one mutual process, still many different templates are used. The overall opinion is that the templates are too general, making it hard to *deep dive* into one specific area. At the same time, a standardized template that would work for all audits and all auditors is demanded. (B.1, 2012) (B.5, 2012) (S., 2012)

#### **4.5.5 Responsibility**

According to key players within the supply and quality departments at ABB PA, there are too few audits being performed. For example, during the year of 2011, the PA division in Sweden conducted only one audit focusing on environmental issues. One explanation for the low number of audits could be a

misunderstanding between the supply and quality departments. Until recently, the quality department considered the supply department to be responsible for supplier audits, and the supply department considered the quality department to be responsible for the audits. However, the problem has been discovered and the supplier audit process is now a subject to improvement and the responsibilities are stated clearer. It is the supply chain management (SCM) organization that has the ownership of the supplier auditing process, and the main responsibility regarding the audits lies within this department. However, ABB sources express the opinion that the supply department should work closer with the quality department in this matter and that the audits should be performed in co-operation between the two departments and the supplier.

There have been cases of different business units conducting similar audits at the same supplier. As commented by ABB auditors; it would save both time and resources for ABB and the supplier if one representative conducted the audit and shared the results with other involved parties at ABB. (B.1, 2012)

#### **4.5.6 Competence and training**

In order to complete a well-performed supplier audit, it is important that the audit team possesses audit competence. Sometimes supply managers are sales and business oriented and less knowledgeable in environmental and social security issues. Internal auditors can be standards and regulations oriented and sometimes are less knowledgeable in business and technical processes. According to a supply manager at ABB, the person conducting an audit should have the following competences:

- Competence in the auditing process;
- Technical competence in the specific production process for which the audit takes place;
- Business oriented knowledge.

According to the division itself, PA consists of very competent people within the different individual competence areas mentioned above. However, there is a lack of people who possess competence in all three areas at the same time. What complicates the issue further, is that when conducting an audit on environmental or sustainability questions, it is almost necessary to have legal competence since many environmental issues are regulated by the law. (B.1, 2012) (B.5, 2012) (K.1, 2012)

In order for the audit teams to have the right competence and experience, it is essential that new auditors as well as existing ones get the right education and time to practice and gain experience as auditors. Specific audit competence could be ensured by giving the auditors audit training. (B.5, 2012)

## 4.6 Summary of Empirical phase II

In the PA SCM corner stones, all five approaches address supplier auditing in some way. Also, in the PACT Supply Chain Management vision there are three areas connected to supplier auditing from a sourcing and supplier relationship perspective.

ABB uses supplier auditing as a tool for measuring supplier performance. Performance related to quality and cost is historically the main focus of the audits. The majority of the key actors within the supply and quality departments of ABB PACT see an improvement potential regarding the audit work.

Four different audit templates, all associated with different processes for how to conduct an audit, regulate the current audit procedures at ABB. However, the general impression among key actors within auditing is that the processes are not followed through according to the guidelines. Summarizing the feedback received from these people:

- *Audit decision policy and time allocation*  
ABB PACT does not have a set rule on how many audits that should be performed during a certain period of time. It is unclear if there is a policy that regulates the decision to conduct an audit. Another issue addressed is the time allocation of the audits; there does not seem to be sufficient time for all working tasks of an auditor.
- *Measurement*  
The measuring of the audits is not consistently done. The commenting on the grades is sometimes neglected. Another opinion is that the suppliers usually get high grades.
- *Documentation*  
The documentation of the audit material differs depending on where the audit has been performed. Different electronic tools are used, with varying user friendliness. The documentation of the audits is of high importance. The new tool ProSupply is supposed to provide one common platform for documentation.
- *Consistency*  
The audit processes are aimed towards becoming more standardized. Still, local procedures impact on how the auditing work is conducted. A standardized template that would work for all audits and all auditors is demanded, but it is not easily developed.
- *Responsibility*  
Better communication and cooperation between the supply and quality departments regarding auditing is requested. Also, sharing of information between business units should increase. This would save time and resources at ABB as well as at the supplier being audited.
- *Competence and training*  
In order to perform an audit efficiently, competence in the production processes at the supplier as well as in the auditing processes is needed. Not all auditors possess these competence areas. One way of ensuring such competence is to provide audit training.





## 5 Analysis phase I

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*In this chapter, the information gathered from the interviews in the Empirical phase I is analyzed into four feedback areas. The generic research questions stated in chapter 1 Introduction are here related to the ABB PACT case and reformulated into the four feedback areas.*

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### 5.1 Analysis of empirical phase I

When conducting the first set of interviews at ABB Sweden, the focus was to understand the supply chain organization for the business division PA and the business unit CT. In a majority of the interviews, the focus on supply chain risk and supplier relationship management led to a discussion about the ABB supplier audit process, see chapter 4.5.

Supplier auditing is a tool for evaluating as well as managing and developing the relationship with the supplier. Pro-activeness and cooperation between the suppliers and the contracting company, in this case ABB, is essential. When evaluating the different auditing processes that ABB uses, as well as interviewing key players in the quality and supply chain organizations, there are some aspects that repeatedly appear. In order for the supplier audit to be the helpful tool that it has the potential to be, there are some factors that the authors conclude to be important:

- There should be an audit decision policy that clearly communicates when to perform an audit.
- The grading of the suppliers should be accurate and motivate for improvement work.
- The grading of the suppliers should be a balanced mixture of scale grading with numbers and free comments.
- The activities prior to, during, and after the audit should be performed in a consequent manner, to facilitate for both the suppliers being audited and the auditors at ABB.
- The audit documentation should be performed in a consequent manner, to facilitate the information sharing between ABBs auditors, key supplier managers, etc.
- The auditors should have competence in the production system/process of the supplier that is to be audited.
- The auditors should have competence in the auditing process, that is, the procedure for how to perform an efficient and productive audit.

Based on the research questions from chapter 1 Introduction, the feedback from the interviews, and with the above stated factors in mind, the following four feedback areas are derived:

1. The audits are conducted too seldom.
2. The suppliers usually get high grades when the audits are conducted.
3. The audits are not performed and documented in a consequent manner.
4. Personnel conducting audits have not participated in audit training.

The four feedback areas are now presented individually.

### **5.1.1 Feedback area 1: The audits are conducted too seldom**

The factors that compose the basis for feedback area 1 are the following:

- There should be an audit decision policy that clearly communicates when to perform an audit.

It seems like quite few audits are performed at ABB PACT today. Also, there seems to be a lack in policy for when an audit should be performed. Moreover, the general impression is that the supplier audits are activities that the auditors find themselves too busy to have time with.

### **5.1.2 Feedback area 2: The suppliers usually get high grades when the audits are conducted**

The factors that compose the basis for feedback area 2 are the following:

- The grading of the suppliers should be accurate and motivate for improvement work.
- The grading of the suppliers should be a balanced mixture of scale grading with numbers and free comments.

The grading scale when performing the audits seems to give the suppliers disproportionate high grades. A way of getting a balanced grading and also valuable information from the audit seems to be to combine both scale grading and free comments that the auditors fill in.

### **5.1.3 Feedback area 3: The audits are not performed and documented in a consequent manner**

The factors that compose the basis for feedback area 3 are the following:

- The activities prior to, during, and after the audit should be performed in a consequent manner, to facilitate for both the suppliers being audited and the auditors at ABB.
- The audit documentation should be performed in a consequent manner, to facilitate the information sharing between ABBs auditors, key supplier managers, etc.

The term consequent in this context means that all audit activities are performed in the same way, including pre, during and post audit, independent of the audit template being used.

There are four different templates available for the auditors to choose from when planning for an audit, and there does not seem to be a standardized way of choosing the documents. Local and individual preferences seem to decide what template that is being used and in what manner it is being used. The administrative parts of the contact with the supplier prior, during and post audit seems to differ as well, as can be seen in the four different templates described in Empirical phase I.

The documentation of the audits also seems to be performed differently depending on the individual auditor. Some auditors use an electronic tool, some auditors save the documents on their personal hard drive, other documents seem not to have been saved at all, or at least impossible to find again. Some auditors fill in all documents, including the follow-up documents, some fill in parts of the documents. A lot of experience and knowledge that could be useful for the auditors to share seem to be lost due to the lack in information sharing procedures.

#### **5.1.4 Feedback area 4: Personnel conducting audits have not participated in audit training**

The factors that compose the basis for feedback area 4 are the following:

- The auditors should have competence in the production system/process of the supplier who is to be audited.
- The auditors should have competence in the auditing process, that is, the procedure for how to perform an efficient and productive audit.

In order to perform an efficient audit it is necessary to have competence in the production process as well as in the audit process. Knowing how to ask the questions, why the questions are being asked, how to document, how to give feedback, and how to implement and follow up the improvements are important skills for an auditor.

ABB PACT has the right competence in the processes and product specifications in order to perform audits. However, it seems like the organization lacks in the second competence area; the auditing process skills.



## 6 Empirical phase II: Feedback area control

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*This chapter describes the continuation of the empirical study at ABB in Singapore. Empirical phase I conducted at ABB Sweden resulted in four feedback areas. This second round of empirics focuses on collecting data to prove or disprove the stated feedback areas.*

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### 6.1 Introduction and procedure

In order to conclude whether the feedback areas from Analysis phase I are accurate, the ABB audit processes and supporting material need to be investigated further. By comparing the audit processes in how they should be used according to ABB policies with how the work is actually performed, both existing variances and no variances might help to prove or disprove the feedback areas.

Empirical phase II is divided into the four feedback areas, where the collected data helps to investigate each feedback area individually. The data collection has been performed using the ABB audit templates, collected audit material and a survey.

#### 6.1.1 Audit templates

ABB has four main audit templates that are used for audits of different nature. Those templates are described in Empirical phase I, see chapter 4.4.

For the comparison of the different templates, the authors have looked at both each questionnaire in the audit template and, if available, the user guide that is attached to the questionnaire.

#### 6.1.2 Audit material

The authors have requested audit material from pre-performed audits within the business division PA and the business unit CT. The aim has been to receive “full cases” of supplier audit material, i.e. all documents connected to an audit conducted at one specific supplier, meaning everything from the supplier’s self-assessment documents prior to the audit and the ABB auditor’s documents from the actual audit to the post-audit feedback forms and the follow-up documents. However, this data collection has been quite difficult and the “cases” have often not contained all required material. The main difficulty in receiving the right material seems to derive from the difficulty in finding the audit documentation. The authors have sent data requests to people with different positions and from different geographical locations, but the difficulty in finding documented audit material seems to be widely spread among the divisions and business units.

Despite the difficulty in finding complete audit material cases, the received documentation contains two complete cases (with supplier self-assessment, ABB auditor’s document and follow-up documents) and seven partly complete cases with the ABB auditor’s document and, in some cases, follow-up documents but all without the supplier self-assessment. The two full cases are compared in a short case study. Most of the suppliers involved in this empirical study are ABB key suppliers operating in different locations, for example in Sweden, India and Singapore.

#### 6.1.3 Survey

For the survey, the authors contacted 40 people by telephone. The contacted people are from the quality and supply departments at PA or PACT and considered to be key players within the supply and quality departments.

The survey was initially prepared as a draft and feedback on its content and design was received. Out of the 40 contacted people, 32 confirmed that they would consider the survey and, if applicable to their working tasks, answer the questions. The updated survey was sent to the 32 people, with a deadline for completion of 10 days. A first reminder was sent to those who had not answered on the ninth day after the survey was sent. After that, a second and finally a third reminder were sent to those who had not yet replied after the deadline. The majority of the people who did not answer the survey simply explained that it is due to not having performed any audits.

Mainly personnel from ABB Sweden participated in the survey, but also coworkers in Singapore, Germany, and USA were asked to take part in the survey. Examples of the survey participants' positions are supply manager, quality manager, and global senior manager quality, risk and sustainability management.

All in all, 10 surveys were answered, providing a feedback percentage of 31% answered surveys, which is quite few. However, the people sharing their opinion about the audit processes are key players within the audit organization and basically the only active auditors. Therefore, the information presented below should be seen as an indication of the AS-IS situation.

#### **6.1.3.1 Survey contents**

The survey consists of nine sections:

1. Your identity and experience;
2. Your audit process;
3. The supplier's role during the audit;
4. Used support – from tools to process and staff;
5. Prior to the audit;
6. When performing the audit;
7. After the audit;
8. For documenting the audit;
9. Statements: Please state your position regarding the following statements.

Each section contains 2-8 questions, mainly open-answer-questions. A few questions come with *yes/no* answers, and the statements come with *I do not agree at all/I partly agree/I agree*.

The full survey can be found in Appendix D.

## 6.2 Feedback Areas

Empirical phase I and Analysis phase I resulted in four feedback areas, which are used as the backbone in this analysis. The aim is to see whether the four feedback areas truthfully apply to the ABB PACT case or not.

As an introduction to the presentation of the audit processes at ABB, it can be stated that the majority of the survey participants do not think that the supplier audits work in satisfactory way today. As can be seen in figure 25 below, 30% agree to the statement *The supplier audit process works in a satisfactory manner today*. However, 40% of the survey participants partly agree with the statement, and 30% disagree with the statement.

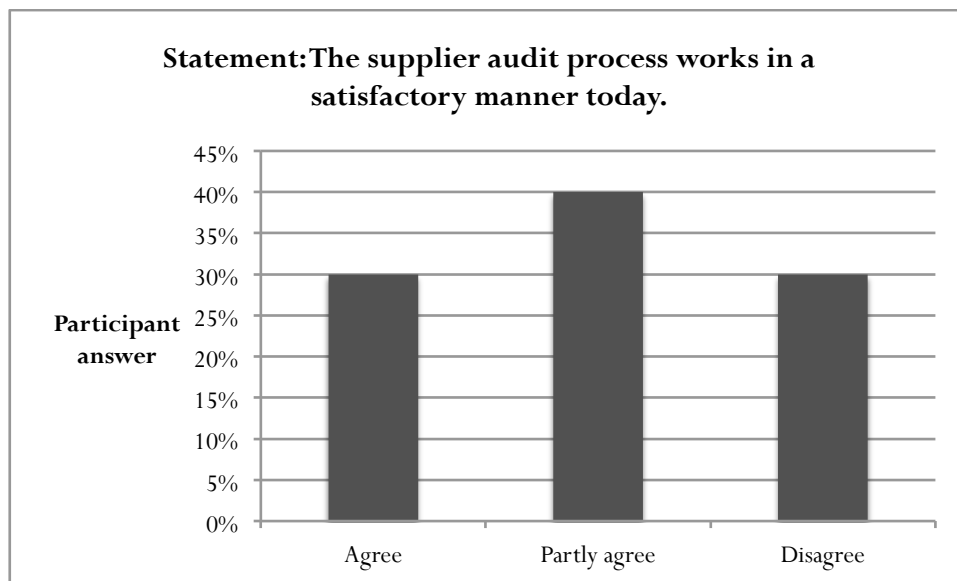


Figure 25: Survey answer regarding the general opinion about the supplier audit process

### 6.2.1 Feedback area 1: The audits are conducted too seldom

In order to investigate *Feedback area 1: The audits are conducted too seldom*, the following areas are studied further.

- The general number of audits conducted in the past two years;
- What templates are most frequently used;
- The opinion regarding a policy when to conduct and audit;
- The planned/completed audit ratio.

The chapters below contain data related to these study areas.

#### 6.2.1.1 General number of audits

One of the first questions in the survey covers the number of audits that the survey participants have performed during the past two years (2010 and 2011).

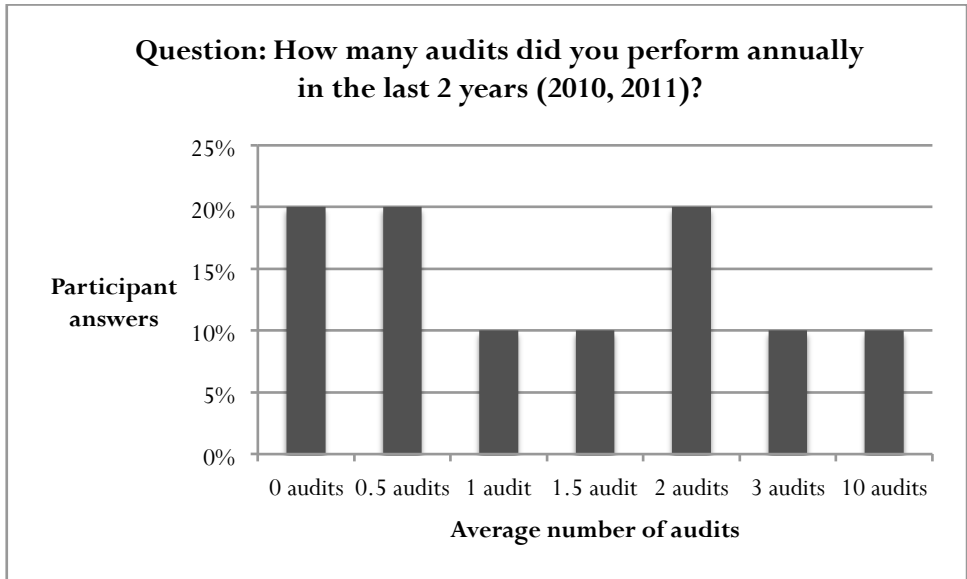


Figure 26: Survey answer regarding the number of conducted audits during 2010 and 2011

Figure 26 above shows the average number of audits conducted per year by the survey participants during 2010 and 2011. The median value is more relevant in this kind of material, and is calculated to be between 1 and 1.5 audits per year, landing on 1.25 audits per person and year. As can be seen, 20% of the survey participants have not conducted any audits during 2010 and 2011.

#### 6.2.1.2 Used templates

The PAQ is the primarily used template. Even though environmental, financial, safety and ethical issues are not the primary focus areas of this template, the PAQ has been used to conduct such audits. Figure 27 below shows the focus of the “alternative” audits that the survey participants have conducted. Since some participants have conducted more than one of these types of audits, the sum of the answers adds up to more than 100%.

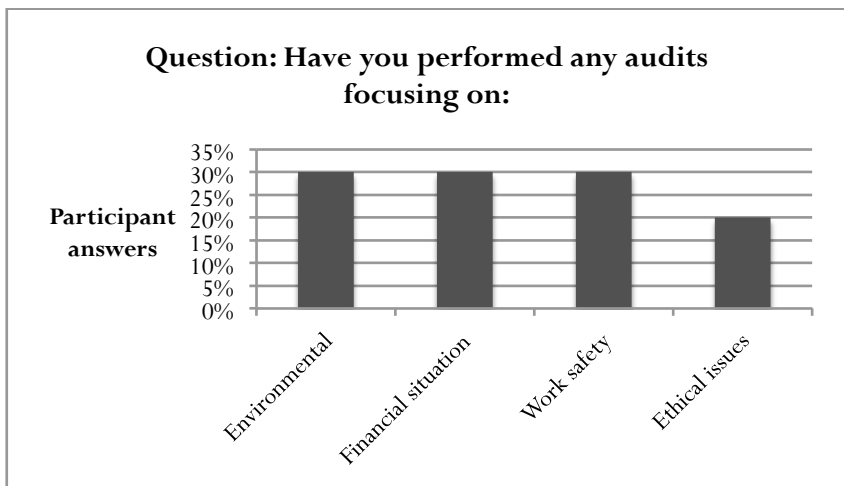


Figure 27: Survey answer regarding audit focus

30% of the survey participants state that they have never performed an audit focusing on questions regarding neither environmental, financial, work safety nor ethical issues. One survey participant working in Singapore comments that it is planned to use the audit template focusing on sustainability for the first time during the third quarter of this year.



### 6.2.1.3 Audit intervals and policy

As can be seen in figure 28 below, the survey participants have different opinions regarding the question *With what interval should audits be conducted in a well performing supplier organization in your personal opinion.*

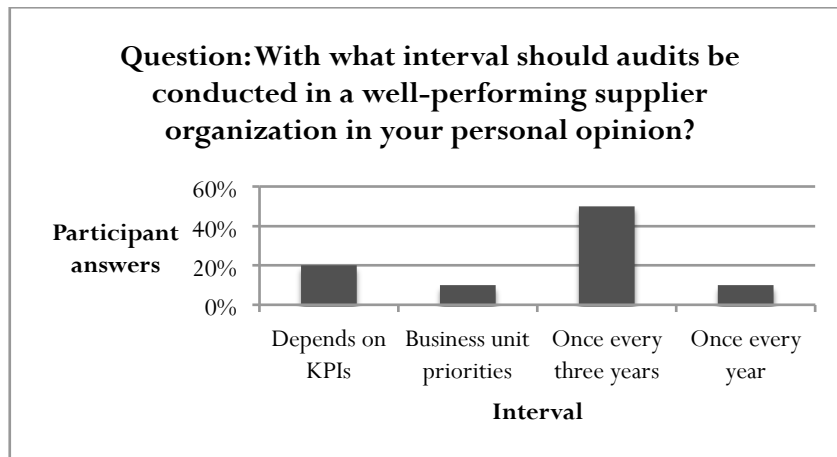


Figure 28: Survey answer regarding the audit interval in a well-performing supplier organization

The answers show that half of the participants consider once every three years to be a good interval for conducting audits. 20% state that the audit frequency depends on KPIs and the supplier’s performance according to those. 10% of the survey participants think that it is up to the business unit’s priorities to decide when and who to audit, and 10% think that once a year is a good interval for auditing. 10% of the survey participants did not answer the question.

The survey participants were also asked whether ABB has a policy for with what interval audits should be conducted.

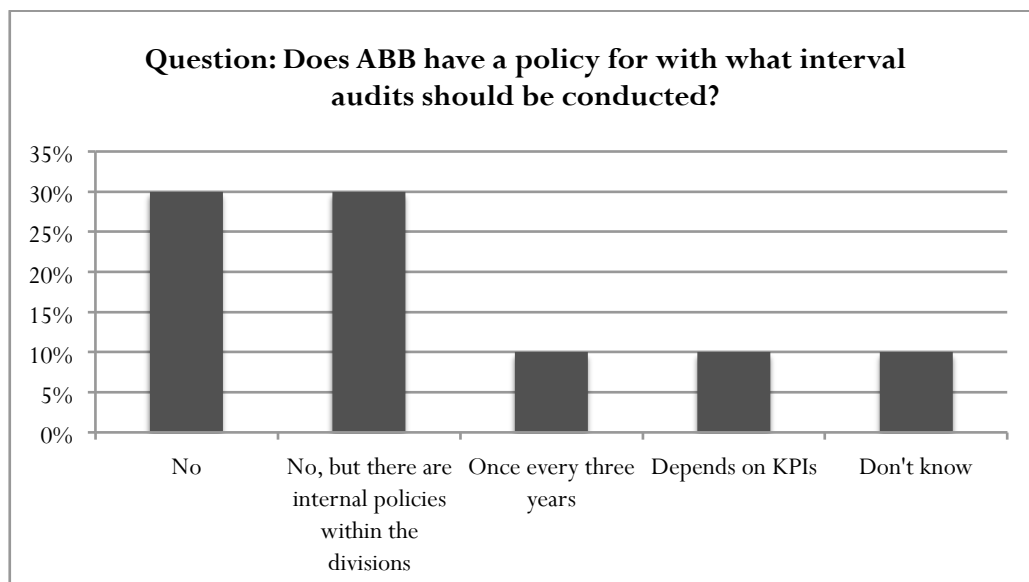


Figure 29: Survey answer regarding ABBs policy for audit material

Figure 29 above shows that 30% of the survey participants answer the question with a *no*, and 30% answer *no, but there are internal policies within the divisions*. 10% of the survey participants did not answer the question.

#### 6.2.1.4 Planned and completed audits

An audit plan is made within the division at the beginning of the year, showing when and how many audits are to be conducted by the division or unit during that year. PA Measurement Products (PAMP) is another business unit within PA. Figure 30 below shows the two business units PACTs and PAMPs number of planned audits for the last 4 years, including 2012. As can be seen, the number of planned audits (blue bars) has not been the same as the actual conducted and completed number of audits (purple bars).

Figure 30 is based on information regarding a number of suppliers within the PACT and PAMP business units. However, in order to avoid confusion, the authors want to mention that these suppliers are not the same as the seven cases of suppliers used for other statistics in this chapter.

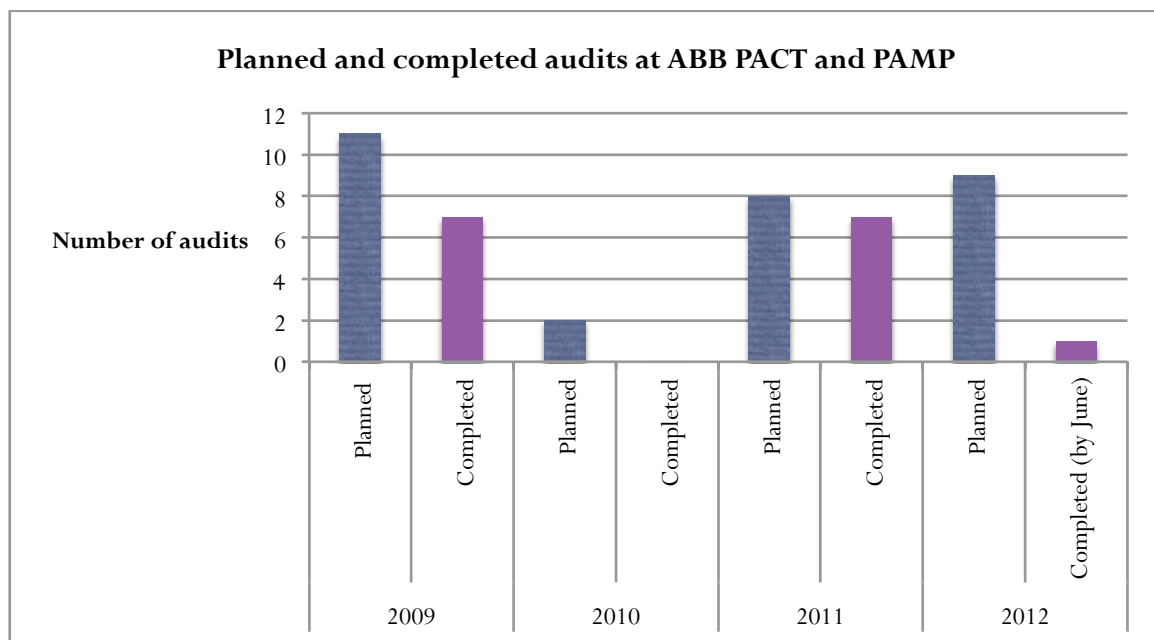


Figure 30: Planned and completed audits at ABB PACT and PAMP 2009-2012

During 2009, there were eleven audits planned for the year, and seven were completed, with a completion ratio of approximately 60%. During 2010, two audits were planned and none was completed. During 2011, there were eight audits planned and seven were completed. There are nine audits planned for the year of 2012 from which one has been completed up till this moment (June, 2012). The remaining audits are planned for quarter three and four of this year.

When an audit that has been planned is postponed, the decision is noted with a short comment. Examples of comments are “for the future”, “prohibited to travel due to current economic situation” and “plan to complete the audit has been adjusted”.

## 6.2.2 Feedback area 2: The suppliers usually get high grades when the audits are conducted

The following factors are studied when investigating feedback area 2:

- The general attitude towards auditing, generally positive, neutral, negative?
- The scoring scales in different templates;
- Average scores from performed audits;
- The consistency between grades and comments in the questionnaires;
- The differences between the supplier self-assessment grades and the ABB grades.

The chapters below contain data related to these study areas.

### 6.2.2.1 Attitude towards auditing

On the question *Have you experienced the suppliers' attitude towards audits as positive, negative, other*, 80% of the survey participants state that the suppliers generally are positive towards audits. The survey participants comment that the suppliers appreciate the fact that with the help of audits, weaknesses can be identified and reduced and improvements can be made. However, 10% of the participants state that the suppliers are positive towards the audits but that they sometimes have a defensive attitude. The remaining 10% withhold their answer.

### 6.2.2.2 Scoring in the different templates

The four different templates that ABB uses for supplier auditing have their own questionnaires. Those different questionnaires also have different scoring scales. As can be seen in table 3 below, the SQP scoring scale consists of three grades – *yes*, *partially* or *no*. The three grades are translated into a corresponding percentage. In that way, an average score of all grades results in a total average score for the supplier. The supplier needs an average score of 80% or above to be qualified. (ABB 9, 2011)

Supplier Qualification Process (SQP)	
Score	Corresponding grade
Yes	1
Partial	0.5
No	0

Table 3: Supplier Qualification Questionnaire scoring scale (ABB 9, 2011)

The PAQ, see table 4 below, has a scoring scale of 0, 2, 5, 8, 10, going from *There is no evidence to support the requirements* (score 0) to *The supplier fully meets requirements* (score 10). (ABB 11, 2012)

Process Audit Questionnaire (PAQ)	
Score	Meaning
10	The supplier fully meets requirements
8	Most required elements of the requirement are present
5	The supplier partially meets the requirements
2	There is some evidence of requirements present
0	There is no evidence to support the requirements

Table 4: Process Audit Questionnaire, scoring scale (ABB 11, 2012)

As can be seen in table 5 below, the Sustainability Audit Process has a scoring scale of 0, 1, 2, 3, 4, where 0 is the lowest score and 4 is the highest score. The authors have not found any other explanation to the scale.

Sustainability Audit Process	
Score	Meaning
4	Highest score
3	
2	
1	
0	Lowest score

**Table 5: Sustainability Audit Process, scoring scale (ABB 15, 2012)**

The Environmental, Health and Safety Assessment, see table 6 below, has a scoring scale of 0, 1, 2, 3, 4, going from *No evidence of a process, or false, unreliable records provided* (score 0) to *Documented process is fully deployed and likely has undergone iterations of process improvement* (score 4). (ABB 14, 2012)

Environmental, Health and Safety Assessment (EHS)	
Score	Meaning
4	Documented process is fully deployed and likely has undergone iterations of process improvement
3	Formal process is fully deployed
2	Informal process or formal process with limited deployment
1	Anecdotal evidence of an informal process with limited or concentrated deployment, with little evidence of repeatability
0	No evidence of a process, or false, unreliable records provided

**Table 6: Environmental, Health and Safety Assessment, scoring scale (ABB 14, 2012)**

As can be seen in the tables above, the four templates all have different scoring systems. This means that the suppliers are graded using different scales depending on which topic the audit is focused on.

#### 6.2.2.4 Average supplier scores

The PAQ template consists of six categories of questions and for each category, also called audit area, ABB gives the supplier a score from 0 to 10, where 10 means that there is no deviation between the ABB requirements and the supplier's performance. Figure 31 below shows the scores that ABB has given seven suppliers using the PAQ.

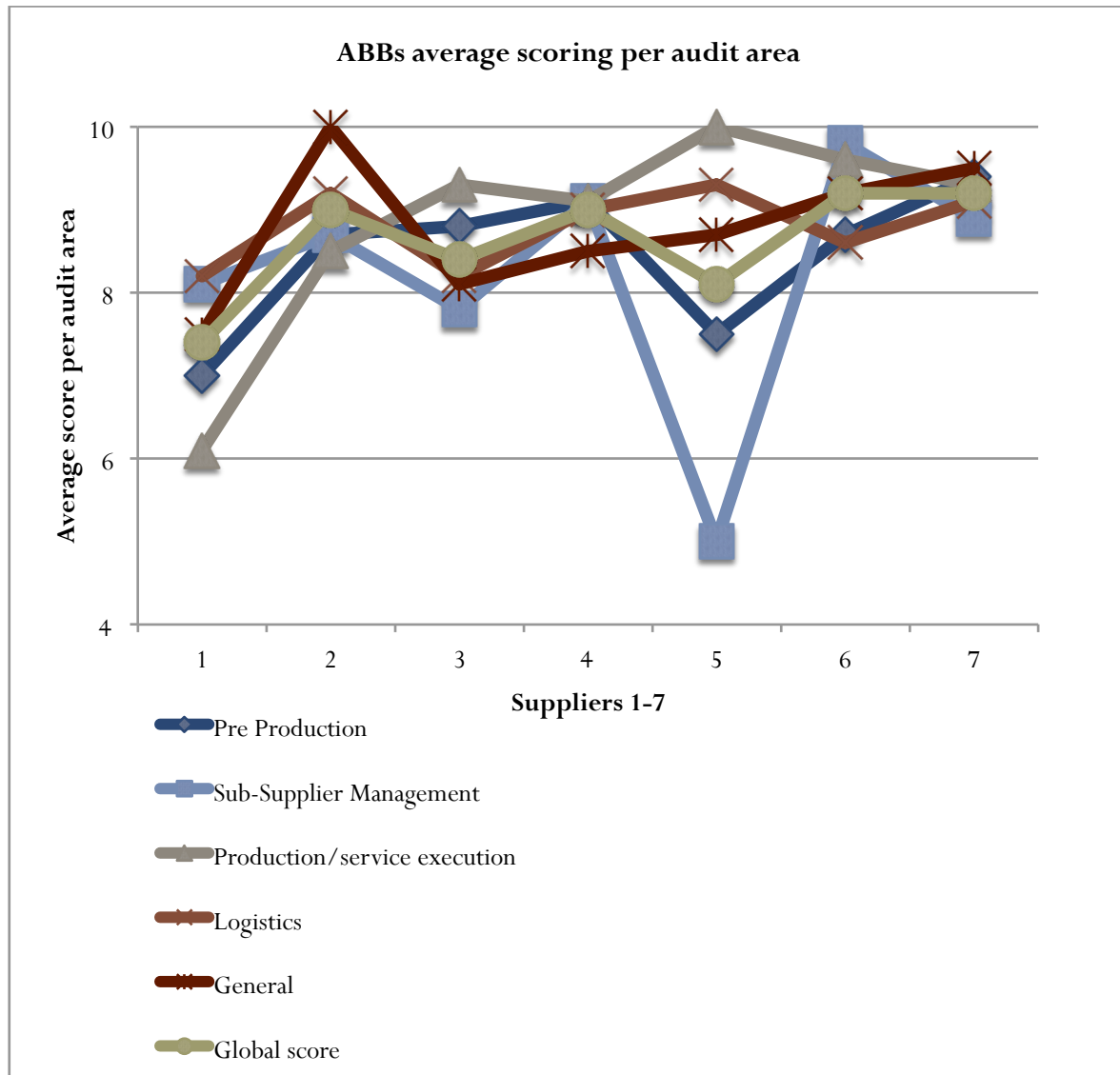


Figure 31: Average scores per audit area of the seven suppliers, PAQ

The scores are averaged and visualized as different colored lines for each of the six audit areas. The vertical axis contains the scoring scale, which is from 0 to 10. The axis starts on score 4, since no scores lower than 5 have been found in the audit material. The horizontal axis shows the seven different suppliers. Below the chart, the six different audit areas are listed in different colors.

The average *Global score* is 8.61, which is also the total score of the audit. In table 7 below, the average scores are summarized.

<b>Audit area</b>	<b>Average scores</b>
Pre Production	8.46
Sub-Supplier Management	8.2
Production/Service Execution	8.84
Logistics	8.8
General	8.79
Global score	8.61

**Table 7: Average scores for the six audit areas in the PAQ-template**

The audit guides require the auditors to comment each grade that deviates from the “perfect” score 10. When investigating filled-in audit material, it was concluded that far from all grades are commented. In order to find out how well the grades are motivated, firstly the total number of questions graded with grade 10 were counted. Secondly, it was investigated how those grades were commented. The results can be seen in table 8 below.

<b>Scored and commented questions</b>	<b>Number</b>
Total average number of questions in 7 cases	420
Total number of score 10 from the 7 cases	199
Out of those 199 questions, number of commented with “excellent”	132
Out of those 199 questions, number of commented with "yes"	12
Number of not commented scores 10	67

**Table 8: Score statistics of the highest score 10 from the seven supplier cases**

Out of the 199 questions that are scored with a 10, 132 were commented with a motivation for the high score, resulting in 66% commented 10-scored questions. Twelve out of those 132 motivations are commented with a simple “yes”, not giving any other explanation for the highest score. Approximately 30% of the 10-scored questions are graded in the questionnaire without a motivation.

### 6.2.2.5 Case study

The authors have received two full cases (including the supplier self assessment and the ABB scoring) of audit material from performed audits, here called case A (supplier A) and case B (supplier B).

#### Case A

In case A, the scores that the supplier has given himself are compared to the scores that ABB has given the supplier, as can be seen in figure 32 below. The case contains a complete supplier self-assessment questionnaire, a complete process audit questionnaire (from ABBs first audit) and a complete follow-up process audit questionnaire (from ABBs final/follow-up audit).

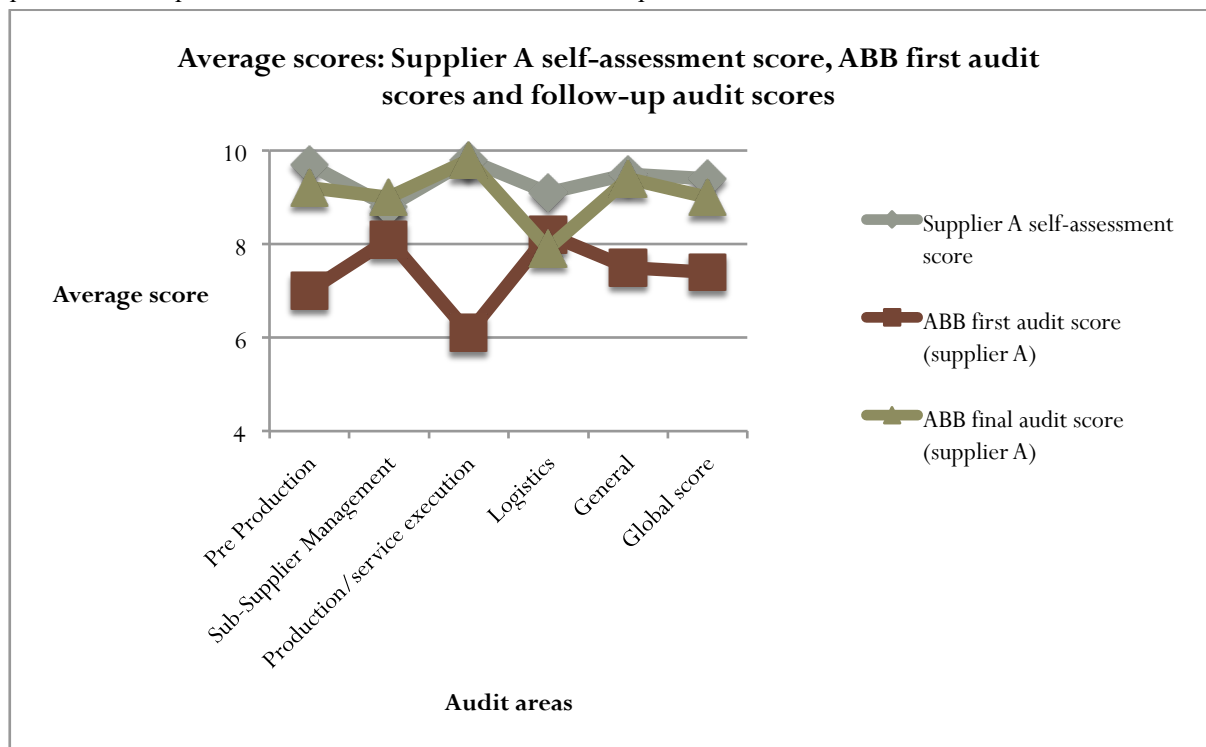


Figure 32: Average scores from supplier A self-assessment, ABB first audit and ABB final audit

The scores from the different audit areas are gathered in the chart. The vertical axis shows the average scores. The horizontal axis shows the audit areas. As can be seen in the figure, the supplier self-assessment grades (grey line) are constantly higher than the initial ABB scores (red line). After the follow-up audit, ABB gives the supplier a higher score (brown line) than after the first audit. The ABB final audit scores (brown) are more similar to the supplier self-assessment scores (grey) than the ABB first audit scores (red).

### Case B

The case of the material from supplier B consists of a complete supplier self-assessment questionnaire and a semi-completed PAQ. The reason for the questionnaire only being partially completed is that the audit only focused on two out of the six audit areas in the PAQ template. Those areas are, as can be seen in figure 33 below, *Sub-Supplier Management* and *Logistics*. This audit case does not contain the follow-up material.

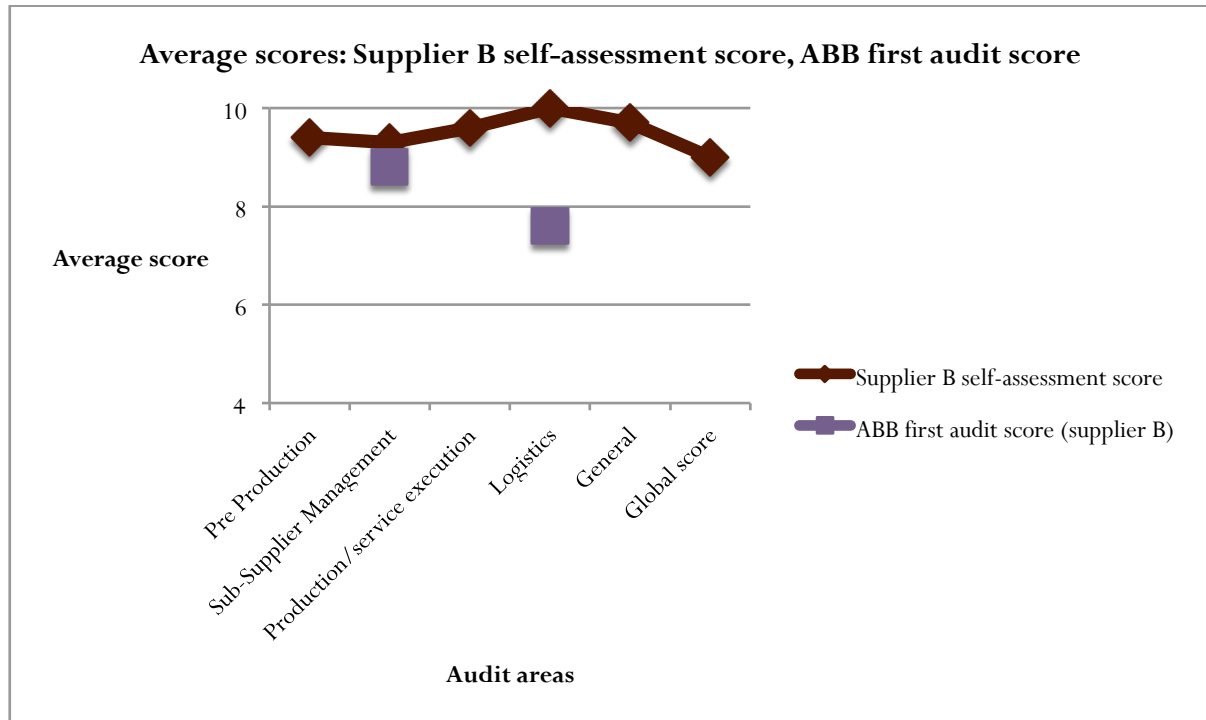


Figure 33: Average scores from supplier B self-assessment and ABB first audit

In the figure, the scores from the supplier B self-assessment questionnaire (red line) are plotted in comparison to the scores from the ABB first audit questionnaire (purple line). The supplier self-assessment grades are higher in both audit areas than the score given by ABB.

### 6.2.3 Feedback area 3: The audits are not performed and documented in a consequent manner

The following areas were studied when investigating feedback area 3:

- The most frequently used audit templates;
- The differences within the audit process, e.g. which documents are sent to the supplier;
- The responsibility for the different steps in the audit, e.g. who is to follow up the audit;
- The communication within the audit process, e.g. how the auditors share the information between each other;
- The documentation of the audits, e.g. where the documents are saved.

80% of the survey participants agree with the statement *Every audit is different and needs to be handled individually, and therefore standard templates are hard to use*. 20% disagree, meaning that they believe it is not difficult to use standard templates.



On the other hand, 70% of the survey participants agree with the statement *It would be good to have one standard template with clear guidelines for how to perform all audits*, whereas 30% partly agree with the statement. One participant comments that it might be a “mission impossible” to have one standard template.

### 6.2.3.1 Most frequently used audit templates

As can be seen in figure 34 below, the template for auditing an already existing supplier, the PAQ audit, has been used by 80% of the survey participants during the last two years. Thereafter follows the SQP, which is the template for auditing potential new suppliers. The templates for Sustainability audit and Environment, Health and Safety (EHS) issues have been used by a relatively small number of survey participants.

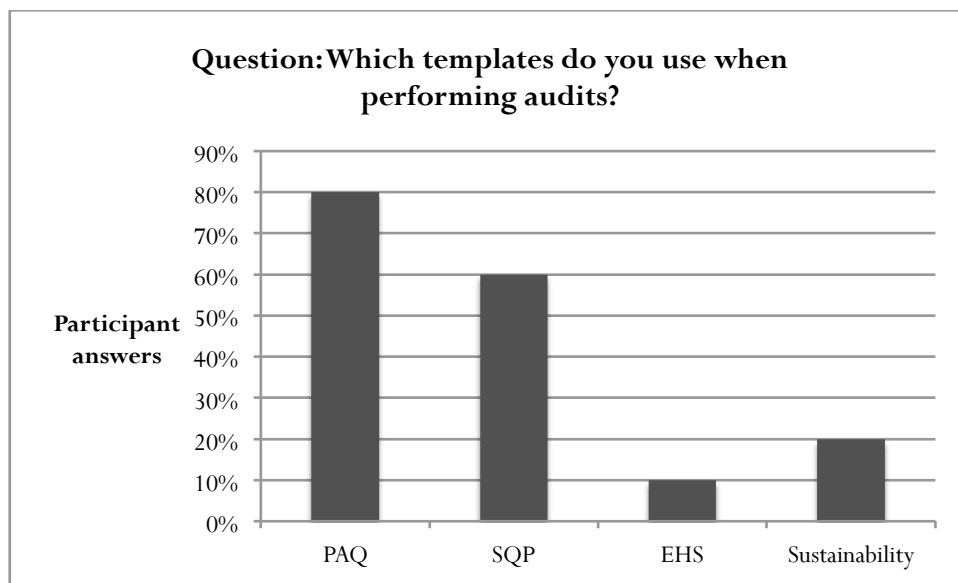


Figure 34: Survey answer regarding the used audit templates during the last two years

According to the survey participants some have also used own made checklists.

The study of old audit material also confirms that the PAQ is the audit template most frequently used. Table 9 below shows what templates were used in the seven supplier cases plus the two complete cases.

Audit case	Template
Case A	PAQ
Case B	PAQ
Case C	PAQ
Case D	PAQ
Case E	PAQ
Case F	SQP
Case G	PAQ
Case H	PAQ & SQP
Case I	PAQ & SQP

Table 9: The audit templates used in the nine cases

In eight out of nine audit cases, the PAQ is used on its own or in combination with the SQP.

### 6.2.3.2 Used documents in the audit process

The continuity of the process is linked to whether the same documents are sent to the supplier each time when conducting an audit, independent of the focus of the audit or the template used. Such information is the Letter to Supplier, stating what the purpose of the audit is, the ABB Supplier Code of Conduct, and the Audit Agenda, giving the supplier a more detailed picture of the upcoming audit. The survey participants are asked which ones of these documents they send to the supplier prior to an audit.

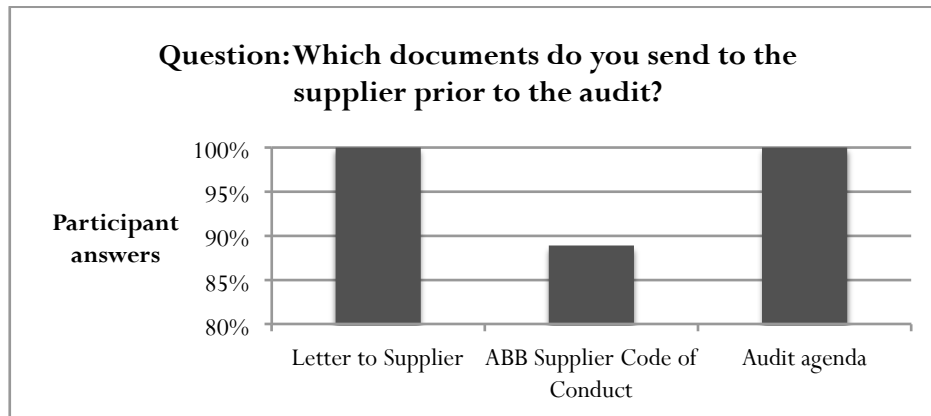


Figure 35: Survey answers regarding what documents the auditors send to the supplier prior to the audit

As can be seen in figure 35 above, all participants of the survey send the Letter to Supplier and Audit Agenda prior to the audit. Approximately 90% of the participants send the ABB Supplier Code of Conduct to the supplier prior to the audit.

However, on the question *When performing the audits, do you always use the same approach or does it differ depending on supplier, product/component, location etc.*, 100% of the participants who answered stated that it differs; the approach depends on the supplier, product/component or location.

What documents to send to the supplier prior to an audit is stated in some of the audit templates' user guides. In some of the guides it is also stated whether more information is to be filled in besides the audit template, such as the Supplier Information Sheet. Table 10 below shows the four different audit templates and what documents, according to the audit template guide, are to be filled in or sent to the supplier prior to the audit. Those documents are marked with a cross in the table. The hyphen means that there is no requirement to use the specific document.

Audit process	SQP	PAQ	Sustainability Audit	EHS Audit
Supplier Information Sheet/Supplier profile	x	-	x	-
Letter to Supplier	-	-	x	-
Audit Agenda	-	-	x	-
ABB Supplier Code of Conduct	x	-	-	-
ABB Supplier Requirements	x	-	-	-
ABB Sustainability Policies	x	-	-	-

Table 10: The audit templates require the auditor to use different documents

As can be seen, while according to the SQP guide, the Supplier Information Sheet, ABB Supplier Code of Conduct, ABB Supplier Requirements and ABB Sustainability Policies are to be sent to the supplier, the PAQ does not require the auditor to use any of those documents. Also, the EHS audit guide does not inform the auditor to send any of the mentioned documents to the supplier. According to the Sustainability Audit, the Supplier Information Sheet, Letter to Supplier and Audit Agenda, are to be included in the audit.

The general data request sent to the supplier should describe the general business and give an indication of whether the supplier’s business is going well. The Supplier Information Sheet is a front page to the SQP, containing information regarding the management team, top 5 shareholders, largest customers, suppliers etc. When asking if this information sheet is updated with every new audit, one third of the survey participants answer *yes*. 30% answer that *It is partly updated or sometimes updated* and another 30% say *No, the Supplier Information Sheet is not updated*. From the 30% who answered no, two out of three explain that they instead pass this task on to the supply department. The Supplier Information Sheet is only part of the SQP.

### 6.2.3.3 Responsibilities when conducting audits

The responsibility of the survey participants when conducting audits is spread, as can be seen in figure 36 below.

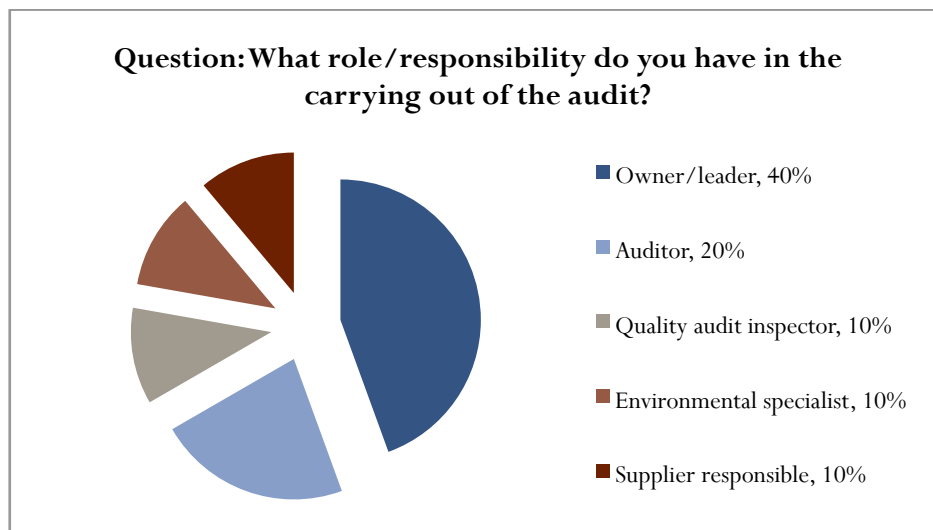
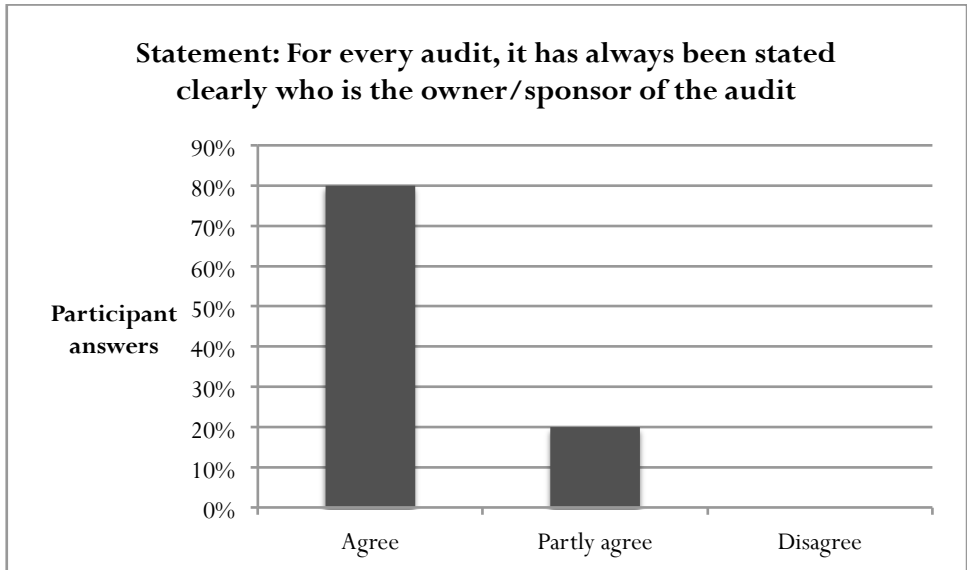


Figure 36: Survey answers regarding the responsibility of the participants from ABB when conducting audits

The responsibilities cover everything from audit owner, over quality audit inspector to environmental specialist. 10% did not answer the question.

The survey participants are also asked about what business function they work in. The number of auditors working in the supply department is the same as the number of auditors from the quality department. 10% of the auditors work for a local sustainability department.

According to the survey answers, the general opinion is that the responsibilities are usually stated clearly when conducting audits, as can be seen in figure 37 below.

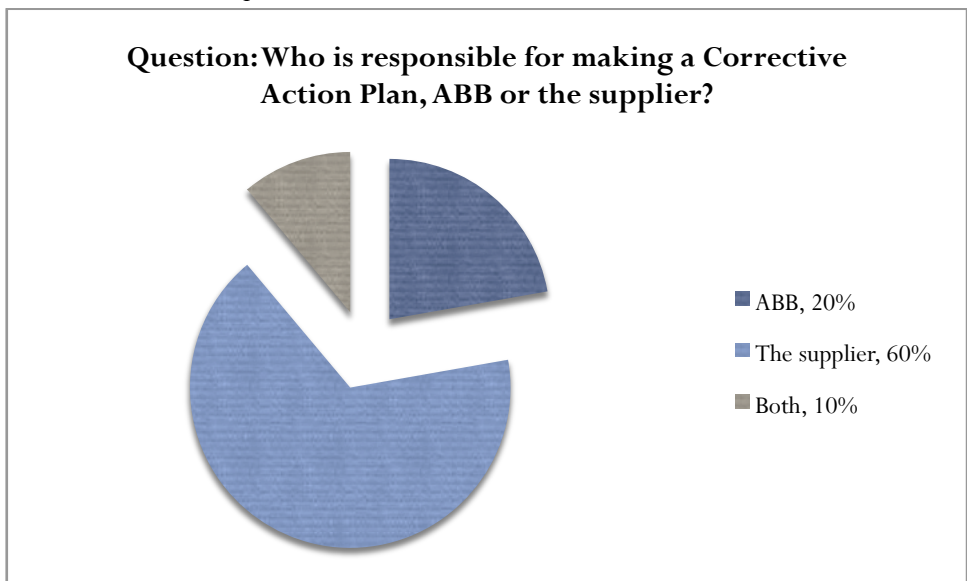


**Figure 37: Survey answers regarding the responsibility of the auditors**

The majority of the survey participants say that it has been clear who is responsible for the audit, i.e. audit owner.

When it comes to the responsibility of following up the audits, the opinions differ. 80% of the survey participants state that ABB is responsible for following up the audit, ensuring that a Corrective Action Plan (CAP) is formulated and corrective actions are followed through. However, the opinion on whose responsibility from the ABB side it is to follow up the audit differs. Approximately 40% of the survey participants who say that ABB is responsible for the follow-up, state that it is the supply department’s responsibility to ensure the follow-up. 25% state that it is the quality department’s responsibility to ensure that the follow-up is performed.

When asking the survey participants whether it is ABBs or the supplier’s responsibility to make a CAP after the audit, the opinions differ.



**Figure 38: Survey answers regarding the responsibility of making a Corrective Action Plan, CAP**

As can be seen in figure 38 above, a majority answers that it is the supplier's responsibility to make a CAP, 20% say that ABB is in charge of that task and 10% believe that it is both ABBs and the supplier's task. The remaining 10% do not answer the question.

The answers also differ when asking the survey participants about what supplier representatives they prefer to work with when conducting an audit. The answers cover all roles from quality, safety, production, assembly, operations, and site management, to HR and senior management.

#### 6.2.3.4 Communication between the auditors

The survey participants are asked to comment the communication between the auditors of different business units. As can be seen in figure 39 below, it is clear that there is a lack of communication. The majority of the survey participants say that there is no communication at all between auditors of different business units or departments.

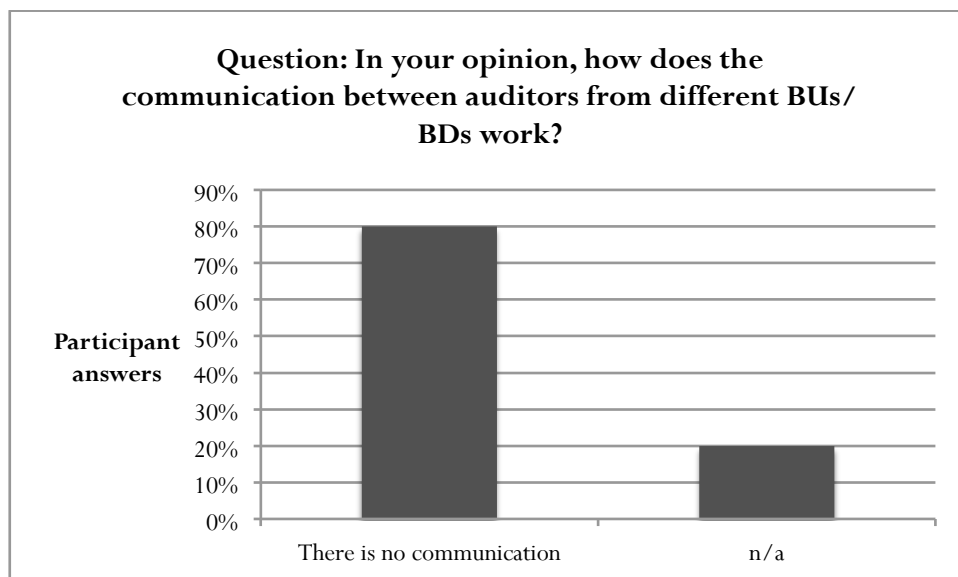


Figure 39: Survey answers regarding the communication between different auditors

The survey participants are also asked if they would find it helpful if the auditors could share information and experiences regarding performed audits. As can be seen in figure 40 below, the majority expresses that they would find it helpful to share auditing experiences.

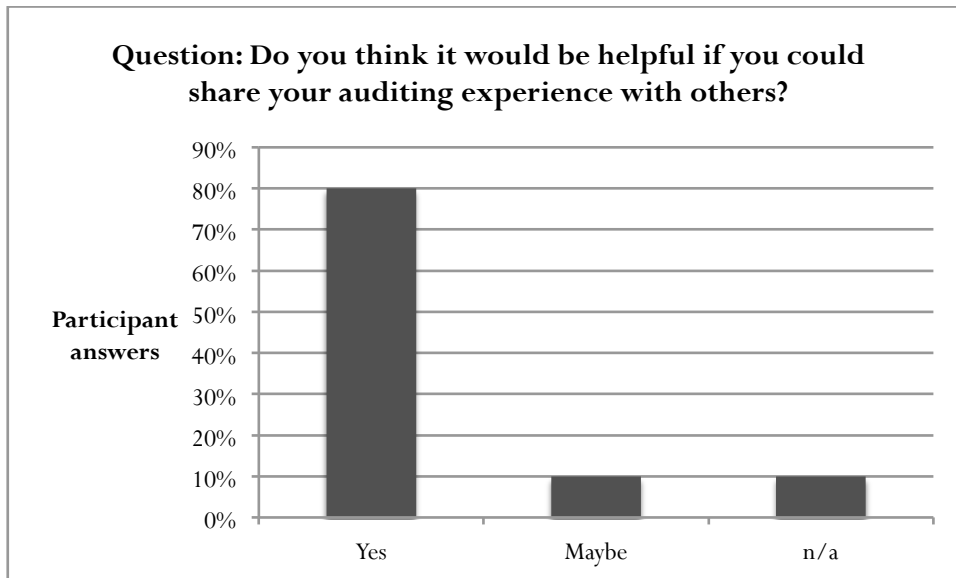


Figure 40: Survey answers regarding the helpfulness of sharing information

The survey participants are also asked how they would like to share the information and how the communication between auditors could be performed. The ideas that are expressed are to have a forum where it is possible to share best practices and difficulties of audits, or have group discussions and personal communication.

#### 6.2.3.5 Documentation of audit material

The audits are documented in different ways. As can be seen in figure 41 below, the majority of the survey participants document the audit information on the so-called Supply Management disc. A minority uses PA Sharepoint and the C2 tool.

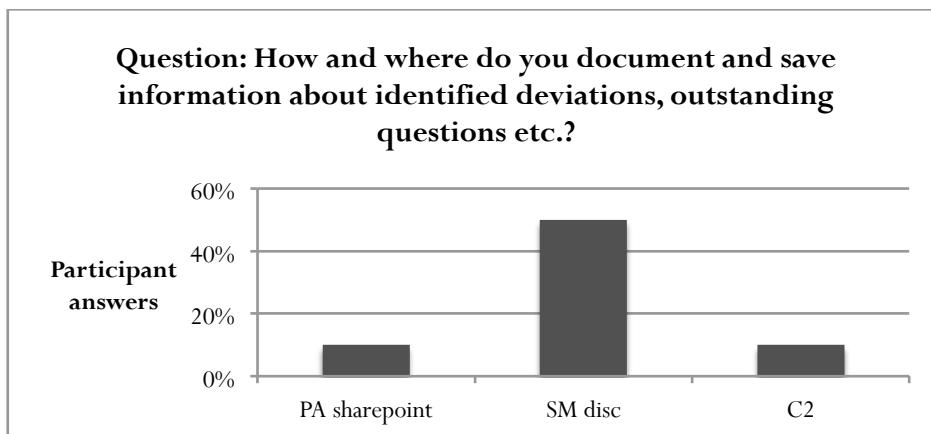


Figure 41: Survey answers regarding the documentation of audits

The tool C2 is today used at PA Sweden to administrate audits. Not all survey participants use the tool. All the participants who use C2 (20%), state that the tool is not or partly helpful. All survey participants who have been in contact with the tool C2, without necessary using it on a regular basis in their documenting work, find it hard to use the tool. For example, the opinion is expressed that it is difficult to find old documents in C2. Another comment on the tool is that the search function is not satisfying.

#### 6.2.4 Feedback area 4: Personnel conducting audits have not participated in audit training

The feedback area regarding audit training covers the questions whether the survey participants have participated in any training, and if not, whether they would like to do so and how such training could be performed.

As can be seen in figure 42 below, 60% of the survey participants have at some point during their employment at ABB participated in audit training.

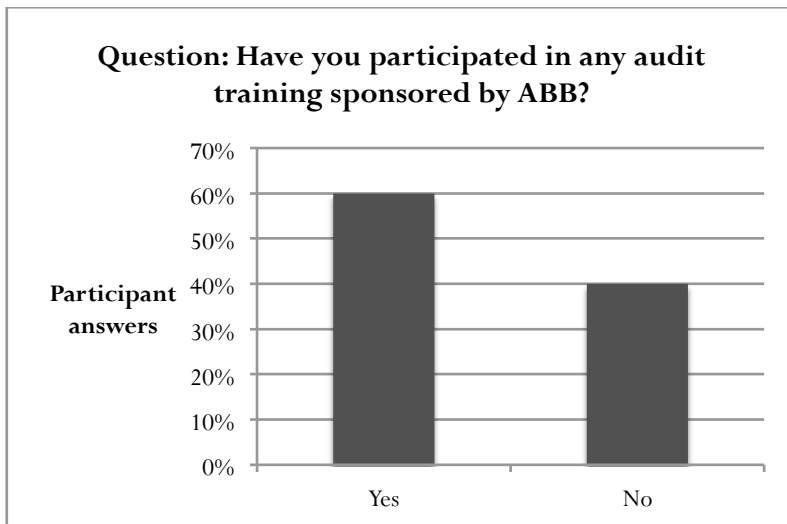


Figure 42: Survey answers regarding audit training sponsored by ABB

From those who have participated in audit training sponsored by ABB, 90% state that the training has helped them in conducting audits, as can be seen in figure 43 below.

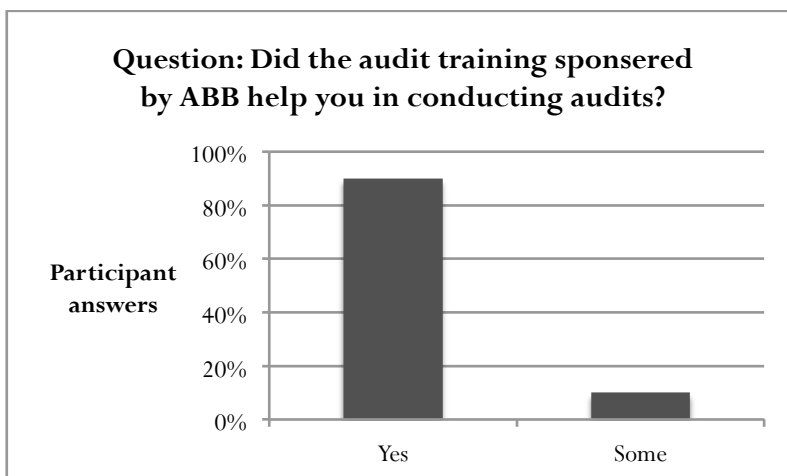


Figure 43: Survey answers regarding the helpfulness of audit training

The participants, who have not participated in any audit training sponsored by ABB, are asked whether they would be interested in participating in such training. With 100% answering yes, it is clear that there is a big interest in audit training, as can be seen in figure 44 below.

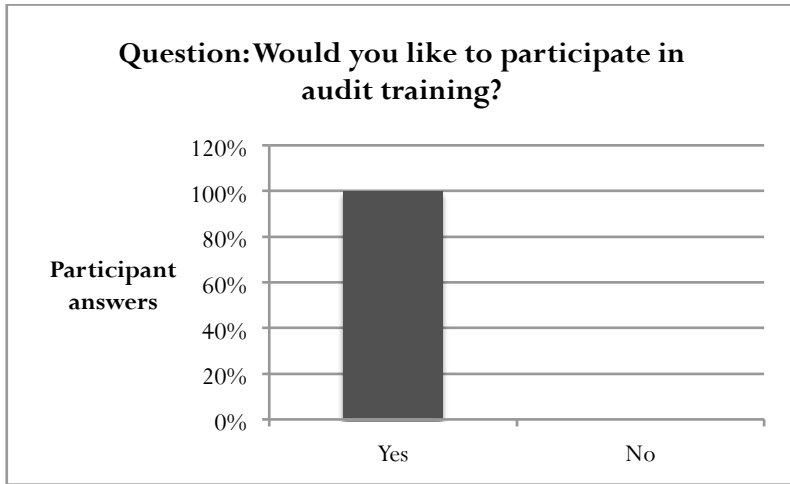


Figure 44: Survey answers regarding the interest in participating in audit training

Even though 60% of the survey participants have received audit training *sponsored* by ABB, that does not mean that the audit training has been *carried out* by ABB.

As can be seen in figure 45 below, only 10% of the survey participants have participated in internal audit training performed by ABB. Of the people who have not undergone internal ABB training, 50% of those have participated in external training performed by different organizations, such as ISO consultants and external auditing organizations.

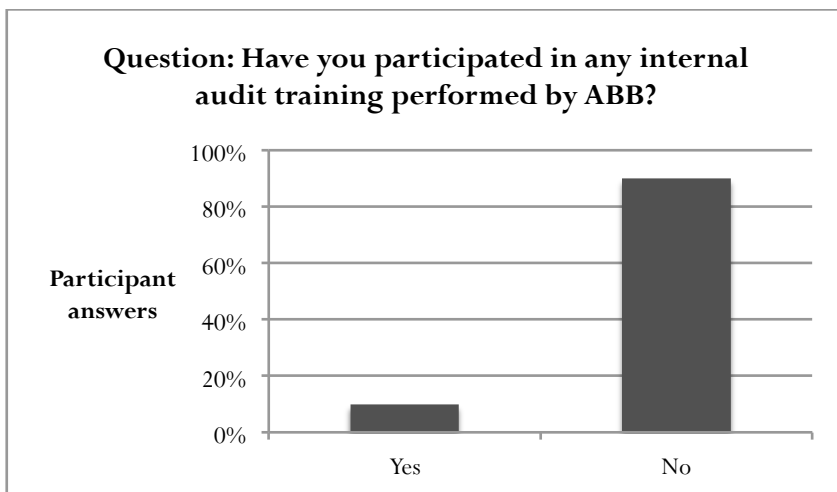


Figure 45: Survey answers regarding participation in internal audit training at ABB

The survey participants are also asked how they would want audit training to be carried out. The different answers can be summarized into two opinions:

- Training sessions should last between two and four days.
- Training sessions should be conducted face-to-face, in other words not online/e-learning.



### 6.3 Summary of Empirical phase II

In this chapter, ABB audit templates, old audit material and a survey make out the basis for the empirical study.

A majority of the survey participants do not find the supplier audit process to be satisfactory as it is designed today. Summarizing the gathered information and survey feedback, the four feedback areas are commented as follows:

- *Feedback area 1: The audits are conducted too seldom*
  - 1.25 audits are conducted per person and year.
  - The PAQ template is the most frequently used, and it has been used to conduct audits focusing on other areas than its main purpose as well.
  - The majority does not know of an ABB policy for the interval of conducting audits.
  - During the years 2009-2011, more audits were planned than completed in the business divisions PACT and PAMP.
- *Feedback area 2: The suppliers usually get high scores when the audits are conducted*
  - The general attitude towards auditing is positive, among ABB auditors as well as suppliers.
  - The four different audit templates all have different scoring scales, meaning that the suppliers are graded with different scores depending on the focus of the audit.
  - The average *Global score*, which is the total score of a PAQ audit, is 8.61. The maximum score is 10.
  - When grading the supplier the highest score 10 on a question, 40% of those questions are not commented or only commented with a simple *yes*. Thus, almost half of the highest scored questions are not motivated at all.
  - The ABB audit score is consistently lower than the supplier self-assessment score graded prior to an audit.
- *Feedback area 3: The audits are not performed and documented in a consequent manner*
  - A majority of the survey participants state that every audit is different and needs to be handled individually. However, many also agree on that a standard template would be good to have.
  - The four different audit templates all have different guidelines regarding what documents to send to the supplier prior to an audit.
  - Regarding the responsibility for the follow-up of an audit, the opinions differ. The majority states that it is ABBs responsibility to ensure the follow-up, but whether it is the supply department's or quality department's responsibility to do so is not clearly communicated.
  - The majority finds the supplier to be responsible for the CAP, but some participants state that it is ABBs responsibility.
  - The majority states that there is no communication between ABB auditors from different BUs/BDs. A majority of the survey participants has the opinion that such communication would be helpful.
  - The survey participants save the audit documents in different locations, such as Supply Management disc, SM disc, PA Sharepoint, C2, and also on local hard drives.

- *Feedback area 4: Personnel conducting audits have not participated in audit training*
  - A majority of the survey participants have participated in audit training, but only 10% have participated in ABB specific training.
  - The majority finds the training to be helpful, and 100% would like to participate in audit training performed by ABB.
  - According to the survey participants, such training sessions should be between two and four days long and conducted face-to-face, thus not online.

## 7 Analysis phase II

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*This chapter collects the data from Empirical phase II, and the evaluation has its focus on proving or disproving the feedback area questions concluded in Analysis phase I. The data is also analyzed using the theory from chapter 3 Theoretical framework. The result from Analysis phase II is the basis for the recommendations that are suggested to ABB.*

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### 7.1 Analysis of Empirical phase II

Firstly, a more general discussion regarding the theory and how it is connected to the ABB case is presented. The discussion is based on the risk management topic, which is the corner stone of this Master Thesis. Secondly, the focus of the analysis is on the four feedback areas:

- *The audits are conducted too seldom.*
- *The suppliers usually get high grades when the audits are conducted.*
- *The audits are not performed and documented in a consequent manner.*
- *Personnel conducting audits have not participated in audit training.*

Each feedback is presented individually and concluded with recommendations.

### 7.2 Returning to the theory

#### 7.2.1 Risk analysis

Figure 46 below shows the Kliem & Ludin *Deming wheel* presented in chapter 3 Theoretical framework, which displays the different steps of risk management. The authors have extended the figure with an overview of how the issues and areas that are covered by the empirical studies and analysis in this study are connected to the general topic of risk management. The authors have added the orange squares to the figure, showing how and which parts of this Master Thesis are related to risk management.

As can be seen in the figure below, the identification of the single source components of the control system Freelance is *risk identification*, which is a *plan* activity according to the model. It is found that an average of 23% of the components in the controller AC 800F are single sourced. The impact and probability of such risk can be analyzed using the *Risk exposure matrix* presented in figure 10 in chapter 3.1.1.4. When calculating the risk exposure using the matrix, it can be explained as a *do* activity according to the *Deming wheel* model. A tool for the *check* activity, including *risk control*, is to perform audits. To follow up the audits, formulate a Corrective Action Plan (CAP) and perform the actions are tools for *risk reporting* and are examples of *act* activities. This closes the risk management circle.

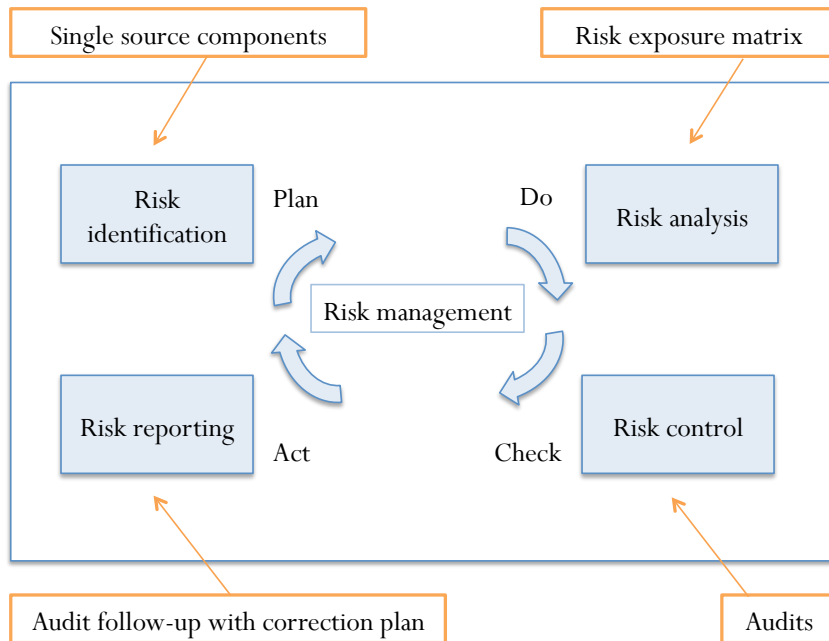


Figure 46: The link between the theoretical framework and findings

### 7.2.1.1 Single source components and the risk exposure matrix

The products that ABB PACT supplies to the end customer consist of about 23% single sourced components, according to the simplified supply chain mapping performed for the controller AC800F, which is a component of Freelance. Single source components pose a risk exposure according to Gardiner’s *Risk exposure matrix* (chapter 3.1.1.4). In the matrix, a risk is categorized based on its probability of occurring and its impact if occurring.

As can be seen in figure 47 below, the authors have modified Gardiner’s *Risk exposure matrix*. The variables are now *substitute suppliers*; the number of alternative suppliers, and *transaction time*; the time it takes to find and contract an alternative supplier. By plotting the single source components in this modified matrix, a rather quick and easy risk assessment could be performed. Naturally, in order to be able to determine the number of existing substitute suppliers and the length of the transaction time, it is necessary to have knowledge about the complexity of the component and the number of alternative suppliers present on the market.

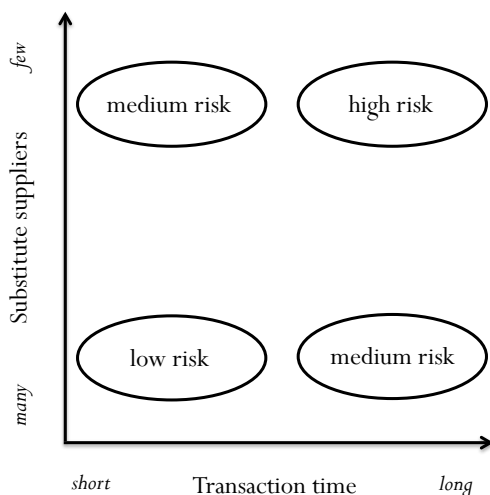


Figure 47: Risk exposure matrix of single source components - modified version

The number of substitute suppliers is the first variable, seen on the vertical axis. If there are *many* companies on the market that could produce an equivalent product satisfying the ABB requirements; i.e. there are many substitute suppliers, the single source component implies a relatively *small risk*. On the other hand, if there are *few* substitute suppliers, the single source component implies a *higher risk* since it would be difficult to switch to another supplier if needed.

The transaction time of changing from one supplier to another is the other variable, seen on the horizontal axis. If it is possible to change the supplier of the component quickly, the transaction time is *short* and the *risk* is considered rather *low*. On the other hand, if it is time intensive to find a different supplier, i.e. the transaction time is *long*, then that specific single source component implies a *higher risk*.

### **7.2.2 Managing risk**

As shown in chapter 3.1.1.2, Gardiner states that there are different kinds of risk. The risks that this Master Thesis touches upon is mainly the risk that single source components imply as well as the risk of being dependent on the supplier's performance. These risks are so called *manageable risks* coming from a source of *factors that are under project control*. According to Kliem & Ludin, conducting audits is a form of *risk control*. By auditing a supplier, ABB has the chance to manage the potential risks. The main risk lies within the supplier's processes and those can be modified by the process owner.

According to Gardiner, when identifying different risks, they should be prioritized according to different elements. At ABB PACT, potential risks within the supplier's processes are identified using the audit questionnaires and templates and corrective actions are proposed. The risks are then ranked according to different factors.

### **7.2.3 Audits as a tool for managing risk**

Oakland states that key is prevention to handling quality control, see chapter 3.3.3. The evaluation of the suppliers using audits should be performed by staff with the appropriate knowledge. Bringing a "separate police force" to an audit is not recommended by Oakland. Instead, operative personnel with the right competences, preferably from the quality and supply departments of the organization, should be responsible. That is how the auditing is organized within ABB PACT today. The quality and supply departments share the responsibilities for conducting audits.

With clearly stated performance targets communicated to the supplier, the supplier should receive the audit results and the post-audit follow-ups without being surprised about the rating. According to Foster, the audit results should have a clear development focus and are aiming at helping the suppliers to ensure and improve product quality and process objectives, see chapter 3.3.3. The follow-ups have the potential to transform deviations into improvement potentials. It is therefore important that the development focus of the audits is emphasized and that there are resources allocated for the supplier development. Performing audit follow-ups is a form of *risk reporting*, as can be seen in figure 46 above. The follow-ups should report the findings from an audit to the supplier as well as to the supply and quality department in charge for the supplier development.

## 7.2.4 The audit process at ABB PACT

According to van Weele, the purchasing activities are divided into primary activities and support activities, see chapter 3.4. Auditing is a support activity that supports the primary activities towards delivering value to ABB. Figure 48 below displays the *purchasing process model* from chapter 3.4.1. It shows where ABBs four audit processes/templates are positioned in the purchasing model (marked with orange).

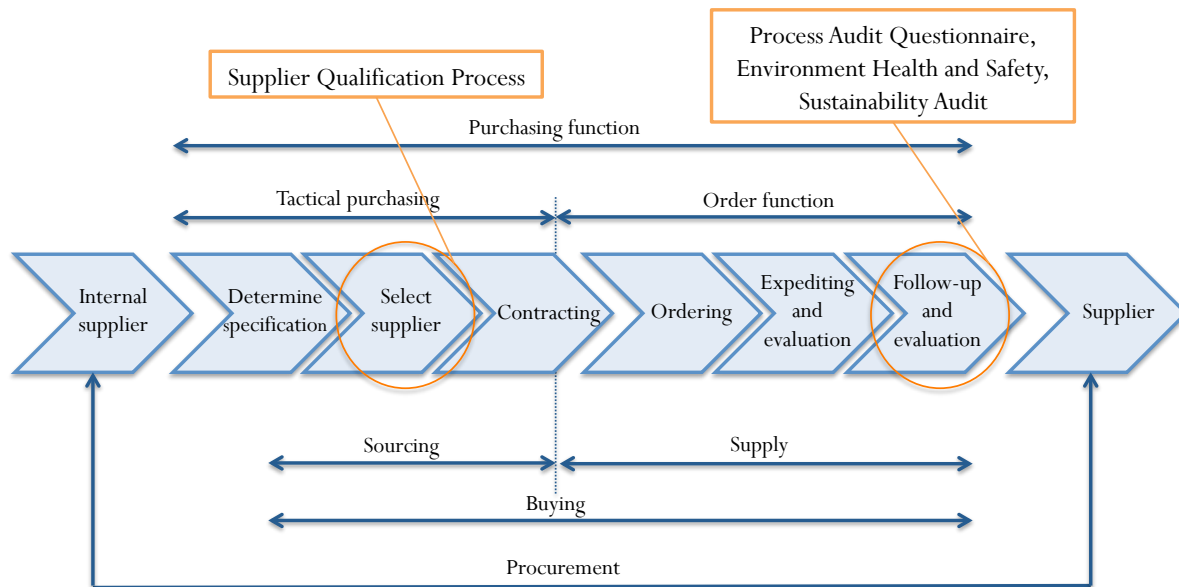


Figure 48: ABBs audit work in the purchasing function

The *Supplier Qualification Process (SQP)* is used when a new supplier is selected. The SQP is a tool that is used to evaluate whether the supplier meets ABBs requirements and can be selected to supply ABB PACT with components or not. When the supplier has been approved and a contract has been formulated, the partnership with the supplier is established. The *Process Audit Questionnaire (PAQ)*, *Environment Health and Safety Audit (EHS)* and the *Sustainability Audit* are used to follow-up and evaluate, or in other words, maintain and develop that partnership.

According to SIS, establishing and communicating clear responsibilities is a crucial step in the start-up phase of the audit. Furthermore, the standard says that individuals conducting audits should have both management, technical and audit understanding, see chapter 3.7.2.1. Professional audit understanding, provided by audit training, is something that the PACT auditors have generally lacked in the past.

Another deviation between the theory and the ABB case is that according to the SIS guidelines for auditing, the supplier's documentation should be reviewed prior to the on-site audit activities. This is not the case for ABB today. ABB PACT would most likely speed up the audit process if the supplier's processes were reviewed prior to the audit and in that way limit the on-site assessment to controlling the information from the supplier. The procedure that ABB PACT uses for conducting audits is in line with the ISO guideline though, which proposes that the audits should be conducted with interviews, observations of activities and reviewing of documents.

### 7.2.5 Returning to the theory – summary

Risk management includes the steps from *risk identification – plan*, and *risk analysis – do*, to *risk control – check*, and *risk reporting – act*. Performing audits is a part of the risk management process and can help in handling and preventing risk issues within supplier relations. Also, conducting audits is a tool used when selecting new suppliers and following-up and evaluating supplier relations. It is important that the audits are performed in an efficient and consequent manner, in order for the suppliers and auditors to get the most out of the audit activities.

The audit processes at ABB PACT at some points follow and at other points deviate from the guidelines presented in the theory.

### 7.3 Analysis of the feedback areas

This part of the chapter is divided into the four feedback areas, where each feedback area is analyzed individually, resulting in the authors' recommendations for each area. The recommendations are categorized using the two factors:

- *Implementation ranking*  
An indication of the difficulty level for the implementation of the recommendation.
- *Potential impact*  
An indication of the potential positive impact the recommendation would have if implemented.

The implementation ranking is divided into easy, medium, and difficult:

- *Easy*: Little time, effort, and/or financial resources needed for the implementation.
- *Medium*: Considerable time, effort, and/or financial resources needed for the implementation.
- *Difficult*: Much time, effort, and/or financial resources needed for the implementation.

The potential impact is divided into small, medium, and large:

- *Small*: The implementation will facilitate and improve the audit process slightly.
- *Medium*: The implementation will facilitate and improve the audit process.
- *Large*: The implementation will facilitate and improve the audit process significantly.

The categorization of the recommendations is based on the authors' assumptions and should only be seen as an indication.

#### 7.3.1 Clear instructions by management – prerequisite for the improvement work

For the analysis and recommendations that follow, there is one main prerequisite requested by the authors. In order to implement changes and improve the audit process at ABB PA/PACT in a consequent and sustainable way, a clear supplier audit organization is needed. Hence, this can be seen as a general recommendation that needs to be implemented in order for the other recommendations to function at all.

A supplier audit organization at ABB could be managed in different ways. One ABB centralized and global audit organization could be an option. However, the authors find that alternative to be too bureaucratic and viscous and not as efficient and alert as needed in this case. Hence, the supplier audit organization should consist of a PA/PACT specific team in charge of the changes, implementation and development of the improved audit process. Key players within auditing should compose such a team and sufficient time should be allocated for the supplier audit organizational tasks.

### **7.3.2 Feedback area 1: The audits are conducted too seldom**

When initiating conversations with ABB employees regarding auditing in Empirical phase I, the issue of time allocation and frequency of conducting audits was addressed. The authors discussed whether there is a policy for the intervals and frequency of audits with supply and quality department key players. According to them, it is true that in order for the supplier audits to be the efficient tool that it has potential to be, it is important to have consistency in the audits. The frequency of the audits has to be chosen so that deviations are detected and corrective actions and improvements are initiated on time. Today, the ABB audit processes are lacking in guidelines regarding when to conduct an audit. In the survey conducted in Empirical phase II, the survey participants answered questions regarding the frequency and nature of the audits conducted in the past.

#### **7.3.2.1 Lack in policy for when to conduct an audit**

When asking the survey participants whether ABB has a policy regarding the interval for conducting audits, the answers are widely spread. When discussing how an audit policy regarding audit frequency should be formulated, the opinions differ as well. Some find a set interval to be an option, such as once every three years or once every year, others think that deciding when to audit should depend on how the suppliers perform according to KPIs and the individual business unit's priorities.

Today, the supply department uses a *Supplier Performance Rating* list where the ranking depends on KPIs in five different criteria, see chapter 4.4.1. Clearly, even among key actors in the supply and quality departments, the knowledge of a policy regarding the frequency of conducting audits is small. Obviously, the policy of using KPIs to rank the suppliers and, according to this ranking, perform audits, is not communicated in an efficient manner. Despite the authors' repeated questions regarding such a policy within PACT, no clear answer could be given. The lack of knowledge regarding the frequency policy is probably due to the lack of clear management of the audit process.

#### **7.3.2.2 Planned and completed audits**

The number of completed audits were fewer than the number of planned audits during the years 2009-2011 for the business units PACT and PAMP. In fact, one year none of the planned audits were completed. If a planned audit cannot be conducted according to schedule, the audit is postponed and commented with a short explanation why it is postponed. This shows that the flexibility of the audit schedule is rather high, which is probably good. However, if the changes in plans are too easily accepted, the audits will not be a prioritized activity. It is clearly not favorable for the audit work. According to the *Supplier Performance Rating*, each business unit should decide at the beginning of the year which suppliers to audit and based on that, schedule the audits annually.

Today, key players in the audit process at ABB PA conduct on average 1.25 audits per year and auditor. Conducting supplier audits is a work task stated in the staff's rules and responsibilities when working



with supplier relationships within the supply and/or quality department. When comparing this with the fact that relatively few audits are performed per person and year, the authors' conclusion is that there is a lack in the frequency policy for conducting audits. Such a policy should state clearly when an audit should be performed, and the information should be communicated to all involved parties.

There is a risk with different auditors deciding differently when and why to conduct an audit. An issue that one auditor finds urgent enough for an audit to be conducted might be something that another auditor would consider less important and not plan an audit for. This might cause priority issues in a team as well as confusion for suppliers who are in contact with different people within the ABB organization.

Also, it seems like a short comment justifying the postponement of a planned audit is sufficient and that no other explanation is needed when rescheduling an audit. The general impression is that the audits are not of prioritized nature.

### ***7.3.2.3 Different types of audits***

Another interesting matter is the fact that 30% of the survey participants state that they have never performed an audit focusing on questions regarding either environmental, financial, work safety or ethical issues. During the year of 2011, the Swedish PA division conducted one environmental audit. Considering the PACT supply chain vision with the goal of sourcing 70% from emerging markets by the year of 2015, one could wonder what risks ABB exposes itself to when conducting only few environmental audits. Considering this vision, such audits should be of high priority.

The authors find that sourcing from emerging markets implies a bigger risk regarding suppliers with environmental, safety and ethical issues than sourcing from developed markets. Moreover, suppliers on emerging markets are located in a wide geographical area in relation to where the main offices of ABB are located, and this also implies less control of the cooperation with them. The loss of control implies a risk, which should not be neglected. A simplified example of a possible worst-case scenario would be if a contracted supplier on an emerging market, where the audit activities have been postponed and not prioritized, would use child labour or any other discrepancies. How would then ABB react and justify the choice of such supplier? However, if having a clear policy for how and when to conduct audits, from the first stage of qualifying a new supplier to the follow-up visits in established relationships, cases like this could be prevented or discovered on-time for corrective actions to take place.

### ***7.3.2.4 Recommendations, feedback area 1***

The lack of a clear policy for when to conduct an audit is obvious. The authors are convinced that with a clearly communicated policy, the audits would be planned and also completed in a more consistent manner.

Furthermore, it seems like all auditors know that the task of conducting audits is within their stated rules and responsibilities. However, the audits are not prioritized and postponed if the time for conducting an audit is lacking. It needs to be clear that conducting audits requires both time and effort, which are crucial factors in a well-performing supplier relationship.

Since rewarding works better than punishment for motivation, it is the authors' suggestion to reward the business units that are best-practice examples of how to conduct audits, including procedure, documentation and frequency. This could motivate the auditors to conduct more of the planned audits, which would raise the priority of doing so. In combination with increased communication between different auditors and audit teams, the procedures and time management of such best-practice teams could then be shared with others in order to streamline the global audit process.

*Recommendation 1.1: Supplier KPI policy for auditing*

- A. All auditors should receive the same clear instructions regarding a policy that requires an annual supplier KPI update.

**Implementation ranking:** Medium

**Potential impact:** Medium

- B. The result of the KPI rating should show clearly if an audit has to be conducted or not. Clear limits and guidelines in the rating should be communicated.

**Implementation ranking:** Easy

**Potential impact:** Medium

*Recommendation 1.2: Audit scheduling and best-practice reward*

- C. Based on the annual audit schedule, the business unit that completes most of the planned audits during that year should be rewarded as a “best-practice BU”. This reward can later be extended to include *how* the audits are performed as well, also covering the procedure and documentation.

**Implementation ranking:** Medium

**Potential impact:** Medium

**7.3.2.5 Summary, feedback area 1 – not proved nor disproved**

Since every supplier is different and the decision to conduct an audit depends on different factors, it is not possible to say whether the audits at PACT are conducted too seldom or not. Naturally, the number of audits per auditor should be in relation to how many suppliers he/she is responsible of. Even though feedback area 1 cannot be confirmed, some general issues have been found regarding the frequency of conducting audits.

The audit process lacks in clear communication regarding a policy for when to conduct an audit. Furthermore, the general trend the past three years has been that more audits have been planned than completed. Also, the average number of conducted audits per person has been relatively low and some of the survey participants state that they have never conducted an audit focusing on environmental, ethical or work safety issues. This is rather startling with the general supply chain vision in mind; to source 70% from emerging markets by 2015.

It is important to remember that conducting audits on a regular basis is crucial for maintaining well functioning supplier relationships. The auditors need to set aside time for conducting the number of audits according to plan.

In summary, feedback area 1 is neither proved nor disproved.

### **7.3.3 Feedback area 2: The suppliers usually get high grades when the audits are conducted**

When first learning about the audit process within PACT, the authors noticed that most people involved in the audits were positive towards the audits. The suppliers also find audits to be a positive element in the relationship with ABB. As some survey participants comment, the suppliers see the audits as a great way of correcting and improving parts of their business. This is an attitude that should be well taken care of and developed even further. It is therefore important to perform audits and follow-up the audits in a way that motivate for changes and improvements. Using accurate scoring is such a motivation factor.

#### **7.3.3.1 High audit scores**

The general impression among the auditors regarding the audit scoring is that it is not functional as it is today. As one survey participant comments; “the scores are a joke!” When comparing the scores from the different audit areas in the nine cases presented in Empirical phase II, the average global score is 8.61 in the PAQ. Considering that the highest possible score is 10, the scores are relatively high. Having constantly high scores can lead to the belief that everything is in order even though there might still be deviations from a perfect performance. The high scores reduce the motivation for both the suppliers and the auditors to focus on improvements. The authors find that the issue depends on the scale and grades that are being used today as well as the simplicity of scoring with the highest score 10 without a required comment.

#### **7.3.3.2 Different templates with different scoring scales**

There are four different audit templates being investigated in this study. All four templates use different scoring scales. The types of scoring reach from commenting questions with *yes, partial, no*, over *0-10*, to two variations of *0-4*. It is obviously confusing and hard to handle four different audit templates with four different scoring systems. This leads to the auditor having to spend more time on understanding the audit template than if the scoring was based on the same system for all templates. These different scoring systems might be a reason for the PAQ by far being the most frequently used audit template. The scoring system in the PAQ is rather simple with scores from 0 to 10. The authors find the other scoring systems more complicated or at least being less explained regarding instructions for usage.

Since the scoring scale of 0 to 10 is rather large and consists of many digits, it is the authors' suggestion to change the grades ranging from 1 to 5 instead. Score 5 would then be the highest score; *the supplier meets all ABB requirements*, and score 1 would mean that *an alternative supplier must be defined*. A 1-5 scoring scale is easier to understand and use, and the full scale would most likely be used. This is not the case today, with the large amount of numbers in the scale from 0 to 10.

#### **7.3.3.3 Wider scales**

The supplier improvement target should always be to reach a 100% score. The current scoring limit in the SQP for a supplier to be qualified by ABB is 80%. This means that the scale from qualified, 80%, to perfect, 100%, is relatively small. In that way, the potential for improvement is suddenly limited. If changing the scale to offer a wider range from qualified to all requirements met, the authors think that the supplier improvement potential would be more obvious and the motivation for improvements

would increase. By increasing the scale to a qualification level at 50%, the distance to a 100% score is larger as well, which should increase the motivation for reaching closer to the 100%.

This in combination with the above proposed 1-5 grading scale, the 50% qualifying grade would be 2.5. To avoid using decimals, the qualifying grade is rounded up to be the closes integer 3.

#### **7.3.3.4 Required comments**

Approximately 35% of the PAQ questions scored with a 10 are not commented at all or only with a “yes”. Unfortunately, the current grading system does not require the auditor to motivate the 10-graded questions. That might tempt the auditor to distribute more 10s than the suppliers would actually deserve. The aim of the audit is to identify areas of improvement. This “simple” way of scoring and commenting the highest grades is therefore counterproductive for the audit outcome for ABB as well as the supplier.

Requiring the auditor to comment and motivate each score would most likely increase the accuracy of the scoring. By having to justify why a particular question got a particular score, independent of what question it is or what the score is, the auditors will reflect more on why a certain score is given. In order to justify and motivate a score, the auditors need to truly understand the question. This would lead to a more accurate supplier score, which, in the long run, would be of greater value to both ABB and the supplier, especially if the scale is widened. Clearly motivated scores also increase the usefulness of documented audit material for ABB personnel, interested in information regarding a supplier.

#### **7.3.3.5 Deviation between supplier scoring and ABB scoring**

Another area of interest is the deviation between the supplier self-assessment grades and the PAQ audit grades performed by ABB auditors. The supplier seems to grade himself/herself higher than ABB, indicating that basing a qualification of a supplier only on the self-assessment grading is risky.

The grades increase from a first PAQ audit performed by ABB to a follow-up audit also performed by ABB. This shows that follow-up audits and corrective actions support the supplier development process and motivate for improvement work.

#### **7.3.3.6 Recommendations, feedback area 2**

An audit template should be a simple tool. With all current audit templates using different grading systems, the tool is more complicated than necessary. Therefore, the authors suggest that all four audit templates being used today should implement the same scoring system. This would simplify the process and probably increase the number of “alternative” audits being performed, such as sustainability and EHS audits. By streamlining one part of the audits – the scoring system, the auditors would also feel more secure in how to perform the audits, making the work more efficient.

The suppliers generally score high with the scale of grades that is used today. This decreases the motivation for improvement work. By simplifying and increasing the grading scale, the scoring will become more accurate. By unitizing the grades used in all templates to a scale of 1-5, the scoring would be simplified. Through making 50% the qualifying level, the differences between suppliers and/or areas of improvement become clearer and it would be easier for the auditors to prioritize between them.

With requiring the auditors to comment all assigned scores, the accuracy of the grades will increase. The motto should be “motivate first – then score”.

*Recommendation 2.1: Same scoring system for all audit templates*

- D. All audit templates should use the same scoring system, using a simpler and more straightforward scale.
  - The grades should be 1, 2, 3, 4, 5, with the grading limits and rules according to recommendation 2.2 and 2.3.
    - 1, *Alternative supplier must be defined.*
    - 2, *Immediate improvement actions to be taken.*
    - 3, *The supplier is qualified but an improvement program is needed.*
    - 4, *Would like to see improvements.*
    - 5, *Supplier meets all ABB requirements.*

**Implementation ranking:** Medium

**Potential impact:** Medium

*Recommendation 2.2: Wider grading scale, qualified from 50%*

- E. Qualifying level in grading should be reduced from 80% to the grade corresponding to 50% on the grading scale, providing a wider grading scale.

**Implementation ranking:** Medium

**Potential impact:** Medium

*Recommendation 2.3: Change the score-comment design in the questionnaires*

- F. Each question in the audit template should first be commented in own words by the auditor, motivating to what extent a certain requirement is met or not. Thereafter an appropriate 1-5 score should be given, reflecting the motivation.

**Implementation ranking:** Difficult

**Potential impact:** Large

**7.3.3.7 Summary, feedback area 2 – proved**

The aim of conducting audits is to improve supplier performance and it is important that the grading triggers the supplier to improve the processes as needed. Hence, the grading has to show clearly the areas of improvement. With an average PAQ total score of 8.61 from a maximum of 10, the scoring is considered high. Furthermore, there is a rather large share of more or less uncommented grades 10. The grades given to the suppliers are to display nothing but the truth and motivate for improvement. The audit areas should therefore be commented and motivated clearly and thereafter graded with a score from 1 to 5.

In summary, feedback area 2 is proved – the suppliers usually get high grades.

**7.3.4 Feedback area 3: The audits are not performed and documented in a consequent manner**

In an early stage of investigating the different audit templates and interviewing ABB personnel conducting audits, the authors understood that all audit templates and their associated processes are

different. The use of more standardized templates and processes could streamline and facilitate the conducting of audits in the future.

Even though the majority of the survey participants state that it is hard to use standard templates since all audit cases differ, 70% express that it would be good to have more standardized processes with clear guidelines. The overall opinion regarding the audit templates is that they are too general, making it hard to *deep dive* into one specific area.

#### **7.3.4.1 Audit templates**

The audit template most frequently used by the survey participants is the PAQ, followed by the SQP. Most participants have at some point conducted audits focusing on environmental, financial, work safety and ethical issues without using the corresponding template for it. Instead, they have used the small sections in the PAQ that are dedicated to those areas. It seems like even though there are special templates for special audits, they are not used.

#### **7.3.4.2 The audit approach**

Even though all survey participants say that the approach for the audits differs depending on the supplier, focus, product, etc., it should be possible to standardize the way a supplier is approached. The audit guides for the four templates contain different information regarding what documents to send to the supplier. Different information in the audit guides regarding the administration of the audits causes unnecessary confusion.

When asking the survey participants if they fill in the Supplier Information Sheet, the majority of the auditors who do not fill in the information instead pass that task to the supply department. The participants from the supply department state that they do not fill in the Supplier Information Sheet either, implying that the task is simply not done.

#### **7.3.4.3 Communication between auditors**

The majority of the survey participants state that there is no communication between the auditors from different BUs and BDs. At the same time, the majority of the survey participants express that they would find it helpful to be able to share experiences, questions, etc. with other auditors. They also express that they want to share such information in a forum. Hopefully, the tool ProSupply, which will be launched this year, will facilitate such communication and make it easier for the auditors to exchange information. If not, ABB should consider this obvious demand for more communication.

#### **7.3.4.4 Documentation of audit material**

The audit material is saved in various locations. Some share the information on the PA Sharepoint, which is globally accessible, some on a local Supply Management disc and other in the documentation tool C2, which is only used in Sweden. All survey participants who have been in contact with C2, without necessarily using it on a regular basis, express that it is hard to navigate in the tool, that the search function is not satisfactory and that it is hard to find old audit documents in it. One of the purposes of the tool is to administrate audit material, implying that it should be easy to extract old audit material from it. This should be stressed as very important in the new tool ProSupply.

The authors have had their own experience of how hard it is to receive complete audit cases with all documents that belong to one audit of a specific supplier. One reason for this is most likely that the

information is stored in different locations, making it hard to share information between auditors. Indirectly, this complicates the process for conducting audits.

#### **7.3.4.5 Audit responsibilities**

Clear roles and responsibilities are important for an audit to be efficiently conducted. The distribution of employees conducting audits from the supply department is the same as the employees from the quality department. However, when it comes to the responsibility of following up the audits, the opinions differ. Even though the majority of the survey participants agree on the fact that ABB is responsible for the follow-up of an audit, the opinions differ on whose responsibility on the ABB side it is. Some state that the supply department is responsible; some say it is the quality department. One part of the follow-up is to make a CAP. 20% believe that ABB should make that CAP, 60% believe it is the supplier's task and others think that ABB and the supplier should do it together. This clear lack in communication of responsibilities poses the risk that some tasks are not performed, since the involved parties do not know whose responsibility it is to do so. Having an audit organization with clearly distributed responsibilities would most likely solve the dilemma.

#### **7.3.4.6 Recommendations, feedback area 3**

In summary, it might not be possible nor the most efficient solution to use one standardized template for all audits, independent of nature. Instead, clear guidelines on how to perform an audit regarding documents, activities, responsibilities, etc. are needed. Also, a platform should be provided for communication between auditors from different business units and departments.

*Recommendation 3.1: Provide the audit guides with a Gantt chart visualizing the audit schedule*

- G. Each audit guide should contain a Gantt chart showing the main audit activities and when what documents are to be sent to the supplier prior and post audit. The listed documents should at least be:
  - The Letter to Supplier
  - The Audit Agenda
  - The ABB Supplier Code of Conduct
  - The ABB Supplier Requirements
  - The ABB Sustainability Policies

**Implementation ranking:** Easy

**Potential impact:** Large

An example of an audit Gantt chart is seen in figure 49 below.

Task	4 week prior to audit	3 weeks prior to audit	2 weeks prior to audit	1 week prior to audit	Audit	Post audit
Send Letter to Supplier						
Send ABB Supplier Code of Conduct						
Send ABB Supplier Requirements						
Send ABB Sustainability Policies						
Send Audit Agenda						
Fill in the Supplier Profile						
Conduct on-site assessment						
Make Corrective Action Plan (CAP)						
Follow-up CAP						

Figure 49: Example of an audit Gantt chart

*Recommendation 3.2: Clear statement of responsibilities*

- H. Each audit guide should state clearly who is responsible for the follow-up of the audit and the making of the CAP – ABB personnel should monitor the follow-up of the audit and the supplier should execute it.

**Implementation ranking:** Easy

**Potential impact:** Medium

*Recommendation 3.3: Clear instructions for where to save audit documentation*

- I. Everybody conducting audits should know where to save the filled-in documents. Also, all documents belonging to one audit should be saved in the same globally accessible database, in one clearly marked supplier specific folder.

**Implementation ranking:** Medium

**Potential impact:** Large

*Recommendation 3.4: Provide a communication platform*

- J. A communication platform should be provided for the auditors, such as a “chat” or similar.

**Implementation ranking:** Difficult

**Potential impact:** Large

**7.3.4.7 Summary, feedback area 3 – proved**

The current situation is that the different audit templates require different documents to be sent to the supplier and filled in by the auditors. The perception of who is responsible for following up the audits also differs. Furthermore, the audit documents are saved in different locations depending on the auditor. However, it is possible to change the audit process into becoming more consistent. A way of performing this is to implement a process where some activities are standardized prior, during and post audit. With clearly stated guidelines for the different steps in the audit process, the audit work will become more consistent and as a natural consequence of that – more efficient as well. Also, it needs to be clear where to save the audit documentation in order to facilitate the information sharing and communication between auditors.



When standardizing the audit processes, there are different aspects deciding why and what parts of the processes to modify. Even though the authors understand that the same audit template cannot be used for all audits, it should still be possible to standardize the general audit approach.

In summary, it is concluded that feedback area 3 is true – the audits are not performed and documented in a consequent manner.

### **7.3.5 Feedback area 4: Personnel conducting audits have not participated in audit training**

In order to get the most out of an audit, the auditor needs to have knowledge in both auditing and the technical process at the specific supplier being audited. It is important to know how and what questions to ask the auditee in order to get the right information. ABB key players within auditing agree on the fact that a good auditor has knowledge in both the supplier's processes and the auditing itself.

While a majority of the survey participants have participated in audit training during their employment at ABB, only 10% of those have participated in audit training performed by ABB internally. All survey participants who have not been educated in ABB specific auditing, state that they would appreciate such training. The majority also states that the audit training has helped them in conducting audits. This shows that there is a clear interest in internal audit training. Unfortunately, until now ABB has only satisfied a small part of that demand.

Even though it might be expensive to offer classroom training in auditing for everyone who conducts audits, it will most likely result in better audit outcomes. This will lead to higher performing suppliers, processes and relationships, which will result in savings in the long run. Also, valuable comments and feedback from auditors will be gathered and directly managed by the audit organization. This way, the development of the audit process will be of an active and continuous nature. An investment in offering more audit training should be seriously considered by ABB.

#### **7.3.5.1 Recommendations, feedback area 4**

Clearly, there is a strong demand for face-to-face internal audit training for auditors. ABB has not been able to meet this demand and a majority of the auditors have not participated in such training performed by ABB internally.

##### *Recommendation 4.1: Provide internal audit training*

- K. Offer ABB specific classroom audit training lasting between two and four days.  
**Implementation ranking:** Medium  
**Potential impact:** Large

### 7.3.5.2 Summary, feedback area 4 – partly proved

There is a clear interest in participating in audit training. Even though the majority of the survey participants have participated in audit training, only 10% of them have participated in ABB specific audit training performed internally. The authors are convinced that internal ABB audit training has potential to prepare the PACT auditors in the best way for conducting audits. Not only should the auditors have production and process knowledge but also auditing knowledge, which for ABB personnel best can be provided with ABB internal audit training.

In summary, it is concluded that feedback area 4 is partly true.

## 7.4 Recommendation implementation matrix

The recommendations presented for the four different feedback areas are summarized in figure 50 below.

Feedback area 1	Feedback area 2	Feedback area 3	Feedback area 4
<p><b>Recommendation 1.1:</b> Supplier KPI policy for auditing</p> <p>(A)</p> <p>(B)</p> <p><b>Recommendation 1.2:</b> Audit scheduling and best-practice reward</p> <p>(C)</p>	<p><b>Recommendation 2.1:</b> Same scoring system for all audit templates</p> <p>(D)</p> <p><b>Recommendation 2.2:</b> Wider grading scale, qualified from 50%</p> <p>(E)</p> <p><b>Recommendation 2.3:</b> Change in score/comment design in questionnaires</p> <p>(F)</p>	<p><b>Recommendation 3.1:</b> Provide the audit guides with a Gantt chart visualizing the audit schedule</p> <p>(G)</p> <p><b>Recommendation 3.2:</b> Clear statement of responsibilities</p> <p>(H)</p> <p><b>Recommendation 3.3:</b> Clear instructions for where to save audit documentation</p> <p>(I)</p> <p><b>Recommendation 3.4:</b> Provide a communication platform</p> <p>(J)</p>	<p><b>Recommendation 4.1:</b> Provide internal audit training</p> <p>(K)</p>

Figure 50: Summary of recommendations

Each recommendation has been evaluated based on its potential impact and how easy or difficult it would be to implement it. In order to prioritize the recommendations, the authors have positioned all recommendations in a matrix, see figure 51 below.

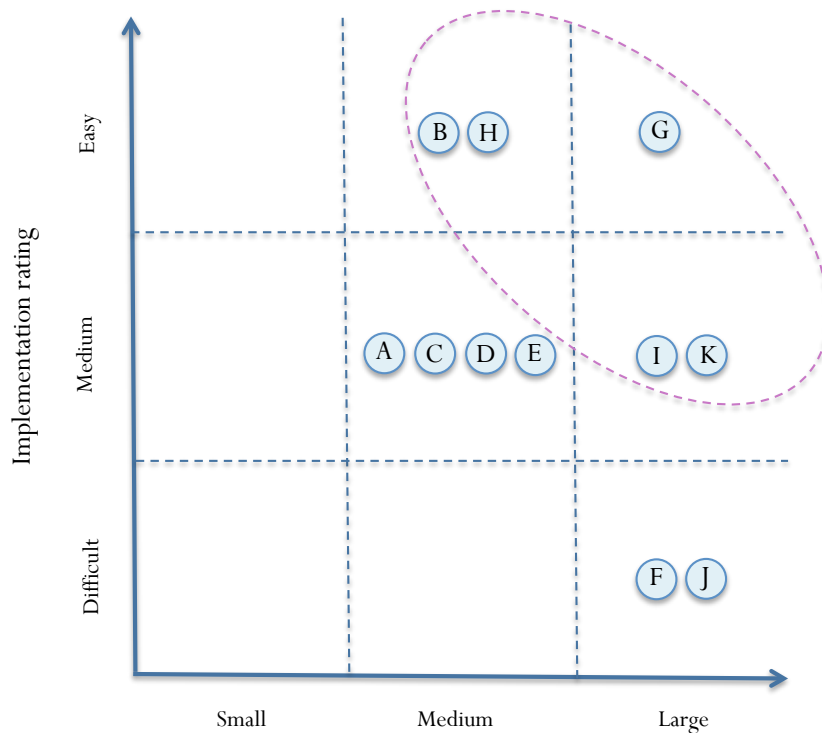


Figure 51: Recommendation implementation matrix

On the horizontal axis, the recommendation’s potential impact if implemented is stated. The potential impact value is small, medium or large. On the vertical axis, the implementation rating is stated. The recommendation can be difficult, medium or easy to implement.

Based on these two factors, the recommendations are positioned in the matrix. The authors find all recommendations to be important but a prioritization is fairly easy to do based on the recommendations’ positions in the matrix. The recommendations that are *easy* or *medium* to implement and have a potential impact that is *large* or *medium* are circled, visualizing what recommendations that the authors would suggest that ABB starts with.

The five prioritized recommendations are the following, one from feedback area 1 *The audits are conducted too seldom*, three from feedback area 3 *The audits are not performed and documented in a consequent manner* and one from feedback area 4 *Personnel conducting audits have not participated in audit training*:

- *Recommendation B*  
The result of the KPI rating should show clearly if an audit has to be conducted or not. Clear limits and guidelines in the rating should be communicated.
- *Recommendation G*  
Each audit guide should contain a Gantt chart showing when and what document is to be sent to the supplier prior to and post audit. The list should also include other audit activities as well as the post audit documents.
- *Recommendation H*  
Each audit guide should state clearly who is responsible for the follow-up of the audit and the making of the CAP – ABB personnel should monitor the follow-up of the audit and the supplier should execute it.

- *Recommendation I*  
Everybody conducting audits should know where to save the filled-in documents. Also, all documents belonging to one audit should be saved in the same globally accessible database, in one clearly marked supplier specific folder.
- *Recommendation K*  
The auditors should be offered audit training.

A prerequisite that the authors propose as a general recommendation is the need for a clear supplier audit organization. In order for the other recommendations to be useful, such an organization is essential.

## 8 General reconnection to ABB business

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*This chapter reconnects to ABBs Supply Chain Management strategy and shows how this Master Thesis is linked to ABBs general supply approach and visions. First, it is shown how the content of this Master Thesis addresses the five ABB SCM corner stones. Thereafter, the relevance of this Master Thesis is described linked to ABBs PA SCM vision.*

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### 8.1 This Master Thesis and ABBs PA SCM corner stones

The supply chain management organization within PA ABB has a corner stone strategy, presented in chapter 4 Empirical phase I, consisting of five approaches:

1. *Strategic sourcing;*
2. *Policies, processes, tools and resourcing;*
3. *Supplier development;*
4. *Collaboration;*
5. *People development.*

The PA *strategic sourcing* approach should consider how the sourced components are positioned in accordance to the risk exposure. The single sourced components imply a higher risk exposure than dual- or multi sourced components. Making the right decisions regarding the single sourced components is therefore essential in order to have an efficient supply chain management function.

From a SCM point of view, there need to be certain *policies, processes, tools and resources* for handling the business. The tools, such as auditing, can be standardized and help the organization working according to a set standard or process. This can help the organization to implement structures and be useful in order to make the work more efficient. However, such instruments can also be too standardized and incorporated in the business that they are used in a “this is how we always have done” way without being questioned.

For a global company like ABB, tools and standards can be implemented in the whole SCM organization globally, in certain geographical areas or in individual business divisions. The supplier auditing processes are at the moment both standardized globally and individualized locally. In Sweden and Germany, the SCM organizations have been conducting audits for a long time. The local “touch” on how the tools have been used is obvious, as can be seen in the differences of the audit templates. In Singapore, where the distribution organization is new, the supplier auditing has just started.

The auditing processes and tools are designed to make the auditing work more efficiently. Well-functioning audit processes will contribute to continuous improvement at the ABB auditing function as well as at the supplier. With an auditing process that identifies and justifies improvement areas, the improvement work will be more motivating for all involved parties.

*Supplier development* is another SCM approach linked to this. Efficient supplier evaluation processes will contribute to productive audits at the supplier and bigger potential for better supplier development. If the motivation for improvement is higher, the likelihood for improvement work naturally increases. With high motivation for continuous improvement, the supplier development is efficient and its positive contribution to the SCM business development is high.

With well-implemented audit processes that are applicable for a global SCM organization, the *collaboration* between business units and geographical areas has big improvement potential. Audit material can be shared through an online platform and valuable experience distributed among the auditors. For example, if the business unit that has conducted a general work safety audit at a supplier would share the documentation from the audit in a globally accessible database, other business units contracting the same supplier would be able to get the same information, thus not having to conduct the same audit. Collaboration leads to more efficient work and the processes could be streamlined. This would save time and other resources at ABB as well as at the supplier.

The fifth strategic approach that the PA SCM corner stones focus on is *people development*. To perform an audit efficiently, the auditor needs to have knowledge in the auditee's production process as well as competence in auditing. Generally, ABB has big production process competence, but less knowledge in the general auditing process. This indicates the need for auditing training. Giving selected personnel the opportunity to participate in such training contributes to individual people development as well as improved supplier audits.

## **8.2 This Master Thesis and ABBs SCM vision**

The three parts of supply chain management vision, described in chapter 4.2, show the importance and necessity of well functioning supplier audits. The vision addresses the need for supplier development and a preventive quality assurance system. Also, the improvement of supplier performance should be addressed in the coming three years. Furthermore, the vision states an increase in sourcing from emerging markets as well as an increase in dual sourcing and a decrease in single sourcing. These issues are addressed in this Master Thesis and show that there is a need to investigate the potential for improving the audit processes at ABB.

Even though the recommendations for improving the supplier auditing processes will drive costs, such investments will in the long run prevent high expenses due to e.g. insufficient supplier performance. Training, enabling communication between auditors, and communicating policies and standards require both time and financial resources. With ABB PACT having approximately 450 suppliers and multiple single source components, the supplier dependency cannot be neglected. Therefore, it is of high importance that the supplier relationships function according to ABBs requirements.

As mentioned earlier, conducting supplier audits is a new task for ABB PACT Singapore. The findings in this Master Thesis are mostly based on information from ABB PACT Sweden. By highlighting the experiences and issues that ABB Sweden has faced in the past when conducting audits, ABB Singapore can learn from the experienced auditors and avoid facing the same issues and with that, get a "jump start" when initiating the auditing. This can facilitate and hopefully even motive the work.

## 9 Conclusion

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*The aim of this final chapter is to reconnect to the initial purpose of this Master Thesis and the research questions. Also, the credibility of the study and the findings are commented and a suggestion for further research is made.*

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### 9.1 Returning to the purpose of this Master Thesis

The first part of the purpose was to find out whether there is improvement potential of the audit processes at ABB PACT. This study proves that there is improvement potential regarding the policy for when to conduct audits, the measurement system in the audit templates, the consistency in the audit process and the level of competence among the auditors.

The second part of the purpose was to find out how the audit process could be improved. The following suggestions are the authors' recommendations to ABB for how more consistent, efficient and probably better audits will be achieved:

- There should be clear instructions regarding the annual supplier KPI update.
- The result of the KPIs should show clearly if an audit has to be conducted or not.
- A "best-practice" reward for auditors should be implemented.
- All audit templates should use the same scoring system with a grading scale of 1-5.
- The passing level in the grading should be 50%, score 3.
- Each graded question in the audit template should be commented and motivated by the auditor.
- Each audit guide should contain a Gantt chart clearly showing the activities in the audit process and the documents used in each step of the process.
- The responsibilities pre, during and post audit should be clearly stated and communicated.
- Everybody conducting audits should save the documents in the same globally accessible database.
- A communication platform, such as a "chat" or similar, should be provided for the auditors.
- Classroom training of internal audit procedures should be offered.

A prerequisite that can be seen as a general recommendation is the need for a clear supplier audit organization. The implementation of such an organization is essential in order for the other recommendations to be useful.

### 9.2 Answering the research questions

The research questions were first presented in chapter 1.4. The same questions were then directed towards the ABB case resulting in four feedback areas presented in chapter 5 Analysis phase I. To summarize the Master Thesis, this chapter now returns to the research questions.

#### 9.2.1 Research question 1

The first research question concerns the *frequency* of conducting audits:

*What is an appropriate frequency for conducting supplier audits in order to maintain and develop supplier relations?*

The opinions regarding the frequency of conducting audits differs from auditor to auditor. Some believe that every supplier should be audited once every three years, some believe they should be audited more frequently. The majority of the auditors state that the time interval is not the primary decision factor for when to conduct an audit. Instead, the general opinion is that annually updated KPIs ranking the supplier's performance should trigger the decision to perform an audit or not. Today, ABB PACTs key suppliers are investigated annually according to defined KPIs. However, the fact that the KPIs trigger the decision to initiate an audit is not clearly communicated to all auditors.

It is concluded that an appropriate frequency for when to conduct an audit could not be found. Instead, the findings show that the importance lies within having a well implemented and communicated policy for deciding whether a supplier has to be audited or not. If such a policy is not already implemented, it should be done and communicated clearly.

### **9.2.2 Research question 2**

The second research question concerns the *measurement*, in form of scoring the supplier's performance according to the audit templates.

*What is an appropriate design for a measurement system that facilitates and motivates for supplier performance improvements?*

Today, the four audit templates that ABB PACT uses all have different scoring systems. This makes it complicated to conduct different types of audits and it might lead to the auditors having one preferred and familiar audit template that they use in most cases. With different audit templates focusing on different areas, it is not appropriate to use only one template for all audits.

Firstly, it is concluded that an appropriate design of a measurement system is one that is the same in all audit templates. The scores in all audit templates should be according to the same scoring scale, a scoring scale that should be simple to use and easy to understand. Imagine every teacher giving the students grades according to different scoring scales. Naturally, the grades from the different teachers could not be compared and the point of grading the students would be missed. The situation is similar at ABB. If the suppliers were graded according to the same scoring system, independent of the audit template used, it would be easier to compare the audit results between different suppliers and different types of audits.

Secondly, the scoring system in the audit templates should give room for the auditor as well as the supplier to clearly see where improvements can be achieved. Hence, the scoring scale should be wide enough for the given scores to be accurate and fair as well as indicate a potential improvement. If the suppliers easily score the highest grade, it gives the auditor and the supplier the impression that there is hardly any improvement potential and the motivation for such is decreased.

Thirdly, an appropriate measurement system would require the auditor to comment and motivate all given scores in the audit template. All grades should be motivated sufficiently so that the reader of the



audit report easily understands the scores given by the auditor. The maximum grade should also be commented and motivated, which is currently not the case at ABB.

It is concluded that an appropriate design for a measurement system was found. The same scoring system should apply for all audits, it should contain an appropriate scoring scale that notices and motivates potential improvements and it should require the auditor to comment and motivate the given scores.

### **9.2.3 Research question 3**

The third research question addresses the *consistency* of audits and more specifically, the use of different documents and the storing and documentation of completed audit questionnaires and reports.

*What is an appropriate way of administrating and documenting audits in a consequent manner in order to facilitate information sharing and communication between auditors?*

Even though it might not be possible to develop one standardized audit template that can be used for all different types of audits, the authors believe that it is possible to standardize parts of the audit process in order to facilitate the audit work.

Firstly, the guideline attached to the audit template should communicate a clear schedule for the administration pre, during and post audit, including what documents to use when, how to fill them in and where to save the documents, etc. The schedule should also address the main audit steps. The content of the audit template naturally differs depending on the audit focus, but the usage of all complementing documents should be standardized.

Secondly, it should be communicated clearly who is responsible for the different tasks and steps included in an audit; the supplier or the audit team.

Thirdly, it should be clearly instructed that all audit documentation should be stored in the same location. It is important that the old audit reports, containing the supplier self-assessment, audit questionnaire and follow-up report, are easily accessible even for individuals who were not involved in the specific audit. Also, the communication between auditors should be encouraged. A communication platform as well as a globally accessible database for information sharing are examples of how the communication could be improved.

It is concluded that an appropriate way of administrating and documenting audits in a consequent manner was found. The audit guidelines should contain a clear schedule for the different steps, tasks and documents used in an audit. The audit responsibilities should also be clearly communicated. The documentation of an audit should be administrated through a global database.

### **9.2.4 Research question 4**

The fourth research question addresses the *competence* of ABB personnel who conduct audits.

*What is an appropriate level of competence for auditors in order to conduct efficient audits and how can it be achieved?*

It is concluded that a competent auditor should have both process and audit knowledge. Process knowledge includes competence within the technical process that the supplier to be audited works with, as well as legal, work ethical and environmental competence depending on the type of audit. Audit knowledge includes competence within the specific audit methods, such as the guidelines, measuring system and general procedures for performing an audit.

The appropriate level of competence for all audit situations is hard to decide on. However, a basic level of knowledge could be implemented by training all auditors within the organization in auditing.

In the ABB case, the general opinion is that the auditors' technical process knowledge is big but that the auditors lack in other process knowledge such as environmental and ethical aspects. Also, the auditors lack in audit competency and the audits tend to be performed in an inconsequent way. By providing internal audit training for the auditors, the appropriate holistic competency level could be achieved.

### 9.3 Why auditing?

As mentioned in the first empirical chapter, the on-time deliveries (OTD) are a performance measurement within ABB. As can be seen in figure 52 below, the OTD from the suppliers to PACT is 81% and the OTD from PACT to the customers is 91%.

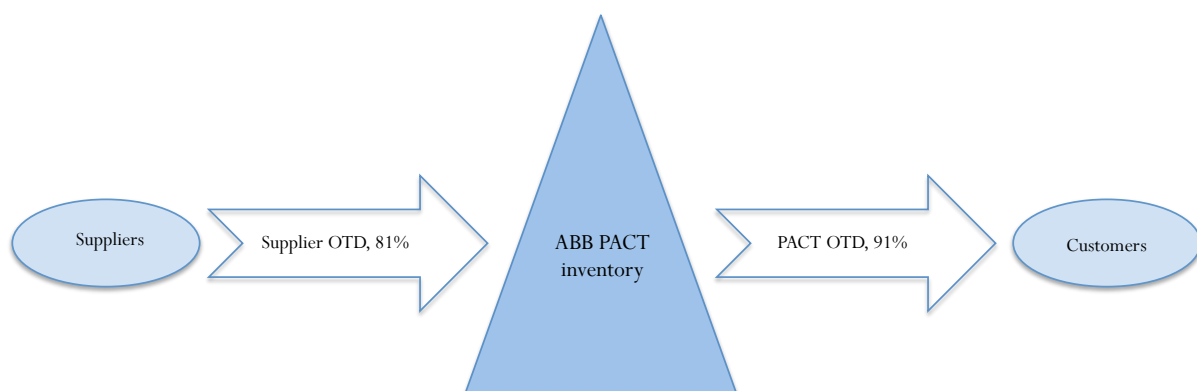


Figure 52: The PACT "iceberg" of inventory

When comparing the supplier OTD with the PACT OTD, it is clear that PACT has a higher OTD performance towards the customer than the suppliers have towards PACT. PACT can achieve the higher OTD through keeping an inventory. That way PACT can compensate for the lower OTD from their suppliers. However, inventory is expensive and means tied-up capital, which could be reduced if the suppliers had a higher delivery performance.

Conducting supplier audits has a high probability of improving the supplier relationship as well as the supplier performance. With a higher supplier OTD, achieved through auditing, PACT could reduce their safety stock and that way cut costs and free up tied-up capital. The reduced tied-up capital as well as higher performing suppliers would most likely result in profits much larger than the costs that auditing stand for.

Supplier audits can therefore be concluded to be an efficient tool for improving supplier relationships, reducing tied-up capital and reducing both cost and risk within the supply chain.

#### **9.4 Comments on credibility**

Reliability refers to whether a study's results can be trusted or not. One way of ensuring high reliability is to choose the interviewees and survey participants thoroughly. In this Master Thesis, key players within auditing were chosen for both the interviews and the survey. However, the number of survey participants is rather low. A majority of the key players within auditing in the PA division were asked to participate in the survey. Many of them replied that the survey was not applicable to them due to not having performed any audits. Hence, the people participating in the survey are considered to be the main active key players within auditing and their answers and opinions considered to be both realistic and truthful.

Also, ABB personnel have reviewed the models visualizing the ABB business. Furthermore, feedback was given on the survey before sending it to the survey participants. Therefore, it is the authors' opinion that the reliability in this Master Thesis is rather high.

Validity addresses the connection between the object to be investigated and what is actually measured. Through using interviews, a survey, audit templates and filled-in audit material in the study, the method of triangulation was applied, which ensures high validity (see chapter 2.4.2).

Finally, representativeness expresses to what extent the results can be generalized. The results in this Master Thesis specifically apply to the business division Process Automation and business unit Control Technologies at ABB and the authors cannot ensure the application of the results on other business division or units. The data collection has mainly been performed at ABB PACT in Sweden but the results are relevant for PACT in Singapore, since audits will be conducted there in the near future.

Supplier auditing is an essential activity for a risk conscious organization involved in supplier relations. The results in this study could therefore function as a conceptual basis for how to improve the supplier auditing process within an organization independent of what sector it belongs to.

#### **9.5 Suggestions for further study**

The study in this Master Thesis regarding auditing could be expanded to cover other ABB business units and business divisions.

Also, the investigation of single source components, as performed in this Master Thesis, could be expanded to include the whole control system Freelance and other products as well.

Furthermore, it would be interesting to perform a thorough study on how well performed audit work influences supplier relations. Finding statistical proof for a positive correlation between auditing and well-functioning supplier relations could increase the awareness of the importance of conducting audits.

One part of such a study could be to evaluate best-practice examples from different organizations regarding auditing.

### 9.6 Contribution to the academy

This Master Thesis has its focus on ABB PACT Sweden and Singapore. However, the generic research questions compose the basis for the Master Thesis, making it both generic and ABB focused.

This Master Thesis is a comprehensive study of the supplier audit process of a business unit in one of the world's biggest industrial companies. Hence, it could be seen as a case study suitable for other students to analyze and learn from as well.

Considering the small amount of theory available regarding supplier auditing, this Master Thesis also contributes with new knowledge to the academy.

Figure 53 below shows what general elements a supplier audit process at any organization should contain in order to make it successful. By looking at those elements when reviewing any organization's audit process, improvement potentials in the audit process can be pinpointed.

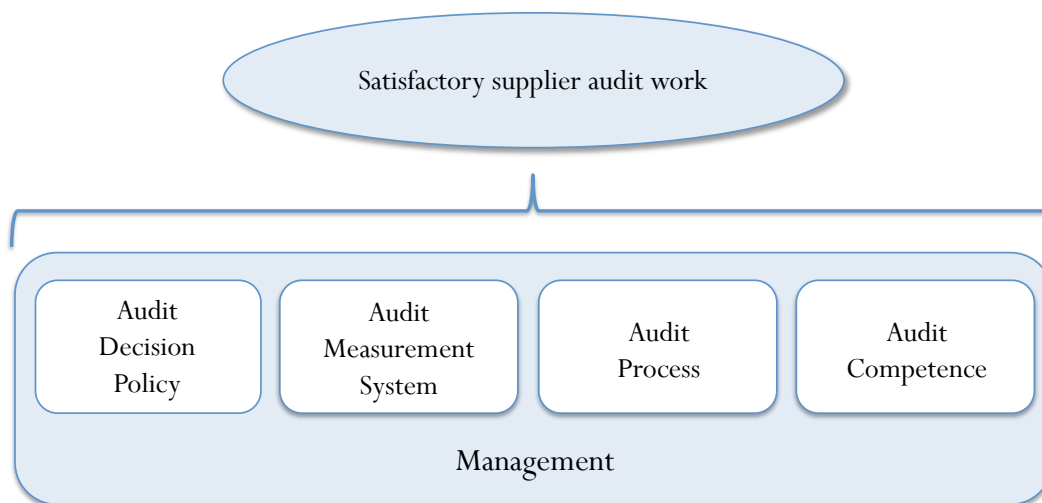


Figure 53: Elements of satisfactory supplier audit work

The figure shows that satisfactory audit work should have a clear *policy* that communicates when an audit has to be conducted. Furthermore, an appropriate *measurement system* should show clearly how the supplier's performance should be measured, what grading is to be used and how the grading is connected with the actions that need to be taken. Also, the audit work should follow a clear and established *process* that is the same for all audits that an organization conducts, independent of the focus of the audit i.e. environment, work safety, process, etc. In addition, the auditors should have appropriate *competence* in how to conduct supplier audits.

Finally, the four elements have to be *managed* by a clear audit organization, which is responsible for the implementation, communication, maintenance, and development of the audit work.

### **9.7 Personal reflections**

Writing this Master Thesis has been a great final project of our Industrial Engineering studies. We have enjoyed working with a large, international company like ABB. Also, we highly appreciate the opportunity of working in Singapore for two months that this Master Thesis has given us.

The general experience is that the work culture at ABB does not differ that much between Sweden and Singapore. However, the biggest difference that we noticed was that the organization is more top-down oriented at ABB Singapore than at ABB Sweden.

We appreciate all the help and support that we have gotten from our supervisors and people involved at ABB and the University.

All in all, it has been a great experience writing this Master Thesis. Thank you ABB!



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B.5: Brodén, Kenth 2012, ABB Sweden, Process Automation, Supply Manager

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C.2: Chong, SiewWan 2012, ABB Singapore, Process Automation, Distribution Centre Manager

D.: Paul Dennis 2012, ABB Singapore, Process Automation, Global Head of Back-End Operations

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## Appendix A: ABB Organization

### ABB Organization, Process Automation, Control Technologies

The following map, figure 54, provides an overview of the ABB organization and the areas this Master Thesis is connected to, highlighted with red. The map shows how the organization tree is built up, looking at a top down perspective. ABB has five different business divisions. Business division Process Automation (PA) is divided into nine business units, one of them being Control Technologies (CT). ABB PACT has around 450 suppliers globally today, out of which 38 are key suppliers. These 38 suppliers provide 80% of the PACT annual volume of supplied components and products. (E., 2012) (G., 2012) (K.2, 2012)

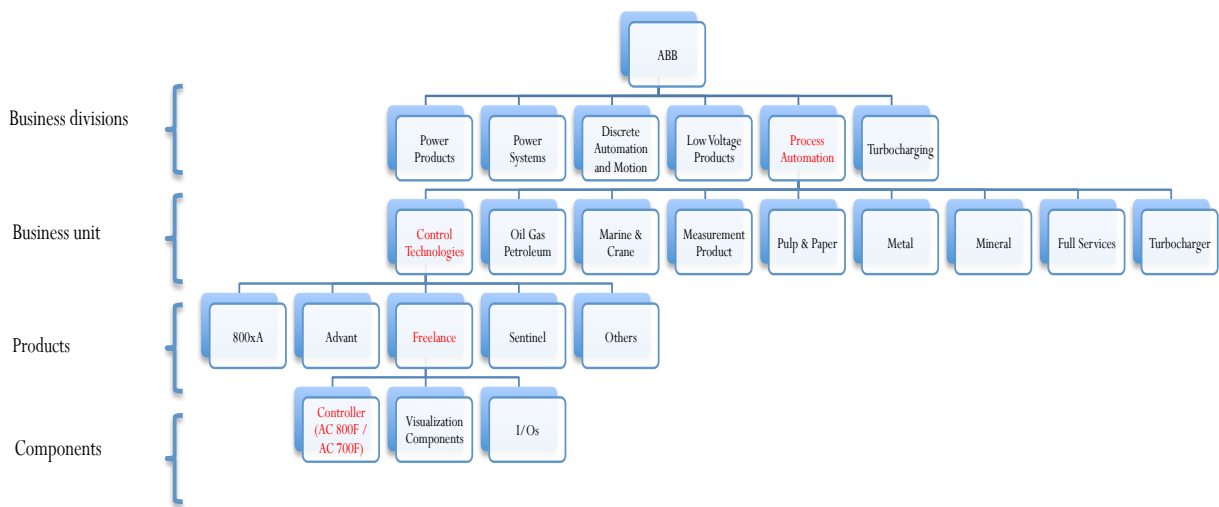


Figure 54: Organization map, ABB, PACT (K.2, 2012) (ABB 1, 2012) (ABB 2, 2012)

### Single source components at ABB PACT

PACT currently has around 500 single source components, meaning that there is only one supplier who manufactures each specific component. Printed Circuit Board Assembly (PCBA) make up the bulk of CTs external spend and is a crucial component of the control systems. (S., 2012)

Supplying a single source component naturally implies a bigger risk than dual sourcing the component. This is a risk that ABB is highly aware of. However, with complex and expensive components, common in the electronics industry, it is common that components are sourced from one single supplier.

Two years ago, the purchasing department at PA started a project with the aim of reducing the number of single source components of the control system 800xA. First, the number of single source components of the control system was determined, resulting in a list of 570 components. Thereafter, the risk that each component implies was determined. For each component it was analysed if there were any alternative suppliers to source from. The components were divided into three sub-groups depending on the level of complexity to engage an alternative supplier:

- *Group 1*

Component design and alternative suppliers are available and a list of alternative suppliers can be provided.

- *Group 2*  
There could be component design alternatives but more information on the component, KPIs etc. is needed.
- *Group 3*  
It is hard to find component design and supplier alternatives.

In this specific case, 144 components were categorized as belonging to group 1, 200 components belonging to group 2, and the rest, 226 components, belonging to group 3. That is, 25% of the single source components could be dual- or multi sourced right away (group 1), and 60% could not (group 3).

As mentioned earlier, ABB sources many modules from EMS. When ABB has chosen one or more suppliers for a component, a Bill of Material (BOM) is written stating what components a product consists of. For each component, there is an Approved Manufacturer List (AML) declaring which supplier/suppliers the EMS is allowed to supply from. This means that the EMS is limited in the choice of suppliers for ABB specific products, which gives ABB more control of the supply chain. (B.5, 2012)

## Appendix B: Description of controller AC 800F and mapping delimitations

### Description of Controller AC 800F

The AC 800F consists of housing, different modules with the PCB (printed circuit boards), fieldbuses, accessory modules such as batteries and power suppliers. For those five general components, there are several alternative types for each of them, as can be seen in figure 56 below. For example, there are nine different types of ethernet modules and eight different types of fieldbuses that can be integrated in the AC 800F.

Since the controller can be configured with different kinds of ethernet modules, fieldbuses, accessory modules and power supplies, this makes the supply chain mapping more difficult and requires some delimitation. The simplest controller would consist of one housing, one ethernet module, one fieldbus interface, one accessory module and one power supply. The difficulty is to choose which one of those different components is to be integrated in this supply chain mapping. The approach that is chosen is to go by an ABB expert's statement on the structure of the most simple AC 800F possible.

The five basic components in the controller are explained as follows.

**Housing:** The housing encases the different ethernet modules and mainly consists of an aluminum profile, side parts, PCB, back parts and additional parts.

**I/O:** An I/O is a system that communicates with parent controllers over industry-standard fieldbuses.

**Ethernet module:** The ethernet module mainly consists of a PCB, including a front plate and mounting parts, which are needed to connect the module to the housing. A picture of the ethernet module can be seen in figure 55 below.

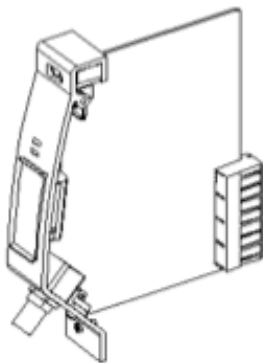


Figure 55; The ethernet modules of AC 800F (ABB 17, 2012)

**Fieldbus interface:** A fieldbus interface is a system, which translates different data languages and enables the communication between different systems.

**Accessory modules:** These modules are needed when the system is to be configured.

Power supplies: The power supply provides the control system with the required energy and the corresponding voltage to the control system. (ABB 17, 2012)

### Delimitations of the mapping of AC 800F

In order to narrow the scope, the following delimitations are chosen.

- Since the control system AC 800F is the heart of Freelance, the mapping only includes AC 800F.
- AC 800F consists of many components, the five main components being:
  - Housing;
  - Ethernet Modules (with the PCBA);
  - Fieldbus Interface;
  - Accessory Modules;
  - Power Supplies.

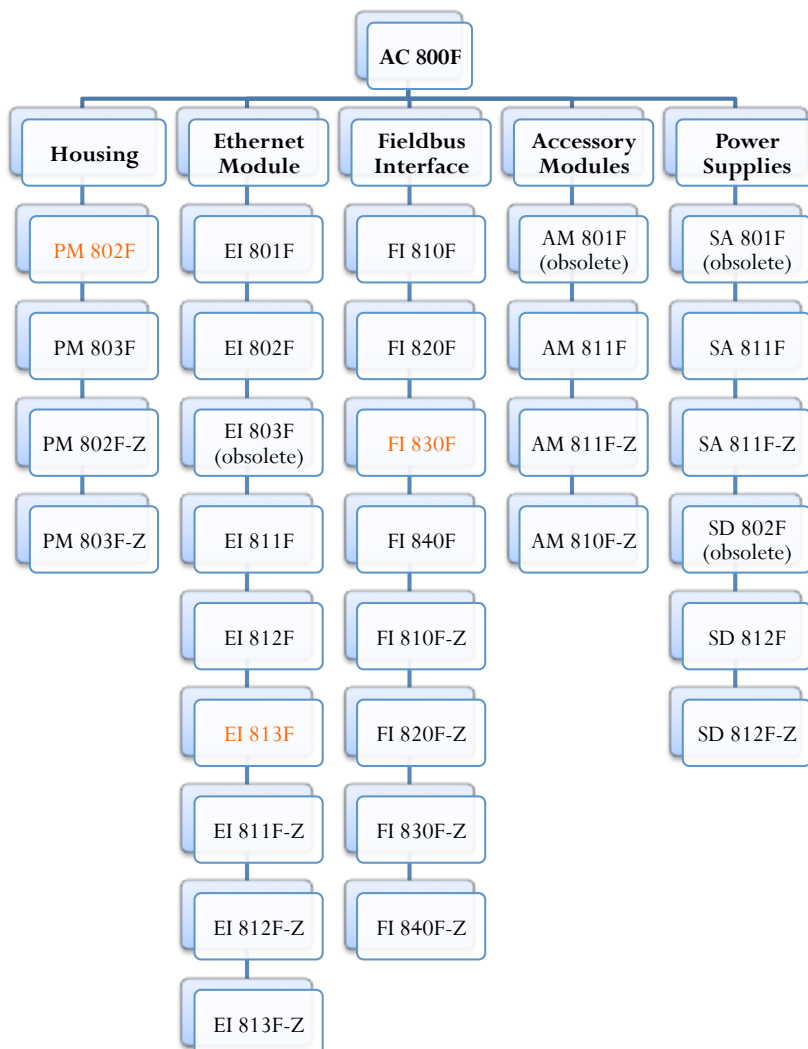


Figure 56: The different components variants of AC 800F (B.3, 2012)

- The simplest AC 800F consists of one type of Ethernet Module and one Fieldbus Interface. In theory it is possible to build the AC 800F with multiple Ethernet Modules and Fieldbuses.

- “Obsolete” means that these types are not produced anymore, though still present in older control systems. The obsolete types are therefore not interesting for the supply chain mapping.
- The capital Z means that the type is coated with a lacquer, in order to protect the component when exposed to harmful surroundings such as toxic gases. These types are identical to their equivalent without a Z. An example of that can be seen in the figure above: PM 802F and PM 802F-Z. Apart from the lacquer the two products are the same. The coated types are sold in smaller quantities. It is decided to only integrate the non-coated types in the supply chain mapping.
- Accessory Modules are components that are only needed when the customer wants to configure the system. This means that the Accessory Module is only used in special situations and is not included in a basic control system. Therefore, the Accessory Modules will not be integrated in the supply chain mapping.
- The choice of the Power supply depends on the electrical charge that the customer uses, either 230V or 24V. For 230V the Power supply SA 811F is needed, for 24V the Power supply SD 812F is needed. Since approximately 80% of the customers have 230V, the natural choice of Power supply for the supply chain mapping is SA 811F. But, since the Power supplies are not produced by ABB, but supplied from an external source, the Power supply is not integrated in the supply chain mapping.
- The choice of housing depends on the number of I/Os that the customer wants to integrate in the control system. For a simple control system (with a rather low number of I/Os), the housing PM 802F is the best choice. Thus, the mapping includes PM 802F.
- The Ethernet Module EI 813F is the simplest module. If the control system is not used in a critical process such as integrated in a nuclear plant, only one Ethernet Module is needed. In case of greater risk if one Ethernet Module should collapse, the system should be backed up with more Ethernet Modules in order to have a solution in case one module was to break down. The supply chain mapping will only include one EI 813F.
- The choice of Fieldbus depends on the type of communication that is to be used in the field. The simplest system only requires one type of communication. The Fieldbus type Profibus is the most commonly used, thus the choice for the supply chain mapping is FI 830F.

In summary, the following types will be included in the supply chain mapping:

- Housing: PM 802F.
- Ethernet Module: EI 813F.
- Fieldbus Interface: FI 830F.
- Accessory Module: not included in the simplest control system.
- Power Supplies: SA 811F, but since it is externally supplied, ABB does not control the supply chain and is therefore not included in the supply chain mapping. (B.3, 2012)

## Appendix C: Survey, supplier audits

Number	Question	Answer			
<b>1</b>	<b><i>Your identity and experience</i></b>				
a	What is your position at ABB, division, business unit, and geographical location?				
b	How many audits did you perform in the past 2 years (2010, 2011)?				
<b>2</b>	<b><i>Your audit process</i></b>				
a	Do you experience a big difference between the audits that you have performed? If yes, please explain briefly in what way they differed.				
b	How many ABB employees are in average involved in the audits?				
c	What was the focus of the audits that you have performed, i.e. quality, environment/health/safety etc. (please list here)?				
d	Have you ever performed an audit especially focusing on: (please mark with "x" in the yes or no column):	Environmental questions	<b>Yes</b>	<b>No</b>	<b>Comment</b>
		Financial stability of the supplier	<b>Yes</b>	<b>No</b>	<b>Comment</b>
		Work safety	<b>Yes</b>	<b>No</b>	<b>Comment</b>
		Ethical questions (e.g. child labour)	<b>Yes</b>	<b>No</b>	<b>Comment</b>
		Or any focus other than quality, performance, or cost? If yes, please comment.	<b>Yes</b>	<b>No</b>	<b>Comment</b>
e	Which role/responsibility do you have in the carrying out of the audit (i.e. owner etc.)?				
f	Do you follow a template (i.e. a timeframe for when to do what, what documents to use and where to save them) when conducting audits?				
g	When auditing an already approved and contracted supplier, do you update the Supplier Information Sheet (in template SQQ) with info regarding management team, financial data, employees, etc.?				
<b>3</b>	<b><i>The supplier's role during the audit</i></b>				
a	Who were the suppliers that you audited (company and short product description that ABB purchases)?				
b	Where was the supplier located that you audited (country, geographical region)?				
c	The representatives from the supplier's organization, which functions did they have (i.e. process owner, production manager, key account manager etc.)?				
d	In your opinion, which functions should the				



representatives of the supplier's organization have in order to make the audit as efficient as possible? I.e., should the representative be key account manager, process owner, production manager or other function?

e Have you experienced the suppliers' attitude towards audits as positive, negative, other? Please specify.

**4 Used support - from tools to process and staff**

a Have you participated in any auditing training? If yes, did it help you?

If yes, who performed the training?

b If no, would you be interested in participating in such training?

c Do you have any preferences regarding such training? Length and design of the education? Location, online?

d Have you read the audit process stated in ABB Sustainability Programme? If yes, have you ever conducted an audit following the steps in the programme?

e In your opinion, how does the communication between auditors from different BUs/BDs work? Is it helpful to your auditing work?

f Do you think it would be helpful for you if you could share your auditing experience with others? How would you prefer to do so?

g Do experienced auditors share their knowledge through a data system, online tool, or during training sessions? If yes, please specify where and when.

**5 Prior to the audit:**

a Do you send a "Letter to Supplier" stating the purpose, aim, scope etc. of the audit?

b Do you send the ABB Supplier Code of Conduct to the supplier?

c Do you send the supplier an Audit Agenda? Any other material? Time schedule, list of interviewees, focused areas?

**6 When performing the audit:**

a When performing the audits, do you always use the same approach or does it differ depending on supplier, product/component, location?

b Which of the following audit questionnaires do you use? (please mark with "x" in the yes or no column)

	The ABB Process Audit Questionnaire (PAQ)?	Yes	No	Comment

		The ABB Supplier Qualification Process (SQP)?	Yes	No	Comment
		The Environment, Health and Safety (EHS) Supplier Assessment Protocol?	Yes	No	Comment
		Sustainability Audit Process	Yes	No	Comment
		Any other? Please specify	Yes	No	Comment

**7** *After the audit:*

a	How and where do you document and save information about identified deviations, outstanding questions etc.?
b	To get qualified, the supplier needs to score 80% or above in the different parts of the audit. What scoring do you find sufficient, i.e. for what score, the need for developing an action plan for that particular area is reduced? 80%, 85%, 90%, 95%, or above?
c	Who, from ABB, was responsible for following up the corrections of any identified gaps in the performance?
d	Do you document the audit in a Feedback Reporting Form and send it back to the supplier?
e	Who was responsible for making a Corrective Action Plan (CAP), ABB or the supplier?
f	Is the next audit scheduled right after closing the prior audit or do you keep in touch in order to reschedule later on?
g	With what interval should audits be conducted in a well performing supplier organization in your personal opinion?
h	Does ABB have a policy for with what interval audits should be conducted?

**8** *For documenting the audit:*

a	What electronic instrument do you use for documenting the audits: C2 or any other?
b	If you did not use an electronic tool, where did you save the submitted documents?
c	How would you rank the user friendliness of the electronic tool (1 to 5)? 1: not user friendly to 5: very user friendly
d	Have you experienced the tool being helpful when documenting audits (i.e. learning from old reports how to conduct an audit more efficiently/learning from mistakes made in the past etc.)?
e	Have you experienced the tool being hard to use or

navigate in? Please specify.

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9	<i>Statements: Please state your position regarding the following statements.</i>	<b>I do not agree at all</b>	<b>I partly agree</b>	<b>I agree</b>	<b>Comment:</b>
a	Every audit is different and needs to be handled individually, and therefore standard templates are hard to use.				
b	For every audit, it has always been stated clearly who is the owner/sponsor of the audit.				
c	It would be good to have one standard template with clear guidelines for how to perform all audits.				
d	The supplier audit process works in a satisfactory manner today.				

## **Appendix D: Interview guides, intervjufrågor**

The authors have communicated with many key actors involved in the supplier audit process at ABB PACT during this Master Thesis. Several interviews have been held, out of which some were prepared with questionnaires beforehand and some not. The interview guides below are therefore a sample of what type of questions that have been discussed during the interviews.

Since this project has been in cooperation with ABB Sweden and ABB Singapore as well as with ABB organizations in other locations, the interview guides and questionnaires below are both in English and Swedish.

### **Interview guide, ABB audit process (ABB personnel)**

#### **Pre audit**

1. What is the time allocation for conducting audits? A task that is to be done in addition to your normal work?
2. How and when is it decided to conduct an audit? KPIs, time interval, incident, other?
3. How much time have you scheduled for this audit?
4. How much time have you allocated/scheduled for the follow-up?
5. Have the supplier been positive to your audit request?
6. Have you requested any general data of the supplier? Have you asked them to fill in the Supplier Information Sheet?
7. What material have you sent them prior to the audit? (Code of conduct, Supplier Requirements, Audit Agenda)?
8. Is the supplier going to do a self-assessment first? What documents have you sent to them for doing this?
9. What is your responsibility/role in the audit team?
10. What responsibilities/roles do the supplier representatives have that you will meet?
11. What responsibilities/roles would you prefer that they have?

#### **During the audit**

12. How many people, from ABBs side, are usually involved in an audit?
13. How many will be involved this time?
14. What is the focus of the audit?
15. Will you use the PAQ?
16. Will you give scores and comment on those?
17. Which documents will you request from the supplier?

#### **Post audit**

18. How will you follow up the audit? (Material, procedure etc.)
19. Where will you save the documents?

#### **General**

20. What do you know about the tool ProSupply?
21. Do you feel confident to have the responsibility for doing audits in the future?

22. Are you interested in audit training?
23. How would you prefer that the training would to be carried out? Length of the course, location etc.?
24. How much contact have you had with other ABB locations about performing audits and about potential issues regarding specific suppliers?

## **Interview guide, ABB supplier relationship (supplier)**

### **Intro**

- Your business mission; your relation to ABB (time, volume/ABB-ABB BU's)?
- Quality Management System – describe QMS; audit by customer and/or 3<sup>rd</sup> party?
- How do you measure and develop your QMS?
- Continuous improvements?
- Your opinion about audits?

### **General questions**

1. How do your customers contact you prior to an audit? By phone, email, letter?
2. What kind of information do they provide you with (time, date, required material) and how long in advance?
3. How do you prepare for an audit, what people do you gather?
4. How long time do the customers normally stay, do you find it sufficient?
5. How often do they come, with what frequency?
6. What kind of documents does the customer normally ask for and which ones do they get when they conduct an audit?
7. What do they bring with them, in terms of material, information, tools, people?
8. How many people normally come from the company?
9. Do you find their questions/areas of interest relevant for the business that you perform?
10. Would you rather communicate other information than the information that they ask for? Why?

### **Questions about ABB's auditing process**

11. ABB, how big is their share of your sales? Does this matter for the auditing process that they perform and in the way that you prepare yourselves?
12. Do different ABB divisions/business units contact you in different ways or are they synced in their communication with you?
13. What kind of documents does ABB ask for and which ones do they get when they perform an audit?
14. Do you see a difference between different business units/divisions' way of conducting audits?
15. Does it seem like ABB shares information between BD/BU or do different auditors ask the same questions?
16. Tell us about the audit process from your point of view. What is your feeling; is it professionally performed? Thoughts of what could be improved?
17. How often does a specific ABB BU come for audits, or does it depend on the BU/BD?

18. How many audits does ABB perform here annually?
19. What is the reason for ABB having performed audits with you? Quality, performance, or other issues?
20. Do you see any potential improvements in how your customers could perform their audits?
21. How do you think that ABB could make their auditing process better?
22. Other comments?

### **Questions about the supplier's auditing process**

23. Can you see a difference in your audit process that you perform and the audit process that ABB performs?
24. Which documents do you require from your suppliers when performing the audit?

### **Intervjufrågor, intern ABB auditutbildning (ABB personal)**

1. Hur går utbildningen till? På plats, online, med praktisk erfarenhet? Tid? När? Var?
2. Vem bestämmer vem som ska gå utbildningen? Är det folk med produktionsprocess-kunskap? Är det kvalitetsfolk?
3. Vem har gått utbildningen hittills? Hur många är de som gått utbildningen?
4. Hur länge har den funnits?
5. Varför började ni med utbildningen?
6. Är det bara Sverige som erbjuder den här typen av audit-träning, finns det utomlands?
7. Finns det intresse från någon annan ABB-organisation/-kontor?
8. Vad tror du att utbildningen ger de som går den, spontan feedback från de som genomgått audit-träning?
9. Vad kostar det? Vem betalar, individen, dennes team?
10. Finns det en utbildningsplan, vad lär man sig?
11. Certifieras de som går kursen?
12. Vilka nivåer på kursmedlemmar har ni? Helt nya auditörer, personer med lite erfarenhet?
13. Tar ni in erfarna auditörer som delar med sig av information och erfarenhet?