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Update and upgrade the current quality assurance in the global supply chain of a heavy truck manufacturing company

MANAGING PRODUCT QUALITY IN THE NORTH BOUND FLOW (NBF) AT SCANIA PRODUCTION ZWOLLE

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Preface

In the framework of completing my master Industrial Engineering and Management (IE&M) with specialization track Production and Logistics Management (IE&M-PLM) at the University of Twente, I conducted research at Scania Production Zwolle B.V. into quality assurance within the North Bound Flow.

I would like to thank Scania Production Zwolle for giving me the opportunity to perform my graduation project at Scania. I had a very pleasant time at Scania under perfect working conditions. I particular would like to thank my supervisor at Scania, M. Smit for realizing this assignment. His expertise, enthusiasm, and constructive feedback has really helped me to complete this research. Our sparring sessions always led to new insights throughout the project. Allowing me to visit Scania plants in Sweden, Belgium, and the Netherlands made my graduation project a wonderful experience. Further, I would like to thank all those at Scania who were directly involved in this project, especially TQI Zwolle and R. van Marle for their support and helpfulness.

I could not have done my research without the help of my supervisors at the University of Twente, P.C. Schuur and H. Kroon. I would like to thank them for their creativity and giving me valuable feedback. With their help I was able to raise my research to a higher level.

Finally I would like to thank my family and friends for their unlimited support. Knowing I can always count on their support motivates me to keep challenging myself.

Jurgen Bremmer

Zwolle, 2015

Management summary

Scania's management has been fully focused on issues of quality. As a premium brand, Scania wants to deliver products and services of a superior quality that fulfil the customers' demand. Therefore, it is important to react quickly and appropriately when a failure or deviation occurs. In our research, we analyze the global supply chain of Scania and determine how Scania can safeguard the quality of its products. The North Bound Flow (NBF) organization enables the production units of Scania to use suppliers outside of Europe. A supplier sends a large batch to a central warehouse and the products are stored and distributed in smaller quantities to the customers of NBF. The NBF organization is only responsible for the logistics.

When a customer of NBF receives a 'NOT OK' part, an eQuality report is issued to the supplier (eQuality is a web-based deviation handling system with all Scania suppliers connected to it). The supplier has to take immediate measures to prevent that Scania receives parts with the actual failure mode anymore. But with suppliers outside of Europe, 'NOT OK' parts could also be in the pipeline and in the warehouse. Today, there is no systematic routine or procedure for a containment action in NBF. Containment are actions necessary to stop the bleeding and protect the downstream customer. So the focus with containment is not problem solving. Because NBF is growing fast, Scania feels a need for developing a routine or standard procedure for containment actions in NBF. In the current situation, no one feels responsible for checking and repairing 'NOT OK' parts in NBF which leads to the following main research question:

"Who is responsible for managing the quality of the products in North Bound Flow (NBF) when there could be parts in the NBF with a technical deviation and how can Scania safeguard the quality of these parts?"

Problems

We started with analyzing the current situation in order to identify the mix of problems that Scania experiences. Because the existing problems are connected in so many ways, an extensive problem knot is created. Based on the problem knot and due to time limitations, we focus on the four major problems:

- *Cultural differences between Scania and NBF supplier lead to responsibility issues.*
- *Manufacturing supplier ships a 'NOT OK' part in the supply chain of NBF.*
- *Lack of internal knowledge about the existence of NBF.*
- *Lack of a systematic way of organizing a containment action*.

Due to the strong and many connections in the problem knot, solving these four issues automatically affect other problems in a positive way. To solve the four issues, literature is reviewed and a benchmark study is performed. The four problems are categorized in three sections: c*ulture*, p*reventive actions*, and *containment actions*. Below, let us dwell upon these specifically.

Recommendations

Let us specify solutions and recommendations for culture, preventive actions, and containment actions. Next to that let us dwell upon the responsibilities involved.

Culture

Countries of NBF suppliers are mainly located in Asia and Latin America and aim to have a low achievement of responsibility in which individuals do not take global issues personally. Additionally, these societies have strong traditional and survival values which indicates a more closed culture. However, creating a more *open culture*, by fostering the willingness to communicate freely in all layers

of the organization, is necessary to solve problems related to individual responsibilities that conflict with corporate purpose.

Preventive actions
Based on the literature and by scrutinizing eQuality reports, five alternatives are identified to prevent that 'NOT OK' products enter the supply chain of NBF. These five alternatives are:

1. *Specification:* Extra specification control between Scania as an organization, Scania Purchase department, and the manufacturing supplier.
2. *Audit:* A tighter audit control at the manufacturing supplier.
3. *Personnel:* More clear work instructions and personnel training at the manufacturing supplier.
4. *Inspection:* 100% outbound goods inspection at the manufacturing supplier.
5. *Packaging:* Pay extra attention to packaging NBF products.

The five alternatives are judged by the following four selection criteria (where scores range from 1 to 5):

1. *Cost:* Refers to the degree how costly the alternative is. A high value refers to a low cost alternative and a low value refers to a costly alternative.
2. *Speed:* Refers to the degree how fast the alternative can be implemented. A high value refers to a fast implementation and a low value refers to a slow implementation.
3. *Difficulty:* Refers to the degree how much expertise is needed for the alternative. A high value refers to a simple alternative and a low value refers to a difficult alternative.
4. *Quality:* Refers to the degree how adequate the alternative is. A high value refers to a high quality alternative and a low value refers to a low quality alternative.

A decision matrix helps to find the most suitable alternative. In consultation with management (Head of Customer Supplier Interface) all five alternatives are scored. The decision matrix is shown below.

Alternatives \ Criteria	C1: Cost	C2: Speed	C3: Difficulty	C4: Quality	Total
Weights:	0.25	0.50	0.75	1.00	
A1: Specification	5	3	2	3	7.25
A2: Audit	4	1	3	4	7.75
A3 Personnel	3	2	1	2	4.5
A4: Inspection	1	5	5	5	11.5
A5: Packaging	2	4	4	1	6.5

The best alternative seems to be alternative 4: *Inspection.* However alternative 1: *Specification* and alternative 2: *Audit* score a like. Both provide high quality, low cost solutions and therefore are good alternatives too. Summarizing, the following three alternatives in order of importance are proposed: *Inspection, Audit,* and *Specification.*

Containment actions
Based on the given recommendations for preventive actions, it is essential that containment actions are present when having 'NOT OK' products in NBF. A literature review and a benchmark study identify six methods for containment actions. These six methods are:

1. *Damage-control:* Five damage-control procedure steps, where minor repairs could be performed at the warehouse and critically damaged products should be shipped to a repair centre or scrapped.
2. *Inspection:* Inbound goods inspection at warehouse.

3. *SCAR:* Supplier Corrective Action Request (SCAR) is a containment model using 5W2H (ask the questions who, what, when, where, why, how, and how much). After the problem identification, 100% screening is done to identify poor quality products.
4. *Customer Quality:* Customer Quality is a containment model using Plan-Do-Check-Act (PDCA), 8 disciplines (8D), and preventive and corrective actions. When implementing corrective actions, look for opportunities to implement preventive actions for other parts or processes.
5. *Benchmark A:* Method used by the first benchmark company. Containment actions by having meetings, 'clean cut' determinations, and consultations with the manufacturing supplier.
6. *Benchmark B:* Method used by the second benchmark company. Containment action by shipping 'NOT OK' parts back to the manufacturing supplier.

The six methods are judged by the following four selection criteria:

1. *Usefulness:* Refers to the degree how suitable the containment method is for Scania.
2. *Speed:* Refers to the degree how fast the containment method is.
3. *Intelligibility:* Refers to the degree how clear the containment method is.
4. *Quality:* Refers to the degree how adequate the containment methods is.

A decision matrix helps to judge the methods. In consultation with management (Head of Customer Supplier Interface) all six methods are scored. The decision matrix is shown below.

methods \ criteria	C1: Usefulness	C2: Speed	C3: Intelligibility	C4: Quality	Total
M1: Damage-control	✗	✓	✗	✗	✗✗
M2: Inspection	✗	✗	✗	✓	✗✗
M3: SCAR	✓	✓	✗	✗	-
M4: Customer Quality	✓	✗	✓	✓	✓✓
M5: Benchmark A	✗	✓	✓	✓	✓✓
M6: Benchmark B	✗	✗	✓	✓	-

Since each of these six methods requires a documentation system which is rather complex, we opt for an adaption that uses the best elements of each of the six methods. The strengths of the six methods are listed in the table below.

Method	Strengths
M1: Damage-control	It is obligatory to take photographs of the damage to give a clear understanding of the damage. All costs involved should be reported to the supplier.
M2: Inspection	100% re-check repaired parts.
M3: SCAR	Clear understanding about the containment area: production, finished goods, customers, incoming material, and warehouse storage.
M4: Customer Quality	Systematic containment process using: 8D, PDCA, and corrective actions. When performing the containment action, look for opportunities to implement preventive actions (additive sorting).
M5: Benchmark A	After an ECO, the first three incoming shipments are 100% inspected. This is done to make sure that only good quality parts are stored in the warehouse.
M6: Benchmark B	Classification of products with additional Dynamic Modification Rules for incoming goods inspection.

A combination of the strengths of each of the six methods leads us to the following five *practical containment recommendations*:

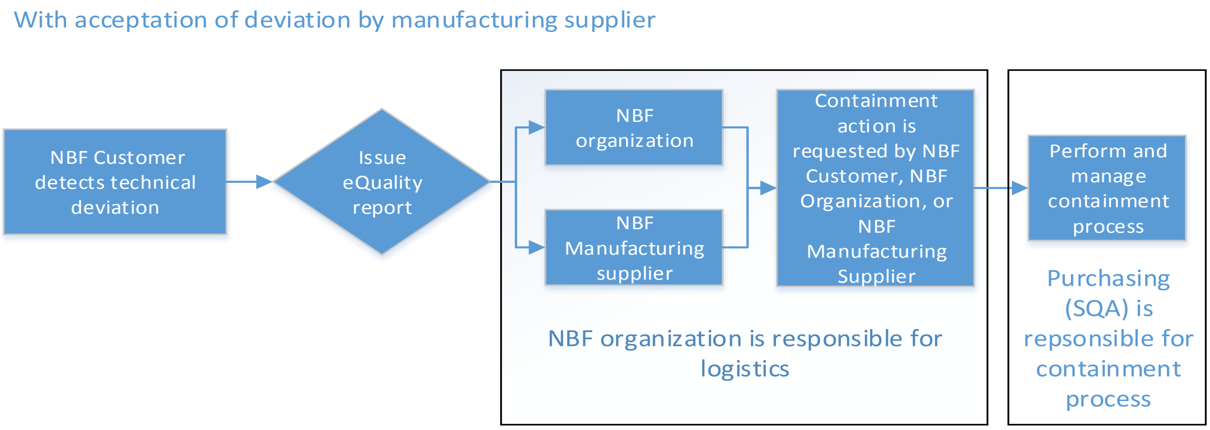
1. eQuality report should not only be sent to the manufacturing supplier but also to NBF organization.
2. In case the manufacturing supplier cannot 100% guarantee where the 'clean cut' is, inspect the whole inventory stored in the warehouse.
3. Note the reason why parts are blocked in the warehouse.
4. NBF organization is responsible for the logistics before the containment action is requested. As soon as a containment action is required, Purchase (SQA Zwolle) is responsible for the containment process.
5. After a containment action, always 100% inspect the first ok delivery from the manufacturing supplier.

By using these five practical containment recommendations, *containment guidelines* are determined and *flowcharts* are developed which represent the proposed containment process.

Responsibilities
In order to address the main research question. Let us dwell upon the responsibilities for preventive actions and containment actions specifically.

As for *preventive actions*, Purchase department is responsible for supplying required material, equipment, and services and has direct contact with the manufacturing supplier. Therefore, Purchase department is given responsibility to monitor NBF suppliers more tightened in order to prevent that 'NOT OK' products enter the complex and extensive supply chain of NBF.

Before the *containment process* is requested, NBF organization is responsible for the logistics and has to inform customers who also received parts from an infected batch. As soon as a containment action is requested by a NBF customer, NBF manufacturing supplier, or the NBF organization, responsibility is given to Purchase (SQA Zwolle) for the containment process. This process is shown in the figure below.



General recommendations and further research
In addition to the recommendations on culture, preventive actions, and containment actions, the following four general recommendations are proposed:

- Inform and provide information about NBF to the customers of NBF, due to the lack of knowledge about NBF.
- Use the systematic containment process as described in this research. In this way, the containment process is more organized and requires less time.
- Implement the improved eQuality report as provided in this research.

- Use an enhanced version of the current engine cost template which can be completed and allocated to the manufacturing supplier. The manufacturing supplier is responsible for the quality of its parts and therefore he is charged for the costs.

Finally, an indication is given of ideas for future research. A lot of information is already analyzed but further research is necessary on the following subjects:

- In contradiction to NBF, Scania does also have a South Bound Flow (SBF). The flow of goods in SBF is going south, instead of north in NFB. Perhaps with minimal changes the outcome of this research can be implemented in SBF as well.
- Further research is necessary to implement a sufficient track and trace system. Because of the global and complex supply chain of Scania together with the expected growth of NBF, an excellent track and trace system is desired.
- The activities in the NBF warehouse are no longer outsourced. The inventory is moved to Scania Logistics Centre Hasselt. Further research is necessary in topics of warehouse design, design of the fast pick area, shaping a warehouse, optimal order picking, optimal lane depths, etc. for an optimal use of the warehouse.
- Due to the importance to prevent that 'NOT OK' products enter the supply chain of NBF, further research on a principle called: 'funded head' is proposed.
- At last we recommend further research about incoming goods inspection in the warehouse with the use of Dynamic Modification Rules as described at benchmark company B.

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List of abbreviations

3PL	Third Party Logistics
5W2H	Who, What, When, Where, Why, How, How Much
8D	Eight disciplines
AS/RS	Automated Storage/Retrieval System
CAP	Corrective Action Plan
CDC	Central Distribution Centre
COD	Classification of Deviation
COR	Classification of Requirements
DMR	Dynamic Modification Rule
ECO	Engineering Change Order
EFR	Exemption From Requirements
FIFO	First-in First-out
FTA	Fault Tree Analysis
IDV	Individualism
IND	Indulgency
JIT	Just In Time
KD	Scania Knock Down
LC	Logistic Centre
LPO	Scania Local Purchase Office
LTA	Long Term Action
LTO	Long Term Orientation
MAS	Masculinity
MCDA	Multi-Criteria Decision Analysis
NBF	North Bound Flow
PDCA	Plan-Do-Check-Act
PDI	Power Distance Index
PPAP	Production Part Approval Process
PRU	Scania Production Unit
QA	Quality Assurance
RC	Root Cause
RFID	Radio-frequency identification
SBF	South Bound Flow
SCAR	Supplier Corrective Action Request
SCM	Supply Chain Management
SPS	Scania Production System
SQA	Supplier Quality Assurance
SQC	Statistical Quality Control
STA	Short Term Action
STD	Scania Standard
TKDQ	Quality department of Scania Knock Down
TQM	Total Quality Management
UAI	Uncertainty Avoidance Index
VDA	Verband der Automobilindustrie - German Quality Management System Standard initiated by Automobile industry
WVS	World Values Survey

1 Company profile

In the framework of completing my Master Industrial Engineering and Management (IE&M) with specialization track Production and Logistics Management (IE&M-PLM) at the University of Twente, I conducted research at Scania Production Zwolle B.V. into quality assurance within the North Bound Flow. The purpose of this chapter is to familiarize the reader with the company that has supported and facilitated this master thesis. Section 1.1 contains a general introduction and background information about Scania as an organization. Section 1.2 aims to give an understanding about the Scania Production System, where we aim to give a general introduction about Scania Production Zwolle in section 1.3. Finally, Section 1.4 aims to give insight in the North Bound Flow.

1.1 Introduction Scania

Scania is a major Swedish manufacturer of heavy trucks, buses and industrial and marine engines. The company was founded in 1891 in Malmö, with the company's head office located in Södertälje since 1912. Today, Scania has production facilities in Sweden, France, the Netherlands, Argentina, Brazil, Poland, and Russia and purchasing offices in four different continents. In addition, there are assembly plants and sales and services units all over the world, shown in Figure 1-1 (Scania, 2015). Scania's objective is to provide the best life-cycle profit for their customers by delivering optimized heavy trucks and buses, engines and services, and thereby be the leading company in their industry (Scania, 2015). The core values of Scania – customer first, respect for the individual and quality – is the basis of Scania's culture, leadership and business success. First of all, the customer is at the centre of every aspect of the business. Respect for the individual means that all employees are involved in continuously improving the business and finally, Scania delivers customized solutions from combining products and services of high quality (Scania annual report, 2013).

Figure 1-1: Scania global. Source: (Scania supplier portal, 2015)

To maintain strong, sustainable competitiveness and profitable growth, Scania should become more efficient every year. To achieve this, the company has to improve continuously in production and streamlining of production structure. To ensure that the products of Scania will maintain a high and uniform quality, Scania has standardised and documented their work processes. By challenging this standardised and documented way of working, Scania is able to identify waste and work with continuous improvement (Scania supplier portal, 2015).

For more than seven decades, Scania has reported a profit every year. Scania's competitive strength is mainly based on their modular system, they use shared components in trucks and busses as well as in industrial and marine engines. Scania laid the groundwork of modularisation more than 50 years ago and has been refining the system ever since. Additionally, with the standardized working methods, Scania ensures products with a high uniform quality. The modular system together with the standardized working methods are the basis for the Scania Production System (SPS) (Scania, 2015).

1.2 Scania Production System

Scania is producing according to the Scania Production System (SPS) which includes principles and methods that lead to continuous improvement, shown in Figure 1-2. The SPS is based on three values, Customer first, Respect for the individual, and Elimination of waste. The values reflect the company's culture and are presented in the grey layer. Normal situation – standardised working method, right from me, consumption – controlled production, and continuous improvement are the principles of the SPS. These principles are helping Scania to make decisions that leads towards a stable and reliable production system which is constantly improving. These principles are presented in yellow. Finally, presented in the green square, are the priorities of Scania. The priorities Safety / Environment, Quality, Delivery, and Cost are needed to quickly make the right decision (Scania, 2007).

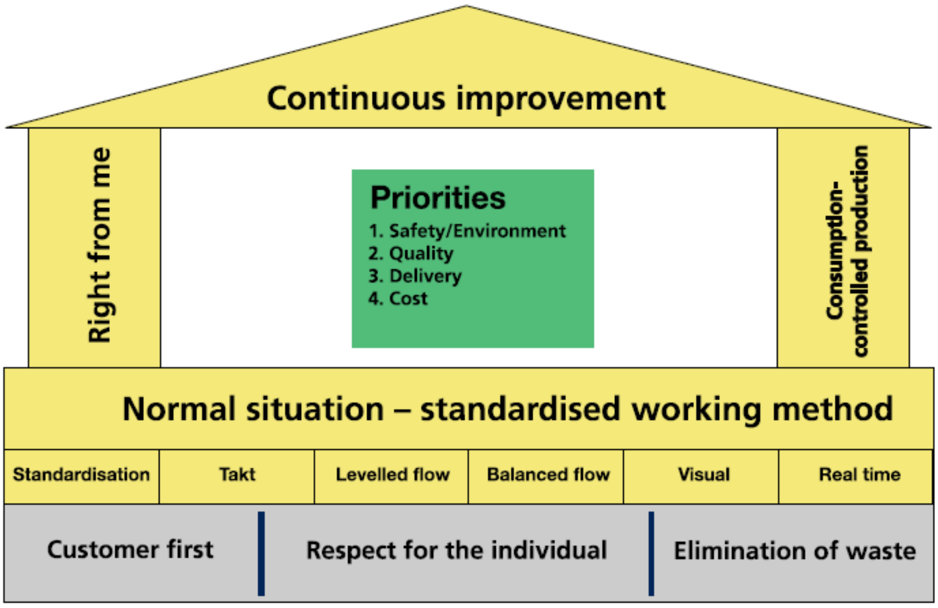

Figure 1-2: Scania Production House. Source: (Scania, 2007)

1.3 Scania Production Zwolle

Scania Production Zwolle is the largest of the three European production units of heavy Scania trucks. In 1964, the first truck was built and the 500,000th truck was assembled in December 2010. The number of employees has increased in that period from 270 to approximately 1,500. In the logistics centre, preparations are made to supply the parts in small quantities for the planned truck specification, just in time (JIT) to the production line (Scania, 2015). The organization that is responsible for managing the goods flow and logistics from suppliers outside of Europe to the Scania Production Units is called the North Bound Flow (NBF) organization. Both, the logistics centre and the North Bound Flow (NBF) organization are located in Zwolle as well.

Figure 1-3: Scania Production Zwolle. Source: (Scania, Scania production Zwolle, 2015)

1.4 North Bound Flow (NBF) organization

The North Bound Flow organization, hereafter referred to as NBF organization, enables the Scania production units (PRUs) to use suppliers outside of Europe. The NBF organization is located in Zwolle with the aim to supply products and services that meet customers' and relevant authorities' defined requirements at the right cost and through planned and efficient utilisation of the company's resources. The NBF organization is responsible for receiving goods from the suppliers, storing the goods at a warehouse and ship goods to their customers. Storage and transportation is outsourced to a third-party logistics provider (3PL). Finally, the business mission of the NBF organization is to enable its customers to work with goods from suppliers that are located outside of Europe.

1.4.1 Customers North Bound Flow (NBF)

The NBF organization has ten customers which are, except for Truck Chassis São Paulo, all located in Europe. The distribution structure can be shown as follows:

Table 1-1: Customers North Bound Flow (NBF)

<table>
<tr><th>Continent</th><th>Country</th><th>City</th><th>Scania</th></tr>
<tr><td>South America</td><td>Brazil</td><td>São Paulo</td><td>Truck Chassis</td></tr>
<tr><td rowspan="9">Europe</td><td rowspan="4">Sweden</td><td rowspan="3">Södertälje</td><td>Truck Chassis</td></tr>
<tr><td>Engine</td></tr>
<tr><td>Transmission</td></tr>
<tr><td>Oskarshamn</td><td>Cabs</td></tr>
<tr><td rowspan="3">The Netherlands</td><td rowspan="2">Zwolle</td><td>Truck Chassis</td></tr>
<tr><td>Knock Down (KD)</td></tr>
<tr><td>Meppel</td><td>Production</td></tr>
<tr><td>France</td><td>Angers</td><td>Truck Chassis</td></tr>
<tr><td>Belgium</td><td>Opglabbeek</td><td>Part Logistics</td></tr>
</table>

Scania Parts Logistics and Scania Knock Down (KD) are more special than the other customers of the NBF organization because the products from NBF for KD as well as for Scania Parts Logistics are at the start of a new supply chain. Scania Parts Logistics takes care of the global distribution of all Scania spare parts within their network of dealers and distributors. Scania Parts Logistics supports the global retail network by securing a high availability of Scania spare parts. The assortment covers truck and bus spare parts, but also vehicle related services. In addition to complete vehicles, Scania also produces KD products for several specific markets. KD trucks are disassembled into components, packed and sent to (simple) assemble plants elsewhere in the world, mainly in Russia, Asia and Africa. Hereafter, the components are locally assembled to a Scania truck. Good product quality of the components and completeness of these components packages are crucial in this type of production.

1.4.2 Suppliers North Bound Flow (NBF)

North Bound Flow (NBF) has around 100 suppliers located across the globe, supplying around 400 unique parts. The suppliers are mainly located in Asia and Latin America. The organization is called NBF since the suppliers are located in the south of the world (Asia and Latin America) and the customers are located in the north of the world (Europe). It can be said that the products are going upwards from the south to the north, in other words, the North Bound Flow. Figure 1-4 gives a representation of the suppliers and the customers of NBF.

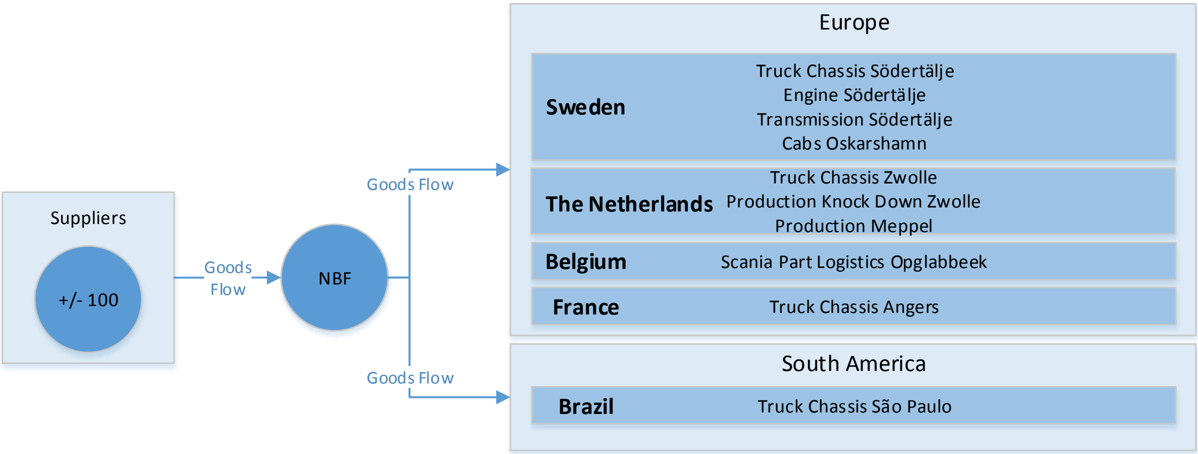

Figure 1-4: Suppliers and customers North Bound Flow (NBF)

Now the suppliers and customers of North Bound Flow (NBF) are known, we can describe the activities of the NBF organization. The customers of NBF are supported by suppliers from all over the world, mainly for three reasons. First, having suppliers oversea could give a price advantage compared to other suppliers, getting new market opportunities is the second reason and the final reason is dual sourcing (Allon & van Mieghem, 2008).

1.4.3 Warehousing

Goods are shipped from the manufacturing supplier to the warehouse across the ocean in large container ships. These long distances are at the basis of some challenges for the logistics system of Scania, in terms of: extensive lead times, forecasting demand, large batches, and the usage of safety stock. For price advantages, compensating extensive lead times, and the requirement of forecasting the demand, NBF uses warehouses located in Ridderkerk and Beringe (both located in the Netherlands). Ridderkerk is the main warehouse of NBF and Beringe is only used when capacity is – for whatever reasons – too small in Ridderkerk. The main advantage of the usage of the warehouse is that customers can be supplied by suppliers oversea as fast as by suppliers within Europe.

The ordering sequence in NBF starts with a demand from the customers of NBF. The goods received from the suppliers can be packed in four ways, wrapped in carton, packed in a box of plastic blue, packed in a larger box of plastic green or the goods are packed in a green wooden box. In some cases, the goods have to be repacked into other boxes. The NBF organization is able to fulfil the demand of the customers of NBF by using the stock at the warehouse. The NBF organization uses a safety stock of four to six weeks and uses the "first-in, first-out" (FIFO) method for valuing inventory (Hughes & Schwartz, 1988). Large batches received from the suppliers, are stored and distributed in smaller quantities to the customers of NBF. As soon as the products arrive at the warehouse, the supplier loses control over its products. In other words, the supplier doesn't have the knowledge which products are distributed to which particular customer. The NBF organization is responsible for collecting the part demand from Scania PRUs, Scania parts logistics and Scania KD, makes delivery plans on supplier level and finally send call offs and dispatch advice to the suppliers.

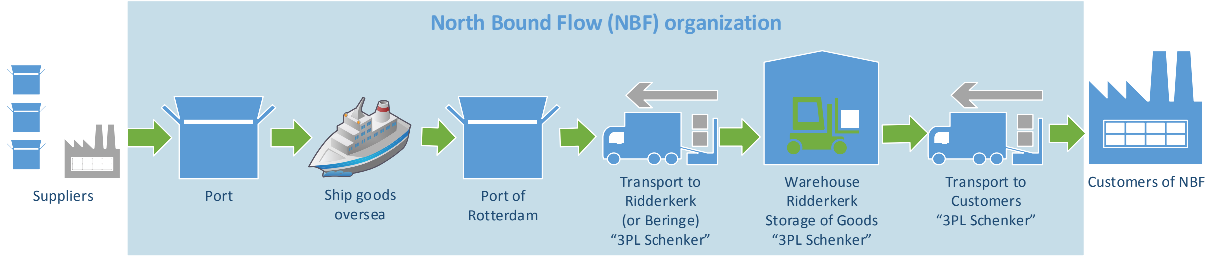

Figure 1-5: Goods flow in the North Bound Flow (NBF)

Schenker, a third-party logistics provider (3PL), is responsible for storage and transport of the parts, as shown in Figure 1-5. Schenker is also the owner of the warehouse.

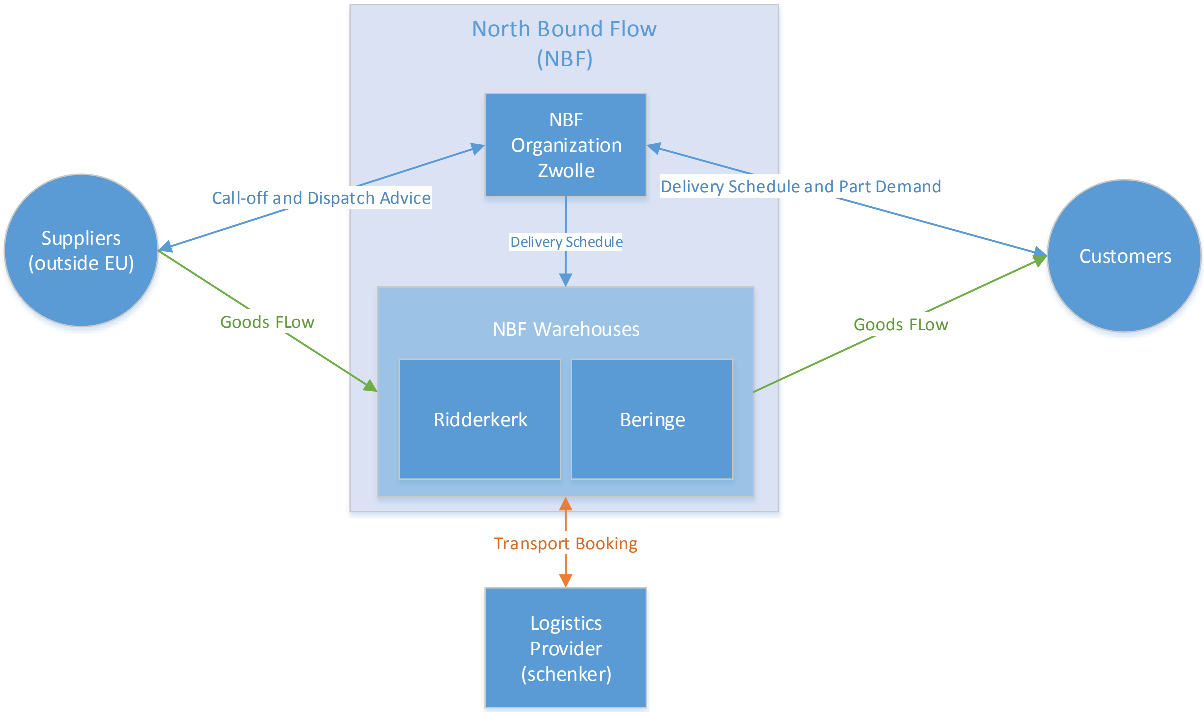

Figure 1-6: Ordering sequence North Bound Flow (NBF)

Summarizing, the NBF organization enables the Scania production units (PRUs) to use suppliers outside of Europe. A supplier sends a large batch to the warehouse located in Ridderkerk. The products are stored and distributed according the "first-in, first-out" (FIFO) method in smaller quantities to the customers of NBF. A 3PL logistic provider is taking charge of the storage and transportation of the parts. The NBF organization is only managing the logistics, as shown in Figure 1-6.

2 Introduction

This chapter aims to give a general introduction about the research which has been performed at Scania Production Zwolle. First, the context description is given in Section 2.1. Section 2.2 defines the problem statement and Section 2.3 defines the research motivation. The research set up with research questions are presented in Section 2.4. Section 2.5 describes the scope of the research and the research approach is defined in Section 2.6. Finally, the research deliverables are listed in Section 2.7.

2.1 Context description

Today's highly competitive environment is forcing companies to establish long term relationships with suppliers. As the market becomes globalized, and all business boundaries collapses, manufacturing companies that once concentrated on domestic sourcing are now concentrating their supply sources around the world. The expansion of global partners or suppliers engage new challenges and complexities (Chan, Kumar, Tiwari, Lau, & Choy, 2008). Nowadays Scania has around 100 suppliers from low cost countries mainly located in Asia and Latin America. Scania created the NBF organization due to an increase of overseas suppliers, additional transports, and to cope with the new challenges and complexities.

The increased global nature of markets and competitiveness have forced many companies to revisit their operations strategy. Companies nowadays have to compete based on multiple competitive performance objectives (Gunasekaran & Ngai, 2005). In order to meet these performance objectives Scania created the NBF organization with the mission to enable the European production at Scania to use suppliers outside of Europe. Scania's Production Units (PRUs) are supported by suppliers from all over the world which results in an extensive and complex supply chain. To compensate the extensive lead times and the requirement of forecasting the demand, NBF uses warehouses. Figure 2-1, gives an overview.

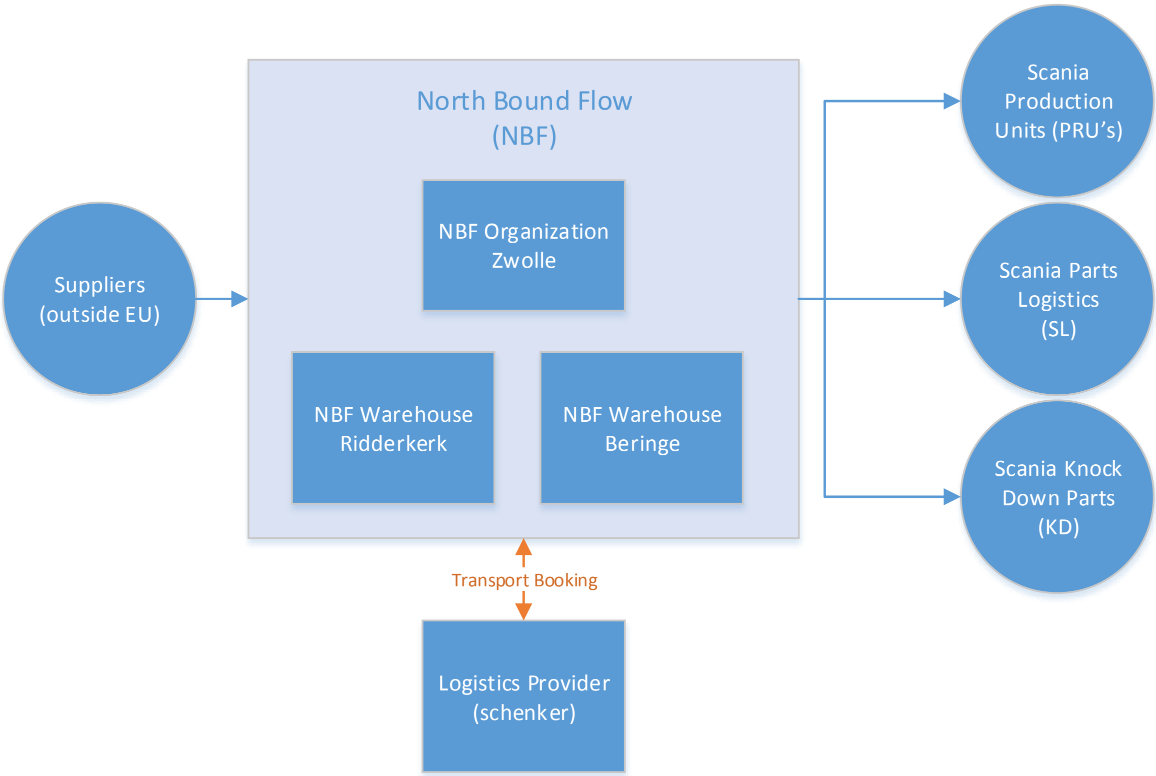

Figure 2-1: North Bound Flow (NBF) simplified

Due to the principle 'right from me', suppliers are forced to manufacture a product which meets the quality standard. However, unfortunately this is not always the case. It occurs occasionally that the quality of a part doesn't meet this quality standard. In that case, Scania issues an eQuality report and sends it to the supplier in order to refit the part (eQuality is a web-based deviation handling system with all Scania suppliers connected to it). For NBF suppliers, parts with a deviation could also be in the pipeline or in the warehouse. However, within Scania, no one is taking responsibility for checking, sorting and possible repairing the parts in NBF.

2.2 Problem statement

Confidential.

2.3 Research motivation

Nowadays, no one is responsible for the product quality in the NBF. When a sorting action is desired, Scania production Zwolle organizes a sorting action with ad-hoc solutions. But it is unclear what to do and who to contact. In other words, there is no systematic way of organizing a sorting action in the NBF. There is interest in an organized way of working which speeds up the process of a containment action. Purchase department in Södertälje expects an increase in goods from Asian suppliers, which results in a growing NBF. Additionally, one of the strategic objectives of NBF is to enlarge the dual source share of suppliers outside of Europe, which will also cause growth. Further, the Local Purchase Office (LPO) in China expects a growth, as can be seen in Figure 2-3. This results also aims to indicate a growing NBF, Figure 2-3 aims to give an indication of the growth in materials that LPO forecasts (note, this is not only NBF).

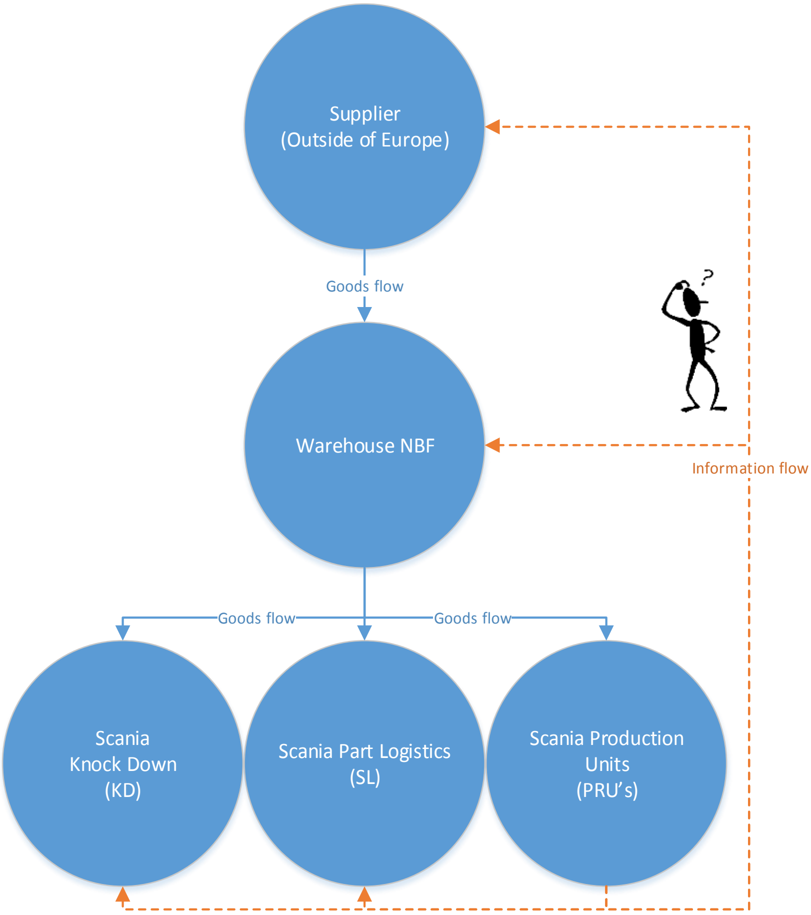

Figure 2-2: Problem statement

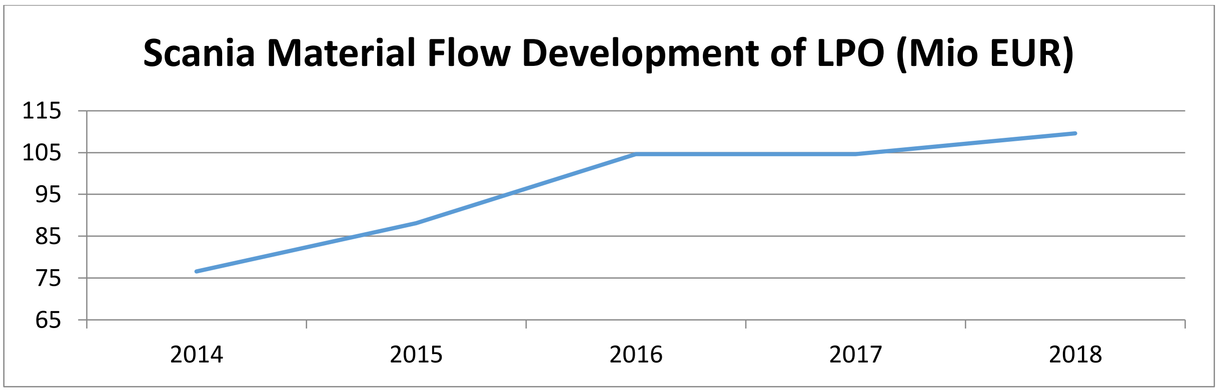

Figure 2-3: Expected growth in material flow of LPO

Finally, purchase department has made a sustainability risk analysis, see Appendix A: Sustainability Risk Analysis. This analysis aims to indicate that suppliers from Latin America and Asia have a high risk and these nations are indicated as having no clear policy, no management system, or management responsibility. This leads to the assumption that the goods from these suppliers needs some sort of extra attention.

2.4 Research setup

Based on the problem statement described in section 2.2, we formulate the main research question to reach the problem statement as follows:

"Who is responsible for managing the quality of the products in North Bound Flow (NBF) when there could be parts in the NBF with a technical deviation and how can Scania safeguard the quality of these parts?"

To be able to answer the main research question, a few sub questions are made with the aim to give a deeper understanding of the research. For each sub question, a brief description is given.

1. ***What is the current situation at Scania for managing quality in the NBF?***
    a. *How does Scania manage part deviations from suppliers outside of Europe?*
    b. *Does Scania have a problem when there are parts with a possible deviation in the NBF?*

Before commencing this research, the current situation with all corresponding problems were not yet known. Therefore the first part of this research is to identify the processes and related actions of the current situation.

2. ***What are the problem areas in the current situation for managing quality in the NBF?***
    a. *Which problems have Scania to cope with?*
    b. *What problems do the stakeholders experience?*
        I. *Who are the stakeholders?*
        II. *What problems do the stakeholders experience?*
        III. *What are the mutual differences between the problems stakeholders experience?*
        IV. *What are the mutual similarities between the problems stakeholders experience?*
        V. *What is the greatest common devisor of their experienced problems?*
    c. *What are the root causes of the problems?*
    d. *Which causes can be influenced and which not?*
    e. *To what extent is the current situation adequate?*

Sub question two aims to give an overview of the problem areas. The mix of problems that Scania and the stakeholders' experiences are described together with the differences and similarities. Further, the root causes of the problems are identified. Finally, an identification has been made for which causes can be influenced and which not.

3. **What alternative approaches are described in the literature?**

To be able to answer sub question four, we search in the literature for similar approaches on how to manage the quality of the products in a global supply chain with suppliers located outside of Europe.

4. **What alternative approaches can be identified from benchmarking?**

In addition to the literature study, we also conduct a benchmark study in order to come up with alternative approaches on how to manage the quality of the products in a global supply chain with suppliers located outside of Europe.

5. **What are the results of the alternative approaches, and what are the recommendations for Scania?**

From the alternative approaches found in sub questions four and five, the most suitable approach is chosen. Based on this approach we describe the recommendations for Scania regarding implementation.

2.5 Research Scope

The scope of this research is the North Bound Flow (NBF) and how to deal with technical deviations from suppliers outside of Europe. The scope of NBF is from the manufacturing suppliers till the customers of NBF. The NBF can be divided into three parts, part A, B, and C. Part A is the part between the supplier and the warehouse, part B is warehousing, and part C is the part between the warehouse and the customers of NBF, see Figure 2-4. Scania Part Logistics and Scania KD do also have several warehouses and business units, but those are not included in this research.

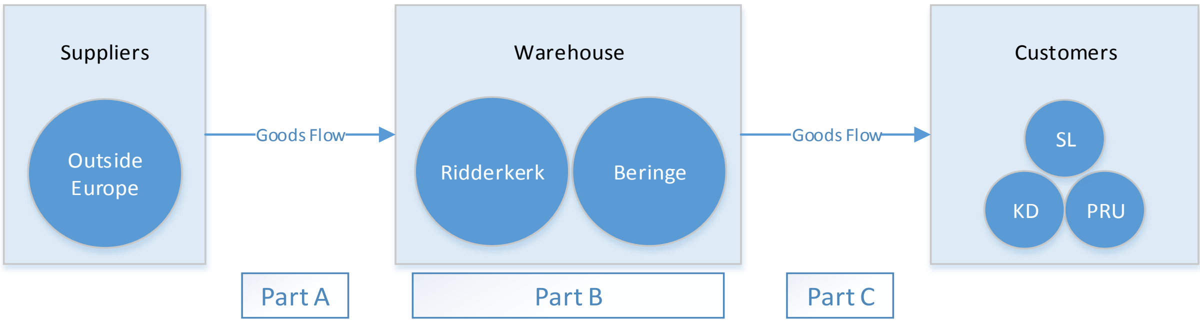

Figure 2-4: Scope North Bound Flow (NBF)

Furthermore, only parts with technical deviations from suppliers outside of Europe is included in this research. The North Bound Flow (NBF) organization is a logistical provider, and therefore responsible for logistical deviations (e.g. transport errors or wrong part labels) (Scania, 2015). The stakeholders involved in this research are the customers of the NBF, Purchase, and the NBF organization. Finally, the scope of this research will be reevaluated throughout the project. As the understanding of the problem grows, the scope and therefore the focus of this research will be clearer.

2.6 Research approach

In answering the research question, several research methods are used. For answering sub questions one and two we use the expertise and knowledge of experts at Scania. Different people are interviewed (e.g. engineers, managers, supervisors, operators, and experts) during this research to gather information. These interviews are not only to gather information, but also to discover the problems that stakeholders experience. To answer sub question one and two, information from Scania Inline and a small survey are used too.

The research method for sub question three is an extensive literature study. To perform this literature study, search engines (e.g. Scopus, ScienceDirect, SpringerLink, and EBSCOHOST), books, reports, internet, and databases are analyzed. Key words in this research are: global supply chain, quality global supply chain, spare part checking, track and trace, or quality. Benchmarking methods, the process of comparing one's business processes or best practices from other companies, are used to answer sub question four.

To answer sub question five, the knowledge obtained from the literature study, benchmarking, and knowledge from experts at Scania are combined. The possible alternatives are discussed with experts at Scania in order to come up with a reliable and sustainable solution.

To summarize this section: interviews, Scania Inline, expertise at Scania, literature study, and benchmarking are used to answer the main research question.

2.7 Deliverables

The deliverables of this research are:

- Identification of the existing problems.
- Cultural differences between Scania and its suppliers outside of Europe.
- Preventive actions proposed at manufacturing supplier to prevent that 'NOT OK' products enter NBF.
- Information document that aims to give insight and knowledge about NBF.
- Proposed manual for organizing a containment action in the NBF.

3 Current Situation

The aim of this chapter is to provide insight in the current situation at Scania. First in Section 3.1, several concepts (e.g. global supply chain management, quality, and containment) are explained. Extra information about NBF is given in Section 3.2. The aim of Section 3.3 is to describe how Scania copes with technical deviations from suppliers outside of Europe. Subsequently, Section 3.4 aims to give an understanding about the new situation where a new warehouse is built for the stock of NBF and Section 3.5 discusses if Scania has a problem with the current situation. Finally, a summary is given in Section 3.6.

3.1 Definitions

The following section aims to give a better understanding of some key words in this research. Key words such as global supply chain management, quality and containment aims to be described and explained in this section.

3.1.1 Global supply chain management

In order to describe global supply chain management, we first need to understand what a supply chain is. Further we aims to describe supply chain management (SCM) and finally the global aspect of SCM can be described.

Having satisfied customers and being successful, supply chain management is essential for a company since customers are at the end of the supply chain. According to Simchi-Levi et al. (2008) raw materials are purchased and products are produced at one or more production facilities, shipped to warehouses or distribution centres for storage, and finally shipped to retailers or customers are activities that characterize a supply chain (Simchi-Levi, Kaminsky, & Simchi-Levi, 2008). In addition to this, Christopher (1992) defines supply chain as “a network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hand of the ultimate customer” (Christopher, 1992, p. 17). In order to improve service levels and reduce cost, effective supply chain strategies must take into account the interactions at the various levels in the supply chain (Simchi-Levi, Kaminsky, & Simchi-Levi, 2008).

Increasing the management of relationships across the levels of the supply chain is being referred to as Supply Chain Management (SCM) (Lambert & Cooper, 2000). Based on this, Stadtler & Kilger (2004) define SCM as “the task of integrating organizational units along a supply chain and coordinating material, information and financial flows in order to fulfill (ultimate) customer demands with the aim of improving competitiveness of a supply chain as a whole” (Stadtler & Kilger, 2004, p. 11). Finally, for the sake of completeness, Li (2007) stated “supply chain management is a set of synchronised decisions and activities utilised to efficiency integrate suppliers, manufactures, warehouses, transporters, retailers, and customers so that the right product or service is distributed at the right quantities, to the right locations, at the right prices, in the right condition, with the right information, and at the right time, in order to minimise system-wide costs while satisfying customer service level requirements” (Li, 2007) (Zhang, et al., 2011, p. 87).

Since the markets gets more globalized, supply chains of companies expands into international locations. Supply chain management exceeds national boundaries, and impose the challenges of globalization on managers who design supply chains for existing and new products (Meixell & Gargeya, 2005). According to Slack, Chambers, & Johnston (2007) “the expansion in the proportion of products and (occasionally) services which businesses are willing to source from outside their home country” is called global sourcing. Global sourcing is common at Scania and the risks of increased complexity and increased distance need managing carefully (Slack, Chambers, & Johnston, 2007).

3.1.2 Quality

Product quality is becoming an important competitive issue. One of the key tasks of the operations function is to ensure that it provides good quality products and services to its internal and external services (Slack, Chambers, & Johnston, 2007). There are all kind of definitions for quality, one of them is the Japanese philosophy where quality is being defined as “zero defects-doing it right the first time” (Parasuraman, Zeithaml, & Berry, 1985). David Garvin (1984) has categorized many quality definitions into the following five approaches (Garvin, 1984) (Slack, Chambers, & Johnston, 2007):

- Transcendent approach: views quality as synonymous with innate excellence.
- Manufacturing-based approach: is concerned with engineering and manufacturing practices, making products or providing services that are free of errors and that conform precisely according the requirements.
- User-based approach: is concerned with providing products or services that fits for its purpose.
- Product-based approach: views quality as a precise and measurable variable which will satisfy customers.
- Value-based approach: defines quality in terms of costs and prices. Quality has to be perceived in relation to price. In other words, a quality product is one that provides performance at an acceptable price or conformance an acceptable cost.

Generally speaking, quality can be defined as the standard of a product which is related to the customer satisfaction level and the provided services. Therefore, the outcomes resulting in customer satisfaction are all important because customer satisfaction is a key indicator for success (Chan F. T., 2003). Quality at Scania can be seen, according to Garvin (1984), as a manufacturing-based approach. Goods have to be produced according one or more Scania standards (STDs) and have to fulfil several requirements. A STD is defined as “document established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines and characteristics or their results, aimed at the achievement of the optimum degree of order in a given context” (Scania, 2015, p. 1).

3.1.3 Containment

Containment is a method within the quality toolbox of Scania in order to protect the downstream customer, in case of product deviations, by "cleaning" the flow from defect parts in real-time. A checking and sorting activity could be a containment activity.

Note that containment is not the same as corrective and preventive actions. Below the differences between containment, preventive, and corrective actions are listed.

Preventive action is a change implemented in order to prevent a potential problem in the future. Preventive actions improve a process or product by removing causes for a potential problem and prevent the occurrence of problems (Keysight Technologies, 2015).

Containment action is to limit the problem extent and safeguard normal operations and processes. Containment is necessary until the root cause is defined and sufficient corrective actions are implemented (Keysight Technologies, 2015). Containment are actions necessary to stop the bleeding and protect the downstream customer instead of solving problems.

Corrective action is used to remove the root cause and prevent that the problem occurs again in the future. The actions are directed to an event that occurred in the past (Keysight Technologies, 2015).

3.2 North Bound Flow (NBF)

The operation of the global supply chain of Scania is challenging due to its diversity of suppliers' geographically distribution and the connected business relationships and processes among players (e.g.

suppliers, manufactures, distributors, retailers, and customers) (Zhang, et al., 2011). It is also challenging due to the pressure of global competitions, continuously changing business environments, culture, and transient demands. Logistics networks have rather acquired decisive roles for achieving excellence. Planning and control of material flows within supply networks have become one of the most complex tasks in practise (Mehrsai, Karimi, Thoben, & Scholz-Reiter, 2013). These reasons are at the basis of the evolution of the North Bound Flow (NBF) organization.

NBF has approximately 100 suppliers, supplying around 400 different part numbers stored in the warehouse. Parts at the warehouse can be available for delivery or can be blocked. Blocked parts are parts out of specification or parts forming an incomplete pallet. Approximately a third of the part numbers have blocked parts. The NBF organization has a safety stock of four to six weeks, which results in 1,1 million parts in stock. More than 30,000 parts of those are blocked, without knowing the exact reason. Table 3-1 gives an overview.

Table 3-1: Facts and figures about the stock at the warehouse (25-03-2015)

Description	Parts (amount)	Parts (percentage)
Total amount of unique part numbers	388	100%
Amount of unique part numbers that is 100% OK	257	66%
Amount of unique part numbers that is not 100% OK	131	34%
Total amount of parts stored in warehouse	1,133,922	100%
Amount of available parts in warehouse	1,100,554	97%
Amount of blocked parts in warehouse	33,368	3%

3.3 Technical deviations from suppliers

High product quality and delivery performance are, and will be, key factors for Scania's success. Since the suppliers contribute to the final products and process quality, they have to operate according to the predefined Scania standards (STDs). Parts out of specification are called technical deviations. The classification of requirements (COR) is based on Scania's business philosophy, product development goals and those product requirements which are of greatest importance to the customer. When Scania receives parts out of specification due to a supplier mistake, Scania issues an eQuality report. All deviations are classified according to Scania's Classification Of Deviation (COD) and can be classified as: critical (C), major (M), Standard (S), or legal (L) (Scania, 2015). These classes indicates levels of consequences, the typical significance of these consequences is presented in the Table 3-2. The classification of the four scores can be found in Appendix B: eQuality classification of technical deviations.

Table 3-2: Classification of C M S L scores

Failing to comply with requirement can mean:	Score
Direct effect on characteristics to the customer - Risk of injury - Substantial economic consequence which can entail unplanned stop and thereby making it impossible to carry out the work task **Substantial economic consequences for Scania**	C
Interference with or reduction of important characteristics to the customer - Significant economic consequence can entailing extra maintenance procedures for replacement or adjustment.	M
Insignificant effect on important characteristics to the customer	S
Requirements of parts, systems and assembly having a direct importance for fulfilling or certifying legal requirements	L

The system named eQuality, is a web-based deviation handling system with all Scania suppliers connected to it. eQuality is an information carrier and must be used for all deviations. The supplier is responsible for acting on the deviation. The description of the deviation is given according to: “what do I see? What should it be?”. For the sake of completeness, drawings and / or Scania Standards (STDs) are added for a clear understanding of the deviation. Suppliers have to check twice a day their mailbox if eQuality reports are issued. If so, then the supplier stops the delivery of those parts and has to report a credible Corrective Action Plan (CAP). A CAP consists of a short term action, a root cause analysis, and a long term action plan with acceptable time schedule for implementation. Activities and responsibilities of the supplier in eQuality for quality and logistics consists of three main actions (Scania, 2015):

Report Short term action (STA)

- Take immediate and adequate measures to secure that Scania will not continue to receive parts with the deviation.
- Sort/replace deviating parts in the pipeline/stocks (at your site and/or within any concerned Scania unit – including spare parts). Report to Scania the number of non-conforming parts that are found.
- Confirm in the eQuality report that the STA has been secured within 24 hours.
- Report if suspicious or proven non-conforming parts have been delivered to other PRUs than the one issued in the report.
- Attach supporting documents and pictures from the action taken within the STA.
- Inform which actions are applied until long term corrective action plan is implemented.
- Write a description of the STA even if you have already added attachments related to it.

Summarizing, the aim of the STA is to make sure that, within 24 hours, the customer is receiving parts without a deviation.

Report Root Cause (RC)

- Execute a thorough root cause analysis using a standardized working method for problem solving (e.g. 5Why, Ishikawa or fishbone diagram, etc.) to determine the true root cause of the deviation.
- Scania does not accept human error as a root cause. Continue the analysis further if that is the result.
- Always report the root cause analysis in the eQuality report.

Summarizing, the aim of the RC is to find the root cause of the deviation such that the supplier can improve its process.

Report Long term action (LTA)

- Present a credible LTA together with implementation schedule within 10 working days.
- Recurrences are not acceptable. If that is the case the root cause was not determined correctly the first time. A repeated deviation will lead to a new report and an escalation.
- Submit proposed changes related to process or product via the eSCR system. Purchaser and SQA must be involved in all product or process changes. The changes must be approved before they are implemented.
- Write a description of the LTA, even if you have already added attachments related to it.

Summarizing, the aim of the LTA is to make sure that, within 10 working days, the particular deviation will not occur again.

The quality handling concept is shown in Figure 3-1. It starts with a deviation. An eQuality report is issued about the deviation and the manufacturing supplier reports a CAP. The eQuality report is closed when the CAP is sufficient enough. The goal is to identify the true root cause of the deviation and to return to the normal situation as soon as possible (Scania, 2015).

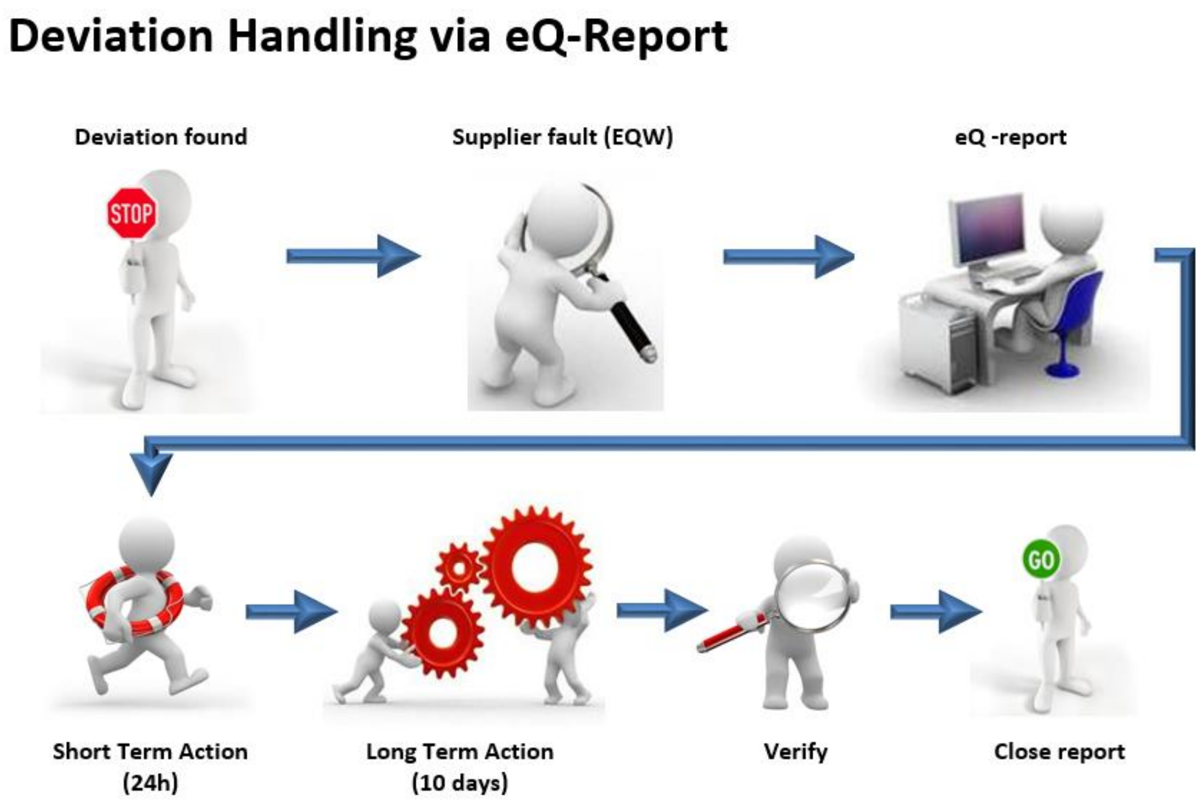

Figure 3-1: Scania quality handling concept. Source: (Scania, 2015)

If the supplier is informed about the 'NOT OK' parts, then it is necessary to make sure that the production line doesn't stop at the production units. Therefore Quality Assurance (QA) checks the stock at the PRU and if possible, repairs the parts as soon as possible. If the deviation is too hard to repair at the PRU, then the parts are returned to the supplier or reworked externally. All costs involved are charged to the supplier since it's the suppliers' responsibility to deliver parts according to the specifications. The previous described handling concept is for suppliers within Europe.

However, due to the North Bound Flow (NBF), the quality handling concept is a bit different. Inventories exists throughout the supply chain in various forms for several reasons (Ganeshan, 1999). In the case of NBF, the inventories exists not only at the PRU but also in the warehouse and in-transit, or "in the pipeline" due to safety buffers. When a PRU detects a part with a deviation, those inventories could also have parts with a deviation. But the problem for Scania lies in the question: who is responsible for this? 'Appendix C: issuing eQuality reports for NBF parts' of the 'User Guide eQuality2 Scania v2.3' state that: "The manufacturing supplier is responsible for product quality – technical and field quality – related eQuality reports to the supplier. Having full product responsibility, the supplier is also responsible for co-ordinating and seeing to that needed corrective actions are carried out throughout the supply chain" (Scania, 2015, p. 27). But in spite of this rule, there are still many problems.

Because suppliers are located far away from the warehouse, it is hard to safeguard the quality of the products in NBF. The Q-team at Scania Production Zwolle is assigned to support this because they are closest related to the NBF warehouse, however this is not known to all customers of NBF. When a PRU detects a deviation due to a supplier mistake, an eQuality is issued for the manufacturing supplier. Quality Assurance (QA) checks the inventory at the particular PRU, the supplier checks his own inventory and if necessary, Scania Production Zwolle comes up with an "ad-hoc solution" to manage the checking and sorting activities at the warehouse of NBF. As said before, all costs involved are charged to the supplier.

One of the first problems that arise for organizing a containment action is that it is unknown for the customers of NBF who they should contact. Since the NBF organization isn't responsible for it and the particular supplier is located (too) far away. In the current situation, four different situations occur for organizing a containment action in NBF:

1. The customer of NBF contacts Q-team in Zwolle. Scania Production Zwolle organizes the sorting action by contacting the NBF organization and Schenker. This should be the common method in the current situation.
2. The customer of NBF contacts the manufacturing supplier. But since the manufacturing supplier is located far away, it is hard for him to organize a containment action.
3. The customer of NBF contacts the NBF organization, but most of the times the NBF organization replies that they are not responsible for technical deviations.
4. The customer of NBF contacts Schenker, the warehouse in Ridderkerk directly. This situation is uncommon and didn't occur often.

In order to arrange a sorting activity in the warehouse, a few things have to be clear. The following five points are based on the current situation when Scania Production Zwolle organizes the sorting activity.

1. The first thing that has to be clear is which part number has to be sorted. The supplier detects the technical deviation and contacts the supplier, NBF organization, and Scania Production Zwolle.
2. The NBF organization determines in cooperation with the manufacturing supplier which quantities have to be checked and sorted at the warehouse.
3. Because the issuer discovered the technical deviation, they know how the checking has to be done. In cooperation with the supplier, they come up with a checking and sorting manual.
4. Schenker organizes the activities in the warehouse. They make sure that space is available for checking and sorting activities. In cooperation with the supplier and the customer, Schenker arranges the tools needed for the checking and sorting activities.
5. If the checking and sorting activity is easy, then Schenker performs the check and sort activity. Otherwise, Scania Production Zwolle performs the check and sort activity by arranging some employees from an employee agency called Randstad. Quality Assurance (QA) is needed for the expertise and the employees from Randstad are needed for the amount. In some cases an external company is reworking the parts.

Each sorting activity is different because of the lack of a written routine. All costs involved for checking and sorting are charged to the supplier, since he is responsible for the quality of its parts.

3.3.1 Example technical deviation handling North Bound Flow (NBF)

Confidential.

3.4 New location NBF warehouse

As we speak, Scania is building a new logistic centre in Hasselt, the Netherlands (LC Hasselt) of 20,000 m^2. Scania Logistics Netherlands (KD) and the NBF stock will be located in LC Hasselt. Figure 3-2 shows the building of LC Hasselt and Figure_i in Appendix C: Floor map LC Hasselt, the Netherlands shows the floor map of LC Hasselt. In June 2015 the total stock of NBF was moved from the warehouse in Ridderkerk and Beringe to LC Hasselt, Figure_ii in Appendix C: Floor map LC Hasselt, the Netherlands show where the stock of NBF is located in LC Hasselt.

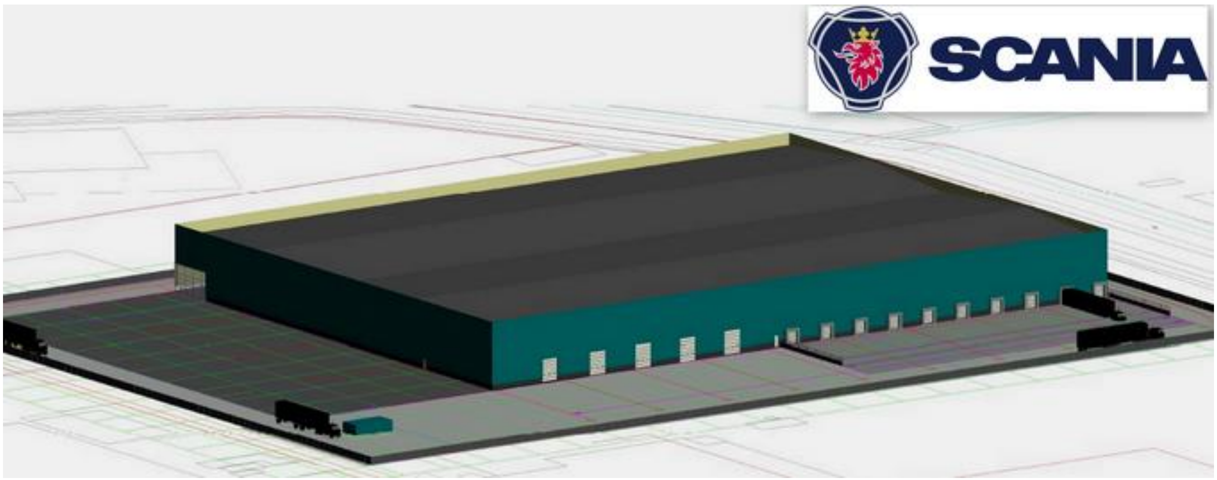

Figure 3-2: Scania LC Hasselt. Source: (Kamplacon, 2014)

The quality department (TKDQ) of Scania Logistics Netherlands (KD) is concerned with many aspects on quality within KD. One of the activities of TKDQ is conducting process checks at component units. During the process checks, all components are 100% inspected on specification, deviations, and packaging. Some vital components are also tested on functionality and necessary tools are available at TKDQ. Another activity of TKDQ is auditing. Auditing is a thorough inspection of the final product before delivery to customers with the aim to improve quality, profitability and enhancing customer satisfaction. The red circle in Figure_iii in Appendix C: Floor map LC Hasselt, the Netherlands aims to indicate the area that is reserved for inspection activities.

3.5 Does Scania have a problem?

The current situation with the different "ad-hoc" solutions for sorting activities in the North Bound Flow (NBF) is the result of a mix of problems. Scania feels that no one is responsible for the NBF and that a contact person is missing for the customers of NBF for organizing a sorting activity. Communication is not functioning optimally and there is a lack of information present about the NBF. Due to the expected growth and the increase of business with suppliers outside of Europe, Scania feels that there is a need to develop a systematic way of working.

Concluding: yes, Scania has a problem. The present current situation is working but it has to be improved, especially due to the expected growth of NBF.

3.6 Summary Chapter 3

This chapter analyzed the current situation at Scania. First relevant definitions (e.g., global supply chain management, quality, and containment) are described. Furthermore the current situation on how Scania is handling technical deviations from suppliers is analyzed, and the current situation is described with reference to an example. Information is given about the new warehouse located in Hasselt.

To answer the question: does Scania have a problem? Yes, Scania has a problem: the current situation is working but it is not optimal. The current situation needs to be improved especially due to the expected growth of NBF.

The next chapter discusses problem areas and their causes from the perspective of Scania and from the perspective of the stakeholders.

4 Problem areas

This chapter aims to identify the mix of problems that Scania experiences. To identify these problems personnel of Scania is interviewed to find out which problems they experience. The interviews were mostly open interviews in order to gather as much information as possible about ongoing difficulties. Problems were discovered during my stay at Scania production Zwolle, during my visit at Scania Södertälje in Sweden or during interviews. Section 4.1 aims to illustrate the general problems from a Scania perspective and in addition to this, Section 4.2 aims to illustrate the problems which stakeholders experience and defines the problem areas. Subsequently, Section 4.3 aims to give the mutual differences and similarities between the problems that stakeholders experience and a problem knot is presented. Finally a summary aims to be given in Section 4.4.

4.1 General problems from a Scania perspective

The problems that Scania as a global organization experiences are more general problems and the problems that customers observe are more in detail. Let us dwell upon two main problems related to this research namely: global supply chain and the warehouse of NBF, as presented in Figure 4-1.

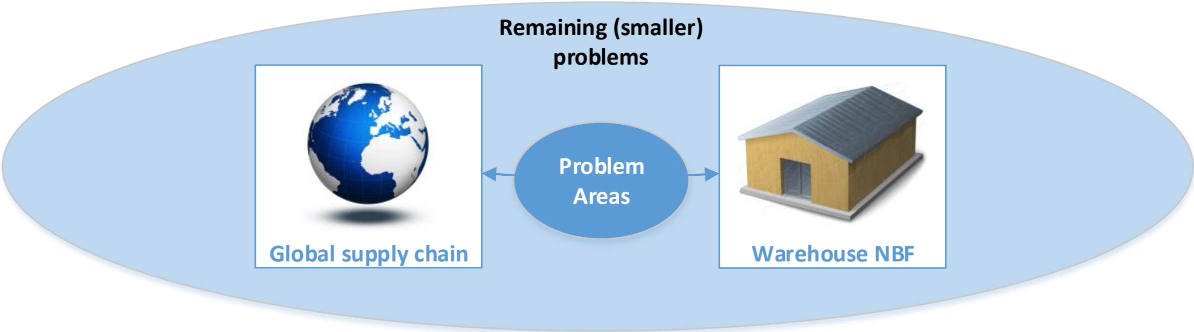

Figure 4-1: Two main general problems related to the North Bound Flow (NBF)

Global supply chain causes the first main problem related to NBF because the NBF organization and the warehouse are both created for using suppliers outside of Europe. When Scania doesn't have suppliers outside of Europe, there isn't a NBF organization and the problem would already be solved. But eliminating the use of suppliers outside of Europe is not an option due to purchase advantages and new market opportunities for Scania. The second main problem is the warehouse of NBF itself. When Scania doesn't use a warehouse, sorting activities can't be organized and the problem would be solved. But due to the long lead times and economies of scale, eliminating the warehouse isn't an option as well.

4.2 Problems which stakeholders experiences

This section aims to give a description of the stakeholders involved, together which problems the stakeholders' experiences in the current situation.

4.2.1 Stakeholders

The stakeholders involved in this research can be divided into three main groups. The first group is the NBF organization itself, since they are organizing the logistics. The second main group are the customers of NBF. Purchase department can be seen as the final group within the stakeholders. Scania purchasing has the direct responsibility for all purchasing activities with Scania and Scania Affiliated Companies with the exception of Scania Sales and Service Companies where Purchasing coordinates and makes recommendations. The focus is to globally support the four main processes: product development, order to delivery, sales and service delivery and all Scania supporting processes. The organization is further divided into quality, projects and strategy, with responsibility for quality of supplied parts, management and coordination of purchasing activities within the product development process, support with regional sourcing knowledge, and development of purchasing strategies, processes and system support. The quality department is responsible for quality assurance of the supplier production processes, support project-, production-, and spare part purchasing. There is also supplier quality assurance (SQA) locally present at the PRUs, taking care of and reporting supplier related quality issues in the daily production (Scania, 2013).

4.2.2 Problem areas

The problems that the stakeholders of the NBF experiences can be categorized into seven categories, namely: responsibilities, information, organization, containment, supply chain / logistics, communication. Problems that can't be categorized fall within the category: remainder, shown in Figure 4-2. For an overview of all identified problems the reader can skip to Section 4.3.1, 'problem knot'.

Figure 4-2: Seven problem areas related to the North Bound Flow (NBF)

Information

The first problem that many customers of the NBF experience is the lack of information about the NBF. While my visit in Södertälje, I discovered that there are three main problems related to the information problem area.

The first problem is how to figure out if a part is supplied from NBF. According to me, it is a bit strange since there are four possibilities to figure out if a part is supplied from the NBF, Appendix D: Supplier North Bound Flow (NBF) shows the four possibilities. However, this does indicate the lack of information regarding NBF.

Another common problem is that the customer doesn't know who to contact for organizing a sorting activity in the warehouse. This problem is strongly related to the problem areas containment and communication.

Finally, when a customer detects a technical deviation, there is a poor information flow between the players in the NBF. In almost all cases the customer informs the supplier about the technical deviation through an eQuality report. However, the customers don't always inform the NBF organization or the other customers about the technical deviation. Because the NBF organization and the other customers of NBF are not informed, the NBF organization keeps distributing possible parts with a technical deviation.
This problem is also related to communication.

Organization

In the current situation, six players are mostly involved for organizing a containment activity: the customer who detects the deviation, the corresponding manufacturing supplier outside of Europe, the NBF organization, Schenker (warehouse Ridderkerk), Scania production Zwolle (Supplier Quality Manager), and Purchase department. Purchase department is mostly involved due to their relationship with the supplier. Because the customer of NBF doesn't know who they should contact, they sometimes contact purchase department in order to get some questions answered (Purchase department has direct contact with the supplier). This problem does again indicate a lack of information concerning the NBF.

One of the outcomes of the interviews with Purchase department was that suppliers outside of Europe are chosen mainly for three reasons. The biggest reason is due to cost advantages, the second reason is dual sourcing and finally the third reason is for new market opportunities. But perhaps Purchasing is too much focused on cost benefits instead of quality improvements, which results in cheap but unreliable parts instead of high quality parts.

Finally, suppliers are more or less ranked based on three criteria: Parts Per Million (PPM), number of eQuality reports, and if short and long term dates are accomplished. Officially, an eQuality can only be closed if a 'first delivery number with 'OK' parts (long term)' is present. But sometimes (one of the reasons could be accomplishing the long term date), an eQuality report is closed without a delivery number and only a date is filled in (Figure 4-3). When an eQuality report is closed, it can't be re-opened to enter a delivery number later on. In this way, it is hard to find a clean cut.

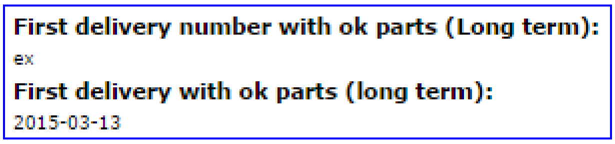
First delivery number with ok parts (Long term):
ex
First delivery with ok parts (long term):
2015-03-13

Figure 4-3: Closed eQuality report without delivery number

Containment
The first problem that many stakeholders experience is that it is unknown who is responsible for organizing a containment action. Many (smaller) sub problems are related to this, like it is unknown who to contact, or how to sort, or it is unknown how to mark pallets when they are sorted. Further it is unknown where to sort, does Schenker have the time and space to check the parts, or should the parts sent to a shack. These (smaller) sub problems are more detailed problems, since the main problem is that it is unknown for the customers how a containment action can be organized.

Communication
Communication within NBF is not functioning optimal. The first remarkable problem is that it is unknown for the customers of NBF who to contact if they want to organize a containment activity. The effect of this problem is speed losses because it takes a while before they have reached the right person for organizing a containment activity. The cause of this problem is the lack of information about who to contact for arranging a sorting activity.

Supply chain / logistics
Since this research is about the NBF which is part of a global supply chain, there are also some supply chain / logistical related problems. Within the supply chain / logistics problem area, there are five main problems.

The first problem that arises is the use of suppliers outside of Europe, but since this can't be influenced, as described in Section 4.1, I don't pay any attention to it. The second problem is that the warehouse is outsourced to a third party (3PL). Outsourcing has many advantages (Chopra & Meindl, 2007) (Vasiliauskas & Jakubauskas, 2007), but in our case also a big disadvantage. When a sorting activity has to be done at the warehouse, and it includes a difficult sorting activity, the 3PL has hardly any expertise and knowledge to do the sorting.

A third problem that is discovered during the interviews is the flow of information sharing, isn't the same as the flow of goods. According to Chopra & Meindl (2007), the NBF can be seen as a distributor storage with carrier delivery, presented in Figure 4-4. With this structure, inventory isn't held by the suppliers but is held in a warehouse, and package carriers are used to transport products from the warehouse to its customers. The information infrastructure needed in this structure is less complex than needed without a warehouse. Due to the warehouse, as Chopra & Meindl (2007) stated, "real-time visibility between customers and the warehouse is needed, whereas real-time visibility between customer and manufacturer is not" (Chopra & Meindl, 2007).

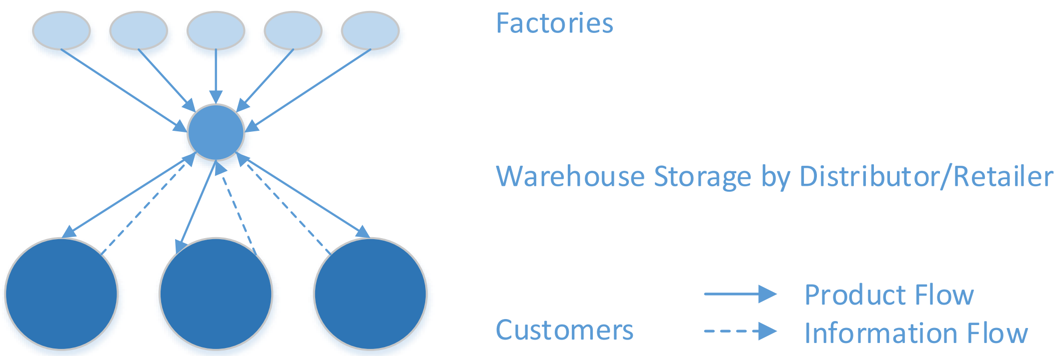

Figure 4-4: Information and goods flow, distributor storage with Carrier Delivery. Source: (Chopra & Meindl, 2007)

Next to this, as presented in Figure 4-5, an integrated supply chain concerns coordination and information sharing up and down the supply chain among all stakeholders (Habib, 2011). Which, in other words, concerns the management of flows of products, information, and finance upstream and downstream in the supply chain (Chopra & Meindl, 2007) (Habib, 2011).

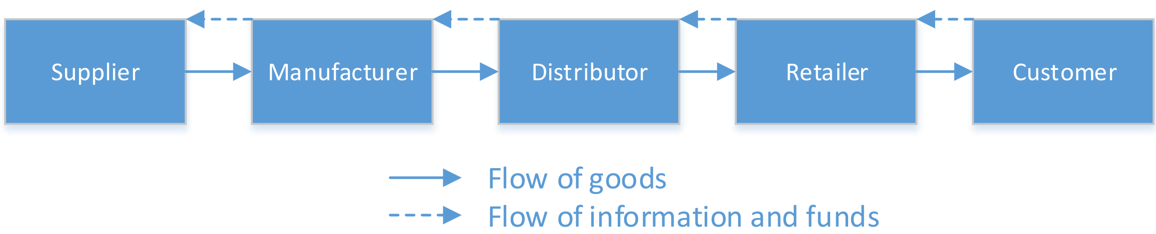

Figure 4-5: Information and goods flow, basic supply chain. Source: (Habib, 2011)

Further, the parts delivered to Scania Parts Logistics and Scania KD are at the beginning of a new supply chain. Especially the supply chain of Scania Parts Logistics is quite extensive, it distributes spare parts to a European retail network (with several warehouses), Asian markets (Singapore, Malaysia, Thailand, and Indonesia), Latin American markets (excluding Mexico), and to export markets. All these supply chains have also warehouses, which makes the track and trace of products difficult. So when a part with a technical deviation is found at a customer, it is hard to determine what the original batch of the supplier was.
The final problem is a 'NOT OK' product manufactured by the supplier.

Responsibilities
Because the warehouse of NBF can be seen as a big cross dock, it is unclear who is responsible for the quality of the parts in the NBF. Some stakeholders state that the manufacturing supplier is always responsible for the quality of the parts. Others state that Scania is responsible since they already own the parts and Purchase department is responsible for supplying required material, equipment and services. Because it is unclear who is responsible for the NBF, it is unknown who to contact for

organizing a sorting activity. As a result of this, it is unclear who is going to sort, who decides that a delivery stop is necessary at the warehouse, who arranges the personnel needed for sorting, etc.

Remainder
Finally, there are some problems that can't be categorized. For instance, in the current situation, technical deviations are found at the final stage of the process. The defaults are discovered at the production line, which is not optimal. The causes of this problem could lie in area of product control at the supplier that is not functioning well, or a lack of early product quality control.

4.3 Mutual differences and similarities between the problems stakeholders experience

As a result of the interviews given to several stakeholders, a numeration is made of the major differences and similarities of the problems stakeholders experiences.

Biggest mutual similarity between the problems that stakeholders experience:
There is a lack of written routine on what to do when a customer of the NBF organization wants to organize a containment activity in the NBF.

Smaller mutual similarities between the problems that stakeholders experiences:
- Customers of NBF don't know who they have to contact for organizing a containment activity in the NBF.
- It is unknown 'who is doing what' when organizing a containment activity.
- Customers of NBF don't know what NBF is and where it stands for (i.e., some of them didn't even know that the NBF organization uses a warehouse).
- Customers of NBF expect the same service from a supplier outside of Europe as from a 'normal' supplier. This could be achieved due to a central warehouse.
- Customers of NBF don't know which products are from suppliers outside of Europe.
- When a containment activity has been organized, a checking manual has to be made by the manufacturing supplier.

Mutual differences between the problems that stakeholders experiences:
- It is unclear who is responsible for the quality of the parts in the NBF. Some stakeholders argue that the manufacturing supplier is always responsible for its parts, while others state that this is short-sighted and that the NBF organization have to take responsibility of the parts in NBF.
- When a sorting activity has to be made in the warehouse, some stakeholders believe that only a small piece of the stock in the warehouse has to be checked, while other stakeholders believe that the whole stock in the warehouse should be checked since it is mostly unclear where the 'clean cut' is.
- Some stakeholders claim that the NBF organization and its warehouse can be seen as the supplier, while other stakeholders claim that the manufacturing supplier is the only supplier since the warehouse is a cross dock or hub. Because this difference, there is a discussion who to contact when a product with a technical deviation is found.
- Because the stakeholders don't agree on who the supplier for the customers is, there is a debate on who receives the eQuality report. Should the NBF organization receive the eQuality report, since they supply the goods to the customer or should the manufacturing supplier receive the eQuality report since the supplier is responsible for the quality of its parts.

4.3.1 Problem knot

However, the problem areas doesn't stand alone as presented in Figure 4-2. Communicational problems might be non-existent if information about NBF was more present or vice versa. All problems are connected with each other and therefore all problem areas are connected.

A useful method to give a better understanding of the problems and to present their underlying causes is a 'problem knot'. A problem knot is a schematic method to display various problems and their relationship that occur within an organization. In this way problems with their causes can be identified. Cause and effect relationships are shown by arrows. After analyzing the problem knot, (possible) key problems can be identified, analyzed and possibly solved (Heerkens, 1998). The problem knot (Figure 4-6) indicates the problems I observed, together with the problems that the stakeholders of NBF experiences. The problem areas are indicated with colours: problems in orange are related to information, light blue to organization, green to communication, grey to supply chain / logistics, purple to containment, yellow to responsibilities, and dark blue indicates the remainder problems. Further, a box contains a problem, an oval contains a statement, and a cloud give some clarification.

Due to the complexity of the problem, a mix of problems is observed. Because problems are interconnected in so many ways, it is hard to say whether one of these problems is more important than another. Based on the problem knot and due to time limitations, we focused on the four major problems.

- Cultural differences between Scania and manufacturing supplier.
- Manufacturing supplier ships a 'NOT OK' part in the supply chain of NBF.
- Lack of internal knowledge about the existence of NBF.
- Lack of a systematic way of organizing a containment action.

Due to the strong connections in the problem knot, solving these four issues automatically affect other problems (problem areas) in a positive way. The four problems are categorized in three sections: culture, preventive actions, and containment actions.

4.4 Summary Chapter 4

This chapter shows that Scania experiences a mix of problems related to North Bound Flow (NBF). First general problems from a Scania perspective are identified, but these can't be influenced. Further, problems experienced by stakeholders were listed and those problems can be influenced. Based on the mix of problems that can be influenced, the following seven problem areas are determined:

- Information
- Organization
- Communication
- Supply chain / Logistics
- Containment
- Responsibilities
- Remainder

Because the problem areas are connected in so many ways, a problem knot is created. Based on the problem knot and due to time limitations, the focus is given to the following four major problems:

- Cultural differences between Scania and NBF supplier lead to responsibility issues.
- Manufacturing supplier ships a 'NOT OK' part in the supply chain of NBF.
- Lack of internal knowledge about the existence of NBF.
- Lack of a systematic way of organizing a containment action.

Due to the strong connections in the problem knot, solving these four issues automatically affect other problems (problem areas) in a positive way. The four problems are categorized in three sections: culture, preventive actions, and containment actions.

In the next chapter, a literature study has been performed about culture. Theories based on Hofstede and Inglehart & Welzel are used.

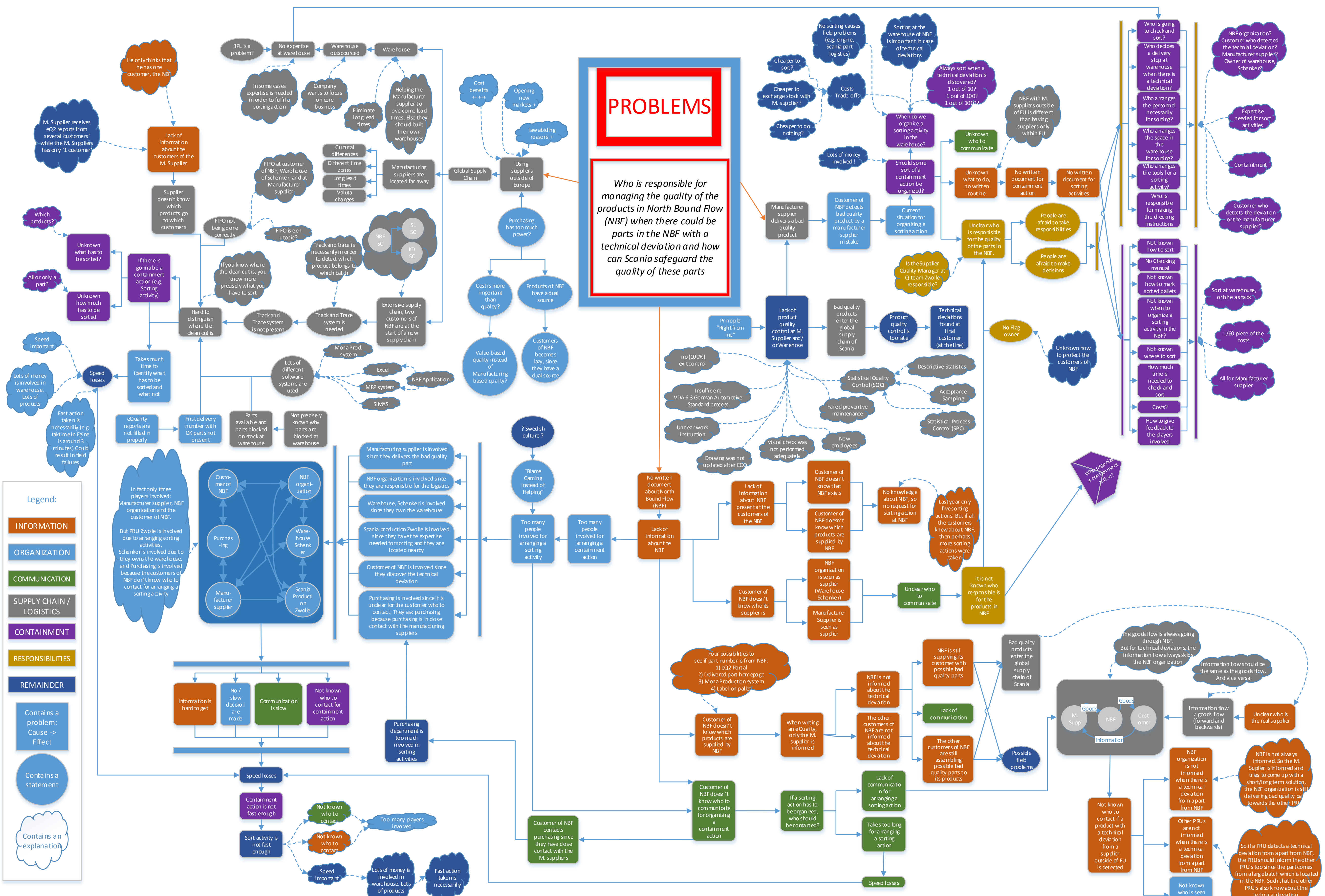

Figure 4-6: Problem knot

5 Culture

This section aims to give insight in the cultural differences based on Hofstede and Inglehart & Welzel. Scania is a global company and cultural differences are analyzed between Scania and its NBF suppliers. Section 5.1 aims to define culture. The theory of Hofstede is described in Section 5.2 and Section 5.3 aims to describe the theory of Inglehart & Welzel. Finally, a summary of this chapter is given in Section 5.4.

5.1 Culture

In this research, culture is the core value that characterize an organization: a collection of ideas and believes of individuals in the organization (Bloch, 1986). According to Valmohammadi & Roshanzamir (2015), managers should be aware of the cultural values of organizations because organizational culture has a direct positive impact on Total Quality Management (TQM) and organizational performance (Valmohammadi & Roshanzamir, 2015). Next to this, culture affects the way individuals handle their responsibilities (Bloch, 1986). According to Bloch (1986), an open culture is necessary for an organization in order to solve the problem of individual responsibilities that conflict with corporate purpose.

5.2 Hofstede

Hofstede conducted a comprehensive study on how values in the workplace are influenced by culture. Six dimensions of national culture can be distinguished (Hofstede, Hofstede, & Minkov, 2010):

- **Power Distance Index (PDI):** deals with the degree to which less powerful members of a society accept and expect that power is distributed unequally. There is acceptance of hierarchy in a large power distance society and there is an aim to power equalisation in small power distance societies.
- **Individualism (IDV)**: high individualism is the degree to which the individual expect personal freedom, low individualism represents a group oriented preference.
- **Masculinity (MAS)**: high masculinity represents a preference for achievement and ambition with specific behaviours whereas low masculinity cultures believe more in quality of life, such as caring for others and social support.
- **Uncertainty Avoidance index (UAI)**: is the degree to which the members of a society feel uncomfortable with uncertainty and ambiguity. A high level of uncertainty avoidance prefer to avoid uncertainty.
- L**ong Term Orientation (LTO)**: measures long term values. Societies which score low on long term orientation prefer to maintain traditions and societies with a high score take a more pragmatic approach.
- **Indulgency (IND)**: indulgency refers to the degree to which a society allows relatively free gratification of basic and natural human drives related to enjoying life and having fun.

Figure 5-1 compares Sweden to three countries where NBF suppliers are located. The countries China, India, and Brazil represents the suppliers and Sweden represents Scania, since Scania is a Swedish truck manufacturing company. The bars of PDI, IDV, and MAS show interesting results. Sweden scores high on IND, in contradiction with Brazil, India, and China. This means a high preference for a loosely-knit social framework and the management is the management of individuals. Taking into account PDI and MAS, Sweden has a much lower value on PDI and MAS than the countries from Asia and Latin America. This indicates that control is disliked, power is decentralized and Sweden has a more preference for quality of life, in contradiction with the other countries. In Sweden, conflicts are resolved by negotiation, while countries from Asia and Latin America have a preference for competition, achievement and success (Hofstede, 2015) (Hofstede, 2015).

According to Kimura (2003), culture and responsibility are linked to individualism. A high degree of individualism is needed for achieving true responsibility. Next to that, individuals take global issues personally and approach personal issues cosmically (Kimura, 2003).

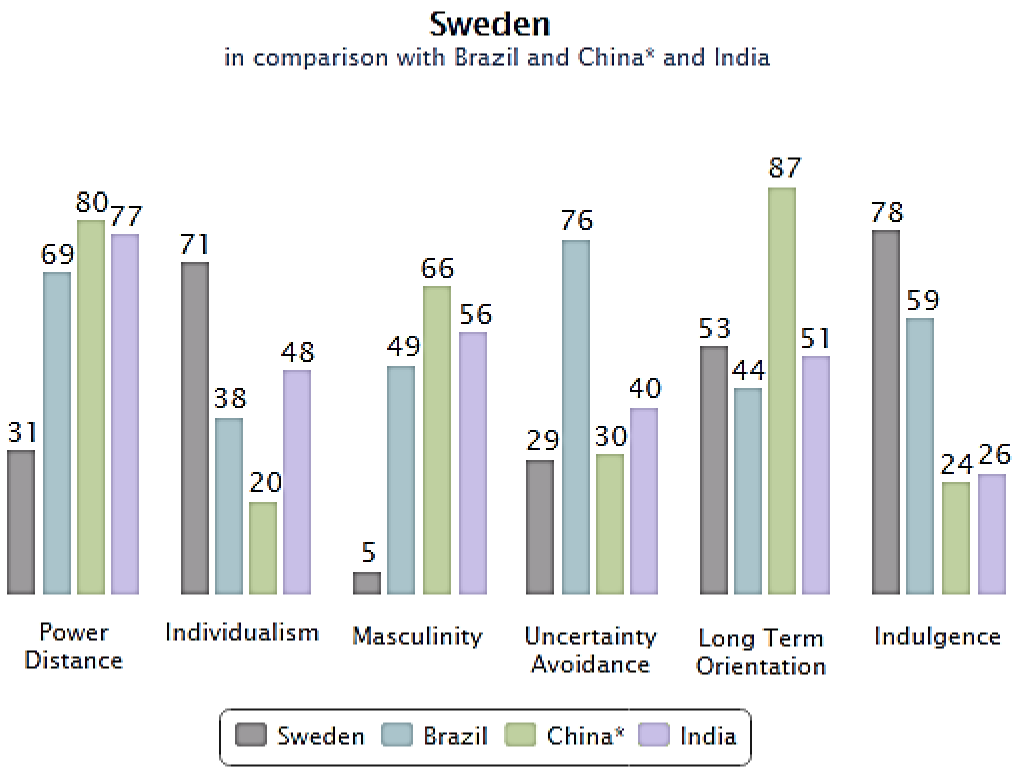

Figure 5-1: Hofstede country comparison, Sweden vs. Brazil, China, and India. Source: (Hofstede, 2015).

5.3 Inglehart & Welzel

The Inglehart & Welzel cultural map of the world is basically a scatter plot based on the World Values Survey (WVS). The scatter plot represents closely linked cultural values that vary between societies. The cultural map asserts that there are two dimensions of cross-cultural variation in the world and shows were societies are located in these two dimensions (Inglehart & Welzel, 2010):

1. X-axis: Survival Values versus Self-Expression Values.
2. Y-axis: Traditional Values versus Secular-Rational Values.

Survival Values: admire economic and physical security and safety, and they are linked to low levels of trust and tolerance.
Self-Expression Values: give high priority to protecting the environment, self-expression and quality of life.
Traditional values: represent the importance of religion, parent-child relationships and authority. Societies with traditional values exhibit high levels of nationalism and national pride.
Secular-Rational Values: tend to relate to liberal ways of thinking and place less emphasis on religion, traditional family values and authority.
Countries can be divided into nine clusters, which are indicated with nine different colours. A somewhat simplified analysis is that countries tends to move diagonally from lower-left (poor) to upper-right (rich), indicating a transit in both dimensions (Inglehart & Welzel, 2010) (Inglehart & Welzel, 2014).

If we draw a line (Figure 5-2) from upper-right (secular-rational value) to lower-left (Self Expression Values), then we can see that NBF suppliers are located in the lower-left (poor) side of the cultural map. This indicates that suppliers of NBF have more traditional and survival values.

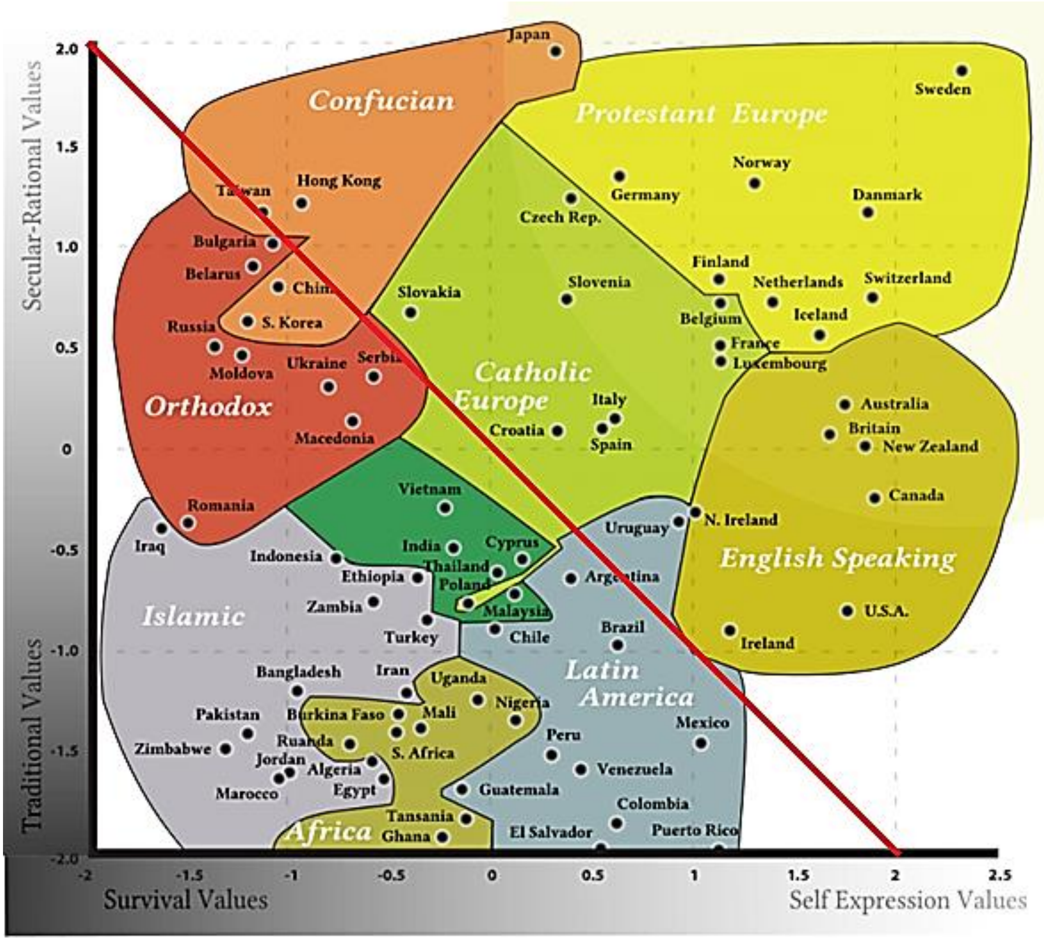

Figure 5-2: Cultural Value Map of Inglehart & Welzel. Source: (Inglehart & Welzel, 2014)

According to Bloch (1986), organizational culture does affect the way individuals handle their responsibilities. An open organizational culture can solve the problem of individual responsibilities that conflict with corporate purpose. Bloch (1986) states an open culture should foster a willingness to communicate freely in all levels of the organization. This willingness to communicate freely is a key element of an open culture (Bloch, 1986).

5.4 Summary chapter 5

The basis of this chapter is culture. First culture is defined and accordingly, theories of Hofstede (2010) and Inglehart & Welzel (2010) are described. Due to the global supply chain of Scania, cultural differences are present which lead to responsibility issues. In order to solve these responsibility issues, bloch (1986) state that an open culture is necessary. Key element of an open culture is the willingness to communicate freely in all levels of the organization.

In the next chapter alternatives are described in order to prevent that 'NOT OK' products enter the supply chain of NBF.

6 Preventive actions

The aim of this section is to provide preventive actions in order to minimize the risk that manufacturing suppliers ship 'NOT OK' products into the supply chain of NBF. This is important because the NBF has a complex and extensive supply chain. Section 6.1 aims to give insight in the sourcing process of Scania. A gap analysis is performed in Section 6.2. Section 6.3 aims to identify the most common causes of technical deviations from NBF suppliers. In Section 6.4, six alternatives are described in order to prevent that 'NOT OK' products enter NBF. Finally, a summary aims to be given in Section 6.5.

Nowadays, the emphasis has shifted from detecting quality problems to preventing quality problems early in the sourcing process (Monczka, Handfield, Giunipero, & Patterson, 2009). A high global sourcing quota doesn't necessary improve the competitiveness of Scania. Rather, there may be limits to global sourcing. Low prices may not automatically translate into lower total costs of ownership, if quality costs arise (Steinle & Schiele, 2008). Next to this, with the drastic competition from all over the world, quality management should be carried out in supply chain wide, instead of company-wide (Zhu, Alard, & Schoensleben, 2007). Goods often are designed in one company and being produced in another company. Quality management in design and manufacturing should implemented from the perspective of supply chain. The designer and manufacturer should improve the end-product quality cooperatively (Zhu, Alard, & Schoensleben, 2007).

6.1 Sourcing process

This section aims to give insight in the sourcing process. First different supplier roles are identified in Section 6.1.1. Section 6.1.2 aims to define interfaces and sourcing strategies are identified in Section 6.1.3. Finally Section 6.1.4 aims to describe the importance of specifications.

6.1.1 Supplier roles

Kamath & Liker (1994) allocated suppliers into four roles: Partner, Mature, Child, and Contractual (or Commodity) suppliers. Partner suppliers are able to work and develop entire subsystems through an independent engineering capacity. Mature suppliers need only rough specifications as a base for starting the development work. Suppliers classified as child needs complete and detailed specifications, which define the materials, dimensions, and functionality of a product. Contractual suppliers are those who manufacture standard parts that can be ordered from a catalogue. Table 6-1 gives an overview (Nellore, Söderquist, Siddall, & Motwani, 1991) (Kamath & Liker, 1994).

Table 6-1: Four supplier roles. Source: (Kamath & Liker, 1994)

Role	Description	Responsibilities during product development
Partner (Full service provider)	Relationship between equals; supplier has technology, size, and global reach.	Entire subsystem. Supplier acts as an arm of the customer and participates from the preconcept stage onward.
Mature (or Adult) (Full-System Supplier)	Customer has superior position; supplier takes major responsibility with close customer guidance	Complex assembly. Customers provides specifications, then supplier develops system on its own. Supplier may suggest alternatives to customer.
Child	Customer calls the shots, and supplier responds to meet demands.	Simple assembly. Customer specifies design requirements, and supplier executes them.
Contractual (or Commodity)	Supplier is used as an extension of customer's manufacturing capability.	Commodity or standard part. Customer gives detailed blueprints or orders from a catalog, and supplier builds.

Based on a survey (Appendix E: Survey) and my own insight, NBF suppliers can be seen as a child supplier. Designers of Scania specifies design requirements and draw production drawings, the suppliers from NBF manufacture according to the drawings received from Scania.

6.1.2 Managing interfaces

According to Araujo, Dubois, & Gadde (1999), there are four different interfaces on how a customer can access its suppliers' resources (Araujo, Dubois, & Gadde, 1999). The first is 'interactive' and is based on open-ended dialogue. Buyer and supplier can combine their knowledge of user and producer contexts and develop the product together. The second type of interface is 'translation' because the manufacturing supplier has to translate the functional characteristics supplied by the customer into a product. 'Specified' is the third interface and the supplier needs certain directions from the customer in order to produce a customized product. The final type of interface is 'standardized'. Table 6-2 aims to give a small overview and Appendix F: Interface categories aims to give an extensive overview.

A strong connection can be seen between Kamath & Liker's (1994) supplier roles and Araujo et al. (1999) proposed supplier interfaces. For instance, the standardized interface reflects the relationship that contractual / commodity suppliers have with their customers, whereas the interactive interface describes the interactions that partner suppliers have with their customers (Wong, 2011).

Table 6-2: Different Types of Supply Interfaces from a Customer-Based Perspective. Source: (Araujo, Dubois, & Gadde, 1999)

Interface Category	Characteristics
Interactive	Joint development based on combined knowledge of use and production.
Translation	Directions given by customer based on user context and functionality required.
Specified	Precise directions given by customer on how to produce.
Standardized	No Directions. No specific connection between user and producer contexts.

Based on a survey and my own insight, the interface that Scania has with the NBF suppliers can be categorized as a mix between specified and translation. Scania aims to give precise directions on how the supplier should produce a Scania part, but the supplier can propose efficient solutions which lead to more benefits.

6.1.3 Sourcing strategies

Scania is roughly divided into three commodity groups (cab, chassis-metal, and powertrain), where a quality- and a project group support each group. The commodity groups "own" the suppliers and are responsible for the business. Being responsible and owning the supplier means dealing with business operations, business development, develop strategies and choosing suppliers and so forth (Fenson & Edin, 2008). Commodity purchasing concerns one commodity, and includes the approach to purchase that specific commodity (Wood, Kaufman, & Merenda, 1996). Kraljic (1983) developed a matrix (see Table 6-3), which enables guidelines for designing commodity strategies and manage the relationship with suppliers in a different way (Kraljic, 1983) (Fenson & Edin, 2008).

Kraljic (1983) product and service position matrix depends on two main factors, when devising purchasing strategies. The first factor 'impact on business' can be defined: "in terms of the volume purchased, percentage of total purchase cost, or impact on product quality or business growth" (Kraljic, 1983). The other factor 'supply risk / supply market complexity' can be defined as: "the complexity of the supply market gauged by supply scarcity, pace of technology and/or materials substitution, entry barriers, logistics cost or complexity, and monopoly or oligopoly conditions" (Kraljic, 1983). Based on these two factors, Kraljic (1983) proposed a 2 x 2 matrix, with four types of strategies (Kraljic, 1983) (Cousins, Lamming, Lawson, & Squire, 2008):

- Strategy 1: Routine. This quadrant consists of commodity products with low value or costs and low technical or supply risk.
- Strategy 2: Bottleneck. This quadrant consists mainly specified items that can seriously affect the delivery of the buyer firm's product or service.
- Strategy 3: Leverage. This quadrant is aimed at a mix of commodities and specified items. This strategy is proposed when the buyer perceives low supply risk yet the cost or value of the product is high.
- Strategy 4: Critical. This quadrant is consists items that are scarce in the market and have a high value for the company.

Table 6-3: Kraljic product and service position matrix. Source: (Kraljic, 1983) (Cousins, Lamming, Lawson, & Squire, 2008)

	Classification of purchase items	
High **Impact on business (internal issues)**	**Leverage: Best deal** (High profit impact, low supply risk) • Unit cost management important because of volume usage. • Substitution possible. • Competitive supply market with several capable suppliers.	**Critical: Cooperation** (High profit impact, high supply risk) • Custom design or unique specification. • Supplier technology important. • Changing source of supply difficult or costly. • Substitution difficult.
Low	**Routine: Efficiency** (Low profit impact, low supply risk) • Standard specifications or 'commodity'-type items. • Substitute products readily available. • Competitive supply market with many suppliers.	**Bottleneck: Supply continuity** (Low profit impact, high supply risk) • Unique specification. • Supplier's technology important. • Production-based scarcity due to low demand and/or few sources of supply. • Usage fluctuation no routinely predictable. • Potential storage risk.
	Low **Supply Risk / supply market complexity (external issues)**	**High**

Based on a survey and my own insight, the sourcing strategy of Scania can be classified as leverage for parts from NBF. The horizontal axis is concerned with supply risk. It can be said that the supply risk is high due to long lead times. However, the following three points aims to conclude the opposite:

1. Because NBF uses a warehouse, the lead times are dropped extensively.
2. Almost all products in the NBF do have a dual source. The second supplier is located within Europe, relatively close to the warehouse and the customers.
3. Because the parts are not complicated, there are more suppliers available in the world who are able to manufacture the exact same product.

The vertical axis is concerned with impact on business. The products in NBF are low cost, but have a high value. Compared to the total cost of a truck, one part in NBF is relatively cheap, but if it fail during a drive the results could be disastrous. Therefore it can be said that the parts from NBF have a low supply risk and a high impact on business. So the parts can be placed in the Leverage quadrant.

6.1.4 Specifications

This section aims to describe the problems caused by disregard for specifications, since suppliers have to supply their products according to specifications. Nellore, Söderquist, Siddal, & Motwani (1991) determined eight dimensions of a specification, shown in Figure 6-1. Satisfying these eight dimensions can improve the written description of a product to guide the development process (Nellore, Söderquist, Siddall, & Motwani, 1991).

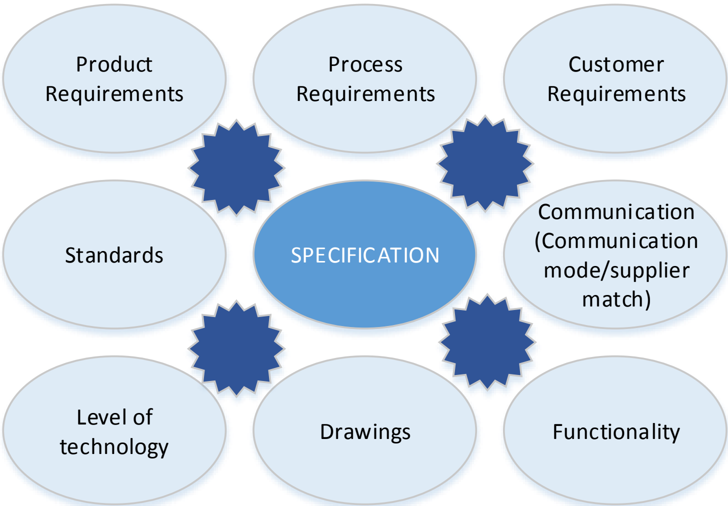

Figure 6-1: Dimensions of a specification. Source: (Nellore, Söderquist, Siddall, & Motwani, 1991)

Due to the variety of suppliers, Scania has to have the same understanding of specifications as their suppliers have. The eight dimensions that are identified must be observed throughout the entire supply chain, including all different levels of suppliers. Combining the eight dimensions of specifications of Nellore et al. (1991) with the four supplier roles of Kamath & Liker (1994), partner suppliers are expected to satisfy each of the eight dimensions. Adult suppliers needs the product, process, and customer requirements to perform their work, so they have to satisfy the other five dimensions. Child suppliers needs detailed specifications, thus they must receive at least a drawing and standards. Finally, commodity suppliers delivers a standard product, so there is no need to exchange specifications (Nellore, Söderquist, Siddall, & Motwani, 1991).

6.2 Gap analysis

Quality management is important for achieving competitive advantage and is defined by Flyn, Schroeder, & Sakakibara (1994) as: “an integrated approach to achieving and sustaining high quality output, focusing on the maintenance and continuous improvement of processes and defect prevention at all levels and in all functions of the organization, in order to meet or exceed customer expectations” (Flynn, Schroeder, & Sakakibara, 1994, p. 342). Flynn et al. (1994) developed a quality management framework, presented in Appendix G: Quality Management, which represents a never-ending cycle on continuous improvement. The framework leads to customer satisfaction and provides a sustainable competitive advantage. A gap analysis is performed because supplier involvement is important for quality management (Flynn, Schroeder, & Sakakibara, 1994) and mistakes at the manufacturing supplier is at the core of the problem knot. Additionally, according to Zhu, Alard, & Schoensleben (2007) the design process together with the production process is the most important and potential phase to enhance quality, as shown in Figure 6-2.

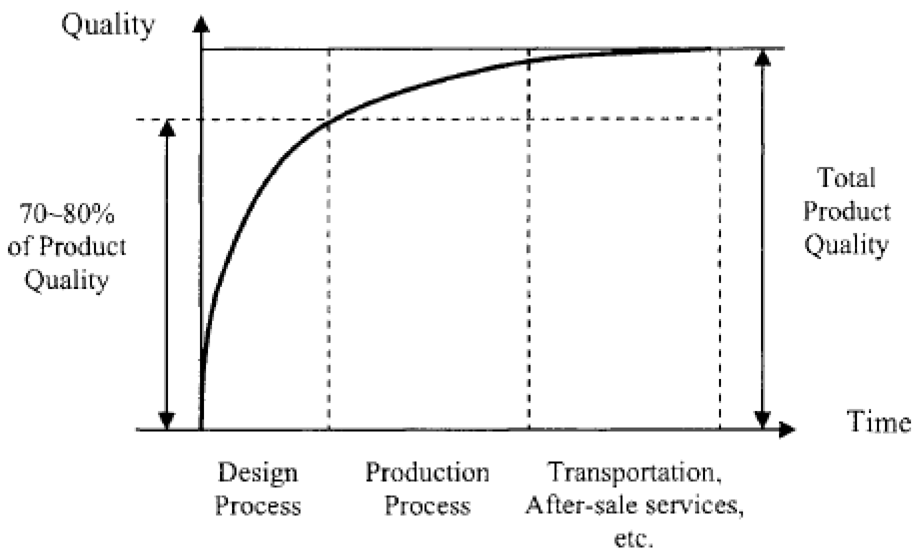

Figure 6-2: Incline of Quality. Source: (Zhu, Alard, & Schoensleben, 2007)

A gap analysis is mainly a determination to what extent the organization meets the requirements of a specification or standard (Brown, 2007). The aim of the gap analysis is to identify and correct gaps between desired levels and levels of performance (Boudreaux, 2010).

The operation's view of quality is concerned with trying to meet customer expectations. In addition, the customer's view of quality is what he or she perceives the product or service to be. In order to create a unified view, quality can be defined as the degree of fit between the customers' expectations and customer perception of the product or service. Three different situations can occur. If the product or service experienced was less than expected, then the customer is not satisfied and the quality is perceived to be low. On the other hand, if the product or service experience was better than expected, then the customer is satisfied and the quality is perceived to be high. In the final situation, if the product and service experience matches with the expectations, then the quality of the product or service is seen to be acceptable (Slack, Chambers, & Johnston, 2007). Figure 6-3 shows the three possible situations with the comparison between customers' expectations and their perceptions of the product or service. Parasuraman, Zeithaml, and Berry (1985) saw this as an expected service-perceived service gap.

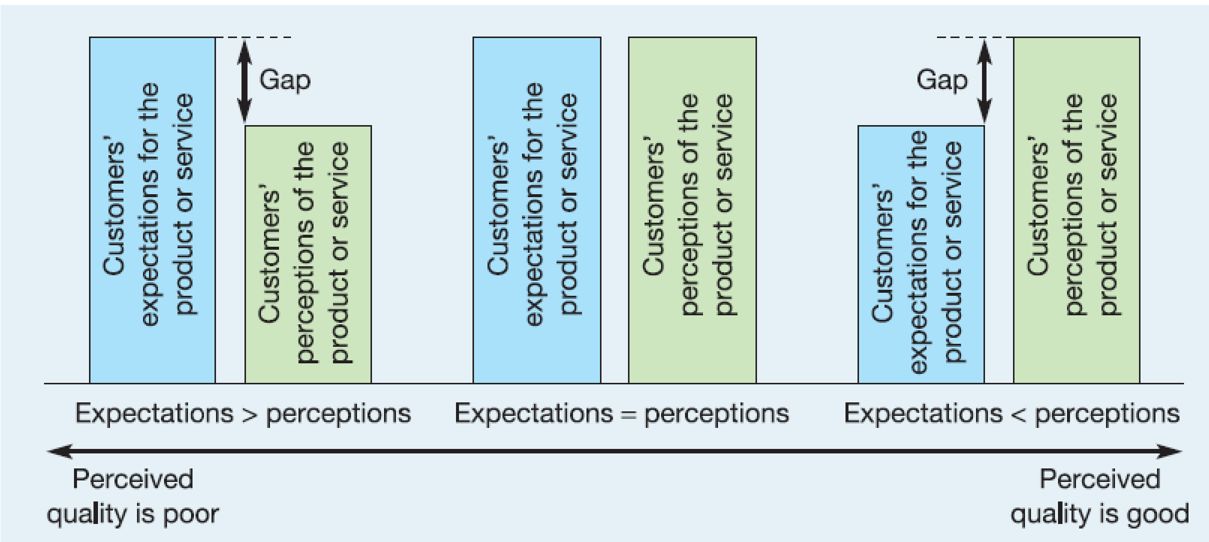

Figure 6-3: Gap between customers' expectations and perceptions. Source: (Slack, Chambers, & Johnston, 2007)

Both customers' expectations and perceptions are influenced by a number of factors, some of these factors can be managed by the company and some can't be controlled. According to Parasuraman, Zeithaml, & Berry (1985) if the product and service experience don't match with the expectations of the customer, then the reason lies in one of the following gaps (Parasuraman, Zeithaml, & Berry, 1985).

- Gap 1: Customer expectation-management perception gap.
- Gap 2: Management perception-service quality specification gap.
- Gap 3: Service quality specification-service delivery gap.
- Gap 4: Service delivery-external communications gap.

The gap between customers' expectations and perceptions can be seen as a fifth gap, Appendix H: Service / Product Quality Model shows the gap model as described by Parasuraman et al. (1985). However, this gap model is named SERVQUAL because it is a service quality gap model and therefore not entirely relevant for my research about product quality.

Slack et al. (2007) slightly changed the SERVQUAL model to a more product focused model. Appendix H: Service / Product Quality Model represents the model of Slack et al. (2007). Just as Parasuraman et al. (1985), Slack et al. (2007) does also have four gaps:

- Gap 1: Customer's specification-operation's specification gap.
- Gap 2: Concept-specification gap.
- Gap 3: Quality specification-actual quality gap.
- Gap 4: Actual quality-communicated image gap.

Yet, even though Slack et al. (2007) slightly changed the service gap model to a more product focused view, it is still not completely suitable for Scania. Therefore, adapted from Parasuraman et al. (1985) and from Slack et al. (2007), I developed my own gap analysis, presented in Figure 6-4.

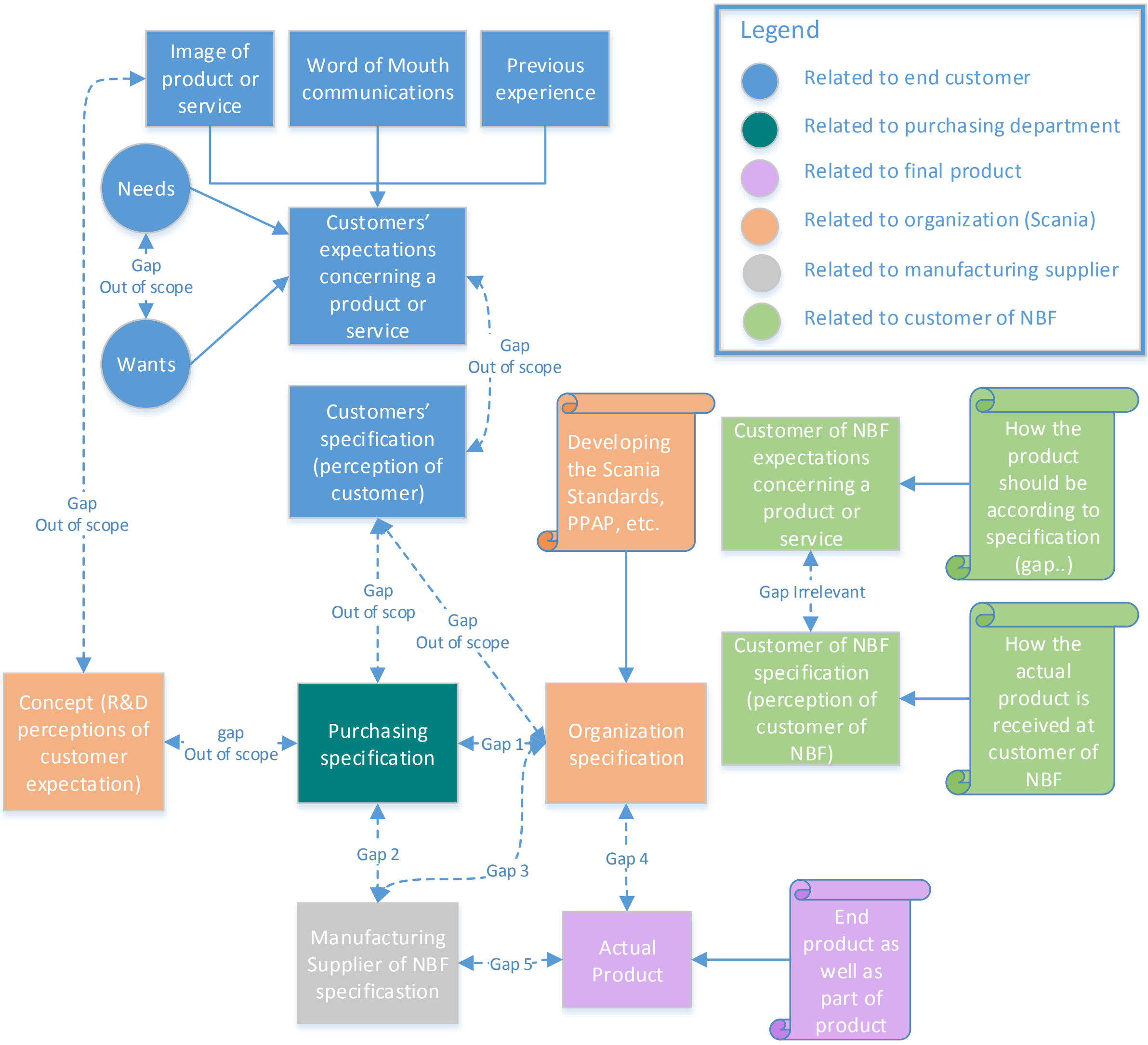

Figure 6-4: Gap analysis applicable to Scania

My gap analysis consists out of several gaps, of which five are relevant for my research. In contradiction to Parasuraman et al. (1985) and Slack et al. (2007) three instead of two players are involved in my gap analysis, namely: purchase department, Scania as an organization, and the manufacturing supplier.

Gap 1: Purchasing specification – Organization specification gap.
Perceived product quality could be poor because there may be a mismatch between the quality specification of the Purchasing department and Scania's own internal quality specification. If there is a mismatch, then this could result in a poor quality product.

Scania develops a product, and purchase department has to find a suitable supplier. Yet, if there is a mismatch about the specifications, then the supplier that has been contracted by Purchasing isn't able to manufacture a product that meets specifications.

Gap 2: Purchasing specification – Manufacturing supplier specification gap.
Perceived product quality could be poor because there may be a mismatch between the quality specification of the Purchasing department and the manufacturing supplier's own internal quality specification. If there is a mismatch, then this could result in a poor quality product.

Purchasers at Scania have to find suitable suppliers. If there is a mismatch between those two players, then the supplier is not be able to manufacture a product that meets specifications.

Gap 3: Organization specification – Manufacturing supplier specification gap.
Perceived product quality could be poor because there may be a mismatch between Scania's own internal quality specification and the quality specification of the manufacturing supplier of NBF. If there is a mismatch, then this could result in a poor quality product.

If a gap exists between Scania and the manufacturing supplier then the manufacturing supplier is not be able to manufacture a product that meets specifications. The product that the supplier manufactures is not according to Scania's specifications and therefore a 'NOT OK' product.

Gap 4: Organization specification – Actual product gap.
Perceived product quality could be poor because there may be a mismatch between the actual quality of the product provided by the supplier and the internal quality specification of Scania.

Gap 5: Manufacturing supplier specification – actual product gap.
Perceived product quality could be poor because there may be a mismatch between the actual quality of the product provided by the supplier and its internal quality specification.

If the first three gaps exists, then this results in gap 4 and gap 5. The gaps in Figure 6-4 that are out of scope are important, but due to my limited time and the scope of my research, I don't investigate this. The gap related to the customer of NBF does lie in the scope of this research, but closing the first three gaps, will automatically close the gap related to the customers of NBF. Therefore it is necessary that the manufacturing supplier doesn't ship 'NOT OK' products into the supply chain of NBF.

6.3 'NOT OK' products manufactured by NBF suppliers

In order to find techniques to monitor NBF suppliers more tightened, causes of technical deviations have to be known. This section aims to identify the most common technical deviations.

6.3.1 Common technical deviations

Based on interviews with SQAs and scrutinizing eQuality reports, a list of common technical deviations and their root causes is made:

- Problems with technical drawings (e.g. misunderstanding about drawings or drawings were not updated after an Engineering Change Order (ECO)).
- Lack of control of production process (e.g. insufficient 'control plan' (PPAP or VDA 6.3) or failed preventive maintenance actions).
- Human errors (e.g. work instructions are not correct or new employees).
- Inspection errors (e.g. visual check is not performed adequately or poor control on finished products).
- Improperly packaging (e.g. packing without plastic bag)

Studying the figures attached to the eQuality reports, it is striking that lots of technical deviations are visible detectable.

6.3.2 Quality improvements techniques

Being a supplier of Scania, the supplier shall conform to and apply the Scania STD3868 as well as all other standards and manuals referred to in any separate instructions from Scania as applicable from time to time described on Scania Supplier Portal. But, because these suppliers are located far away and have large quantities in stock in the warehouse, more control at the supplier aims to be needed in order to safeguard the supply chain. A decision matrix is used to aid in decision-making (Davis, 2011). Based on a literature study and my own insight, six alternatives are identified.

6.4 Alternatives and criteria

This section aims to show techniques to monitor NBF suppliers more tightened. Due to the long lead times from suppliers to the warehouse and the complex global supply chain, it is important to prevent that 'NOT OK' products enter NBF. The following five alternatives are identified based on scrutinizing equality reports:

1. Specification
2. Audit
3. Personnel
4. Inspection
5. Packaging

It could be said that one of the alternatives is not having something extra for suppliers from NBF and just treat them the same as suppliers within Europe. However, due to the complex situation, cultural differences, and the extensive supply chain, the aim is to have some extra control at NBF suppliers.

6.4.1 Alternatives

First the specific alternative is described, then the advantages and drawbacks are listed and finally considerations for further research are given. For a quick overview of all six alternatives with their corresponding advantages, disadvantages, and considerations for further research, the reader can skip to Table 6-12.

Alternative 1: Extra specification control

The quality of a product, as defined by Dhafr, Ahmad, Burgess & Canagassababady (2006), means elimination of defects from the product. Defects are deviations from specification or, the performance gap between desired and an observed result (Dhafr, Ahmad, Burgess, & Canagassababady, 2006). According to my own gap analysis, described in 6.2, three different gaps are at the origin of a misunderstanding about specifications. Because the suppliers in NBF can be characterized as Child and the interface between Scania and the suppliers are categorized as a mix between translation and specified, suppliers need detailed specifications. Subsequently, based on Hofstede (2010) and Inglehart & Welzel (2010), there are cultural differences between Scania and its suppliers which make a clear understanding of specifications even more complex.

One of the advantages of this alternative is the elimination of misunderstanding about specifications. This leads to an early poor quality prevention because the errors are already identified before the manufacturing starts. Next to that, there is less ´blame gaming´ about the specifications and drawings, because of the mutual understanding of the specifications. Finally, it is a low cost alternative. The biggest disadvantage is that is hard to discover when there is no misunderstanding anymore about the specifications. The personnel at the manufacturing supplier have to be medium skilled in order to understand the specifications. A consideration for further research is to develop a tool or method in order to be certain that any misunderstanding about specifications is eliminated. Finally, in this alternative, Scania is in full control. Table 6-4 aims to give an overview of the advantages, disadvantages, and considerations for future research.

Table 6-4: Preventive actions: Pros and cons alternative 1

Alternative	Advantage	Disadvantage	Considerations for further research
A1: Specification	- Less misunderstanding about specifications. - Early poor quality prevention - Less blame gaming about specifications and drawings - Low cost	- Hard to know when there is no misunderstanding anymore. - Medium skilled personnel	Develop a tool to be certain that all misunderstandings about specifications are eliminated.

Alternative 2: Extra supplier audit

The purpose of alternative 2 is to have a tighter control at the manufacturing process of a NBF supplier. Let us dwell upon some examples. Defect life cycle provides manufactures with a standard set of states where a defect could occur, these states are intended to help standardize defect reporting. In order to gather the information based on defect status, learning from the defects is possible and therefore the performance of the production line can be improved (Dhafr, Ahmad, Burgess, & Canagassababady, 2006). Figure 6-5 shows the proposed model for a defect cycle.

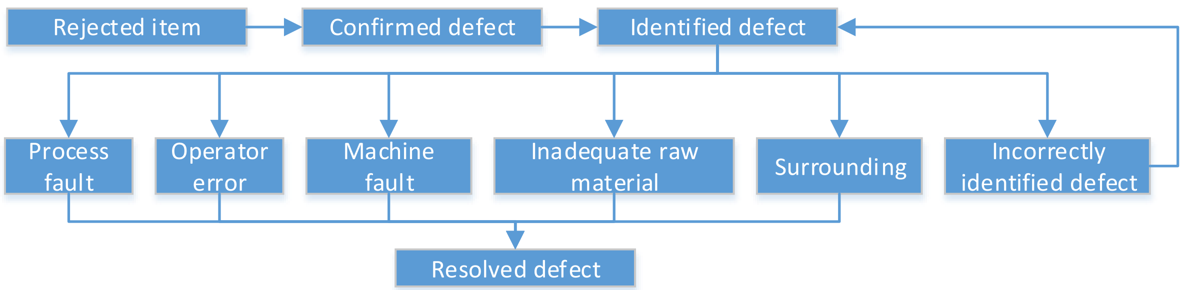

Figure 6-5: Defect cycle. Source: (Dhafr, Ahmad, Burgess, & Canagassababady, 2006)

Based on the analysis of a defect life cycle, a fault tree can be structured in order to determine the overall probability for the production of a defective product (Dhafr, Ahmad, Burgess, & Canagassababady, 2006). A fault tree analysis (FTA) is a method for analyzing the cause of risks. FTA is deductive, since it starts with a top event and develop down through specific input invents that must occur in order generate the top event (Akgün, Gümüşbuğa, & Tansel, 2015). According to Akgün et al. (2015) "each event is analyzed by asking, "how could this happen?"" (Akgün, Gümüşbuğa, & Tansel, 2015, p. 171). Dhafr et al. (2006) show an example as presented in Figure 6-6 with the aim to show a fault tree that can be structured in order to determine the overall probability for the production of a product with a defect with the following probability function.[1]

$$P(defective\ part) = (B^1 \cap B^2) \cup (B^3 \cap B^4) \cup (B^5 \cap B^6) \cup (B^7 \cap B^8)$$

The fault tree in Figure 6-6, given as an example, assumes that a single or a combination of faults may lead to a defective product (Dhafr, Ahmad, Burgess, & Canagassababady, 2006). FTA is a useful tool to identify the root cause and an effective risk assessment tool. But when the problem is complex, the fault tree could become enormous and takes a tremendous times to be completed (Baig, Ruzli, & Buang, 2013).

[1] Note that the example of Dhafr et al. (2006) contains two errors. First, the fault tree is missing B_9 since 'Faulty Raw Material' is a primary basic event. Second, there is an OR-gate instead of an AND-gate after the output event 'Machine Fault'. So $(B^3 \cap B^4)$ should be changed to $(B^3 \cup B^4)$. This gives the new formula: $P(defective\ part) = (B^1 \cap B^2) \cup (B^3 \cup B^4) \cup (B^5 \cap B^6) \cup (B^7 \cap B^8) \cup B^9$.

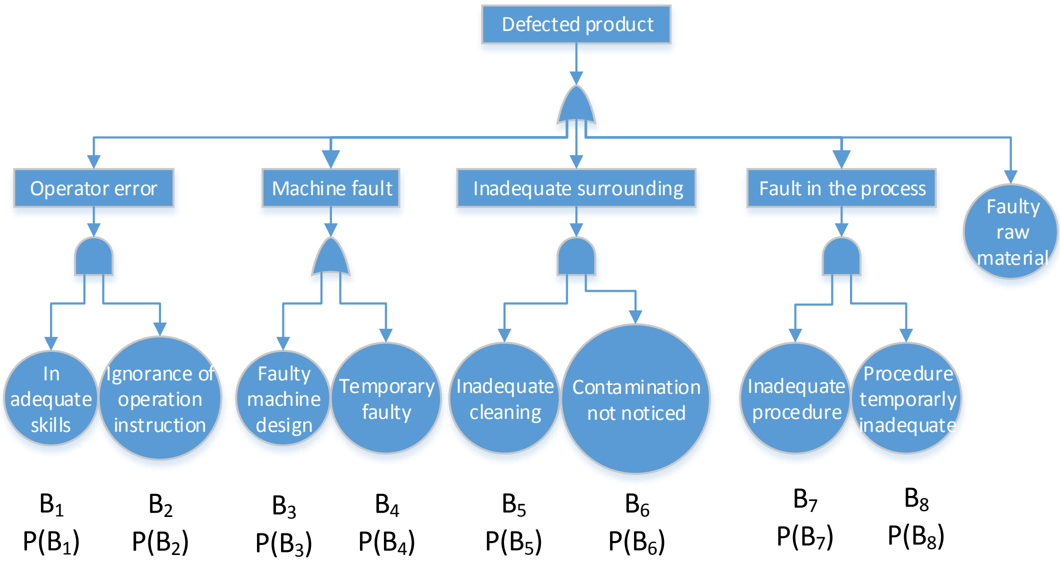

Figure 6-6: Fault tree for defining source of defects. Source: (Dhafr, Ahmad, Burgess, & Canagassababady, 2006)

The German Association of the Automotive Industry (VDA) published a series of standards based on ISO 9001 which was initiated by the automobile industry. VDA 6.3 defines a process based audit standard for evaluating and improving controls in a manufacturing organization. The processes get analyzed in such a way that risk and weaknesses are detected in work processes and their corresponding interfaces. At the end of the audit the supplier may get one of the following ratings (VDA 6.3, 2010):

Table 6-5: Overall level of achievement

Classification	Overall level of achievement (E_g)	Description of the classification
A	$E_g \geq 90$	Quality Capable
B	$80 \leq E_g \leq 90$	Conditionally quality capable
C	$E_g \leq 80$	Not quality capable

The biggest advantage of this alternative, is that suppliers of NBF have a better overall level of achievement in comparison to suppliers within Europe. This means more controlled processes, a better risk identification and a quality capable process. However, it doesn't guarantee hundred percent good quality parts. Table 6-6 aims to give an overview of the advantages, disadvantages, and considerations of future research. In this alternative, the whole process is controlled by Scania. Table 6-6 aims to give an overview of the advantages, disadvantages, and considerations for future research.

Table 6-6: Preventive actions: Pros and cons alternative 2

Alternative	Advantage	Disadvantage	Considerations for further research
A2: Audit	- More controlled processes - Better risk identification - Quality capable process	- Doesn't guarantee 100% good quality products	-

Alternative 3: More clear work instructions and personnel training at supplier

The human errors that lead to poor product quality are mainly twofold, namely: wrong work instructions or new employees who make mistakes. Employees at factories in Asia are commonly low skilled. In China for instance, ex-agricultural workers are often working as factory employees. These employees have a low level of education and no experience of working within a factory environment

(Glover & Siu, 2000). Because of incomplete work instructions and a lack of a proper introduction of new employees, employees don't perform optimally.

Advantage of this alternative is an increase in high skilled personnel at the manufacturing supplier, who makes less mistakes during the production process. Due to the better work instruction, fewer 'simple to avoid' errors are made. However, it takes a lot of time to train the personnel, it is costly and a high skilled tutor needs to available. A consideration for further research is to rewrite the work instruction is such a way that all the personnel understand the instructions. Next to this, a training program for new employees has to be developed. The process of work instructions and personnel training is controlled by the manufacturing supplier. Table 6-7 aims to give an overview of the advantages, disadvantages, and considerations for future research.

Table 6-7: Preventive actions: Pros and cons alternative 3

Alternative	Advantage	Disadvantage	Considerations for further research
A3: Personnel	-More skilled personnel - Less 'easy to avoid' errors	- Takes time to train personnel - Trainer has to be available - Training costs	Rewriting of work instructions and a training plan has to be developed

Alternative 4: More (visual) product inspection at supplier
Many poor quality products are visual detectable. Rajendra, Babu, & Naidu (2011) state that inspection is a method of attaining standardisation, uniformity and quality of workmanship and can be seen as controlling the product quality after comparison between specifications. If an item does not fall within the zone of acceptability it is rejected and a corrective action has to be applied in order to prevent this failure in the future. The objectives of inspection are (Rajendra, Babu, & Naidu, 2011):

- To collect information regarding the performance of the product.
- To sort out poor quality of manufactured products and thus to maintain standards.
- To increase the supplier reputation by protecting the customer form receiving poor quality products.
- Detect source of weakness and failures in the finished products, and thus check the specifications.

According to Rajendra et al. (2011), there are three stages of inspection:

1. Inspection of incoming materials:
   Inspection of incoming materials consist of inspecting and checking all the purchased raw materials and parts that are supplied by suppliers. This inspection takes place before the raw materials are taken on to stock or used in the production (Rajendra, Babu, & Naidu, 2011). The biggest advantage of this is that poor quality parts are not entering the production process.
2. Inspection of production process:
   Inspection is done at various work centres of men and machines and at the bottleneck, while production is simultaneously going on (Rajendra, Babu, & Naidu, 2011). The biggest advantage of this is preventing delays in production.
3. Inspection of finished goods:
   Inspection of finished goods is the final stage where inspection can take place. The finished goods inspected and poor quality products are rejected and reworked (Rajendra, Babu, & Naidu, 2011). The biggest advantage of this is poor quality products are not shipped to the customer.

Rajendra et al. (2011) state that there are two methods of inspection, Table 6-8 aims to give an overview:

1. 100 % Inspection:
   In 100 % inspection each product is separately inspected, which requires more inspectors than sampling inspection and this makes it a costly method. 100 % Inspection is suitable if a high degree of quality is required (Rajendra, Babu, & Naidu, 2011). It can be stated that 100% inspection performs slightly better than sample inspection, however only 80% of the errors are detected with 100% inspection (Pesante, Williges, & Woldstad, 2001).
2. Sampling inspection:
   Sampling inspection is a method where randomly selected samples are inspected. Samples taken from different batches of products are representatives. If a poor quality product is identified, then the entire batch has to be rejected or reworked. Sampling inspection is cheaper, quicker, and requires less number of inspectors. But it is subjected to sampling errors (Rajendra, Babu, & Naidu, 2011).

Table 6-8: Pros and cons between inspection methods

Type of inspection	Advantage	Disadvantage
100% inspection	- All products are inspected. - Less change that poor quality products enter the supply chain of NBF. - Reliable.	- Slow method. - Costly method.
Sampling inspection	- Faster than 100% inspection. - Cheaper than 100% inspection. - Less reliable.	- Not all products are inspected. - Still a change that poor quality products enter the supply chain of NBF.

Because quality is of such importance, alternative 4 is narrowed to a 100% inspection of finished goods. In this way, it is unlikely that poor quality products entering the NBF.

Inspection at the supplier is proposed instead of inspection of incoming goods at the warehouse because, goods entering the warehouse are already in the supply chain of NBF and these goods have to be of good quality. Another benefit for inspection at the supplier is that poor quality products can be easier and faster reworked at the supplier instead of in the warehouse. Table 6-9 aims to give an overview of the advantages and disadvantages.

Table 6-9: Pros and cons of location of 100% inspection

Inspection at:	Advantage	Disadvantage
Supplier (outbound)	- Early detection of poor quality products. - Close to production process. - Rework done by supplier	-
Warehouse (inbound)	- Products are already close at customer	- Poor quality products are stored in warehouse - Rework is not done by supplier - Space for inspection has to be available

Advantage of this alternative is that only good quality products enter the supply chain of NBF, since many poor quality products can be identified due to visual inspection. Further, it is a low cost method, which can be implemented as soon as possible. Additionally, visual inspection is an easy and effective solution. But inspection is also costly, which is a disadvantage of this alternative. A consideration for further research is to make an inspection list for each product. Alternative 4 is controlled by the manufacturing supplier. Table 6-10 aims to give an overview of the advantages, disadvantages, and considerations for future research.

Table 6-10: Preventive actions: Pros and cons alternative 4

Alternative	Advantage	Disadvantage	Considerations for further research
A4: Inspection	- Only good quality products enter NBF. - Low cost method - Easy and fast implementation	- Costly	Inspection list per product is needed.

Alternative 5: Improved product packaging

According to the expertise of some SQAs, improperly packing leads to poor product quality as well. In order to prevent any damage to parts during transport in large container ships, I propose to pay extra attention to packaging NBF parts. Some NBF suppliers do use Scania boxes for packaging their products. However, some NBF suppliers use one-way packaging which sometimes does lead to poor product quality since the one-way package is not always adequate enough. Or if the supplier forget to pack the goods properly, which could lead to rust (as can be seen in Figure 6-7).

Figure 6-7: Rust on parts due to improper packaging

Advantages of an improved product packaging is that products are not harmed during transport. The biggest disadvantage of this alternative is the lack of product quality control, it only safeguards the transport. Next to this, it takes time to develop the right package per product and it has several cost disadvantages. A consideration for further research is to develop a suitable package for each product. The last alternative is controlled by Scania and the manufacturing supplier. Table 6-11 aims to give an overview of the advantages, disadvantages, and considerations for future research.

Table 6-11: Preventive actions: Pros and cons alternative 5

Alternative	Advantage	Disadvantage	Considerations for further research
A5: Packaging	- Products are not damaged during transport	- It only safeguards transport, not production - Development time - Package and transport costs	Suitable package for each product has to be developed.

Table 6-12 gives a summary of the five alternatives with the corresponding advantages, disadvantages, and considerations for future research.

Table 6-12: Summary of alternatives for preventive actions at manufacturing supplier

Alternative	Advantage	Disadvantage	Considerations for further research
A1: Specification	- Less misunderstanding about specifications. - Early poor quality prevention - Less blame gaming about specifications and drawings - Low cost	- Hard to know when there is no misunderstanding anymore. - Medium skilled personnel	Develop a tool to be certain that all misunderstandings about specifications are eliminated.
A2: Audit	- More controlled processes - Better risk identification - Quality capable process	- Doesn't guarantee 100% good quality products	-
A3: Personnel	-More skilled personnel - Less 'easy to avoid' errors	- Takes time to train personnel - Trainer has to be available - Training costs	Rewriting of work instructions and a training plan has to be developed
A4: Inspection	- Only good quality products enter NBF. - Low cost method - Easy and fast implementation	- Costly method	Inspection list per product is needed.
A5: Packaging	- Products are not damaged during transport	- It only safeguards transport, not production - Development time - Package and transport costs	Suitable package for each product has to be developed.

6.4.2 Criteria

After the identification of five alternatives, four selection criteria are composed for judging the alternatives. In consultation with management (Head of Customer Supplier Interface), it has been determined that each of the four criteria are not equally important. The four criteria and there weights are given below:

Criteria 1: Costs
Costs refers to the degree how costly the proposed alternative is. A high value refers to a low cost alternative and a low value refers to a costly alternative. This criteria is the least important criteria and has a weight of 0.25.

Criteria 2: Speed
Speed refers to the degree how fast the proposed alternative can be implemented. A high value refers to a fast implementation and a low value refers to a slow implementation. This criteria has a weight of 0.50.

Criteria 3: Difficulty
Difficulty refers to the degree how much expertise is needed to perform the proposed alternative. A high value refers to a simple alternative and a low value refers to a difficult alternative. This criteria has a weight of 0.75.

Criteria 4: Quality
Quality refers to the degree how adequate the proposed alternative is. A high value refers to a high quality alternative and a low value refers to a low quality alternative. This criteria is the most important criteria and has a weight of 1.00.

Working in one column at a time, the proposed alternatives are ranked based on each individual criteria where scores range from 1 to 5. The alternative which performs best on a criteria is given a score of 5 and the alternative which performs least well (not necessarily badly in any absolute sense) is given a score of 1. All other alternatives are rated in between. The scores are given in consultation with the Head of Customer Supplier Interface. The total score is calculated with the formula:

$$t_j = \sum w_i * s_{ij}$$

where:

$$t_j = Total\ score\ of\ alternative\ j$$
$$w_j = Weight\ of\ criterion\ i$$
$$s_{ij} = Score\ on\ criterion\ i\ assigned\ to\ alternative\ j$$

Table 6-13: Decision matrix, preventive actions

Alternatives \ Criteria	C1: Cost	C2: Speed	C3: Difficulty	C4: Quality	Total
Weights:	0.25	0.50	0.75	1.00	
A1: Specification	5	3	2	3	7.25
A2: Audit	4	1	3	4	7.75
A3 Personnel	3	2	1	2	4.5
A4: Inspection	1	5	5	5	11.5
A5: Packaging	2	4	4	1	6.5

The decision matrix (Table 6-13) aims to conclude that alternative 4: 'product inspection at the supplier' is the best alternative for Scania.

6.5 Summary Chapter 6

In this chapter, we first investigated NBF suppliers. Suppliers of NBF can be seen as child supplier, the interface that Scania has with the suppliers of NBF can be categorized as a mix between specified and translation, and the sourcing strategy can be classified as leverage for parts from NBF. This indicates that it is very important to have a clear understanding of specifications.

As indicated in our own gap analysis, three gaps are at the basis of a misunderstanding between specifications. The three important gaps are: Purchasing specification – Organization specification gap, Purchasing specification – Manufacturing supplier specification gap, and Organization specification – Manufacturing supplier specification gap.

Finally, five different alternatives are identified to prevent that 'NOT OK' products enter NBF. These five alternatives are:

1. Specification: Extra specification control between Scania as an organization, Scania Purchase department, and the manufacturing supplier.
2. Audit: A tighter audit control at the manufacturing supplier.
3. Personnel: More clear work instructions and personnel training at the manufacturing supplier.
4. Inspection: 100% outbound goods inspection at the manufacturing supplier.
5. Packaging: Pay extra attention to packaging NBF products.

In consultation with management (Head of Customer Supplier Interface) each of the five alternatives are judged by the following four criteria:

1. Cost: Refers to the degree how costly the alternative is.
2. Speed: Refers to the degree how fast the alternative can be implemented.
3. Difficulty: Refers to the degree how much expertise is needed for the alternative.

4. Quality: Refers to the degree how adequate the alternative is.

A decision matrix aims to conclude that Alternative 4: inspection is the best alternative for Scania. Containment actions based on a literature study and a benchmark study aimed to be described in the next chapter.

7 Containment action

Now that preventive actions are described in Chapter 6, it is essential that containment actions are present when having 'NOT OK' products in NBF. This section aims to identify containment activities which are relevant for protecting the downstream customer in case of 'NOT OK' products. Section 7.1 aims to describe containment actions derived from reviewing the literature and Section 7.2 aims to describe containment actions derived from a benchmark study. Section 7.3 aims to provide an overview of alternatives and criteria of containment action and finally in Section 7.4 a summary is given.

7.1 Literature study

Scania is not the first company to cope with containment actions. One of the means for finding a solution for Scania's problems related to containment is to perform a literature study. A lot of research is done to find proven techniques and solutions that are generally applied. Four methods are identified based on a literature study:

1. Damage-control
2. Inspection
3. Supplier Corrective Action Request (SCAR)
4. Customer Quality

7.1.1 Damage-control procedure steps

When it is known that goods in the warehouse could be damaged, Ackerman (1997) proposed the following five damage-control procedure steps (Ackerman, 1997):

1. Separate the products in which damage is suspected and take photographs of the damage.
2. In a public warehouse, do notify the owner of the products about the damaged products.
3. After identification of the products, each piece of damaged merchandise should be moved to a separate area.
4. After inspection, merchandise that has suffered damage to packaging should be repacked and returned to stock. In some cases, minor repairs could be performed in the warehouse. More critically damaged merchandise should be shipped to a repair centre or scrapped.
5. Finally, all costs involved should be calculated and reported. The costs include handling, storing and processing damaged merchandise.

Table 7-1 aims to show the advantages and disadvantages of alternative 1.

Table 7-1: Containment actions: Pros and cons method 1

Method	Advantage	Disadvantage
M1: Damage-control procedure steps	- Applicable for public warehouse. - Take photographs of the damage. - Good description of costs involved.	- Not very detailed description on how to organize containment activity.

7.1.2 Inspection method

Because the risk of loss due to product failure is great for Scania (i.e., Scania can't effort production stops in PRUs), it can be stated that the class of quality management problems is called mission-critical (Burke, 2001). The outcome of Burke's paper in 2001 state that mission-critical quality management problems require not only an effective process control, but do also require complete inspection. In order to assure 'OK' products are in stock in the warehouse, the literature provides two general types of inspection methods namely: Sample inspection and 100 % inspection (Burke, 2001). The advantages and disadvantages of the two inspection methods are described in Section 6.4.

Judgment inspection
Inspection, as described in this section, can be formulated as judgment inspection (Hinckley, 1997). Someone decides whether a product is acceptable for unacceptable. If the part is unacceptable it is tried to rework the part or else discard the part if it can't be adjusted to function properly. Judgment inspection is made after the process that inputs are transformed into a product (Hinckley, 1997). Figure 7-1 shows the process of judgment inspection.

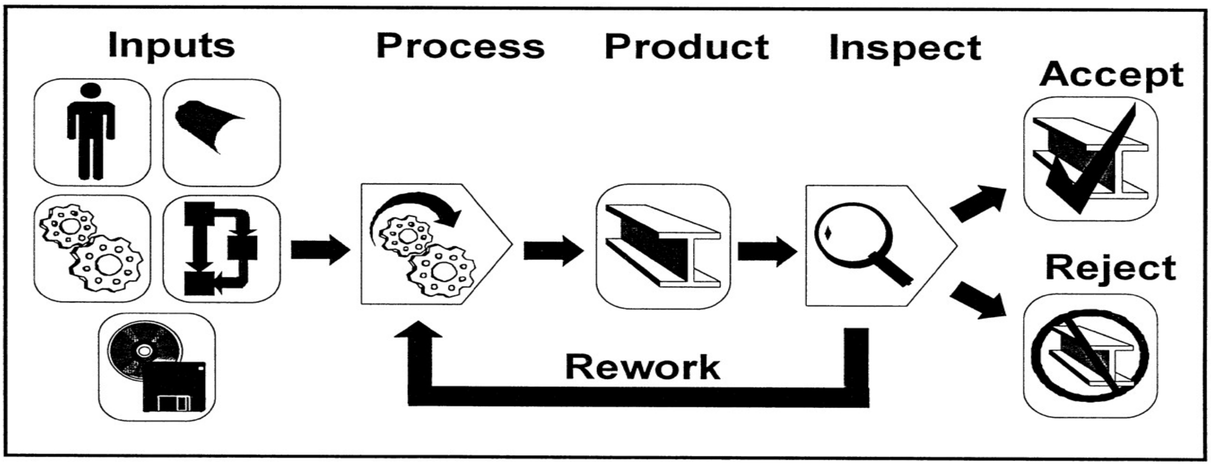

Figure 7-1: Judgment inspection process. Source: (Hinckley, 1997)

To provide evidence that products reach required quality levels, quality inspection based on the statistical theory of acceptance sampling inspection can be performed (Tong, et al., 2011). Acceptance sampling inspection is concerned with inspecting sampled items to check whether products have met quality specifications. Two issues in acceptance sampling inspection theory are present. The first is concerned with the acceptance sampling plan, this is characterized by sample size and acceptance number. The goal is designing an acceptance plan is to minimize the inspection cost while optimizing the accuracy of product inspection (Tong, et al., 2011). The second is concerned to determine the method to select a sample. Commonly used methods include simple random sampling, system sampling, stratified sampling, and cluster sampling (Tong, et al., 2011) (Ma, Wang, & Zhang, 2012).

NPCA (2012) state that prior to shipment, products shall be inspected to assure that good quality products are shipped towards the customer. Next to this, inspection is necessary to assure design conformance and proper identification. Where the inspection is performed shall establish a procedure for sampling and inspecting products that are shipped in large quantities (e.g., bulk). Many products are handled individually, and those should be inspected individually. In contradiction, modular products can be inspected in groups. Inspections have to be documented and reviewed by management in order to minimize poor quality products shipped towards customers (NPCA, 2012).

Products not conforming to requirements, standards, and specifications have to be labelled and the defects noted on the inspection reports. Only products that do meet the requirements, standards, and specifications shall be shipped. Management shall be informed about the poor quality products prior to shipment so that action can be taken (NPCA, 2012).

Document any damage, poor dimensional tolerances, or other problems during the inspection. A mark is made on the product indicating whether the deviation is acceptable, requires repair, or the product is rejected (NPCA, 2012). Defects not affecting the function of the product are seen as minor defects and may be repaired by any method that does not harm the product. Products with major defects are evaluated by high skilled personnel to determine if repairs are feasible, otherwise the products are rejected. Both minor and major repairs are inspected to assure that no damage has been done to the products being repaired (NPCA, 2012).

In contradiction to inbound quality control inspection, outbound inspection is also possible. However, Anjoran (2011) wants to emphasize the sooner errors are eliminated the better (Anjoran, 2011). This aims to indicate that inbound inspection is preferred over outbound inspection.

Statistical Quality Control (SQC) inspection

Statistical Quality Control (SQC) inspection, illustrated in Figure 7-2 uses statistical data to identify if the manufacturing process was drifting out of control (Hinckley, 1997). SQC relies on sampling inspection, which reduces significantly the amount of inspection activities. Next to this, SQC provides feedback to production in order to change and improve the production process. The improvement in quality achieved through SQC reduce rework, scrap, and wasted resources (Hinckley, 1997). A drawback of SCQ inspection is that is less useful for warehouse or distribution centre usage.

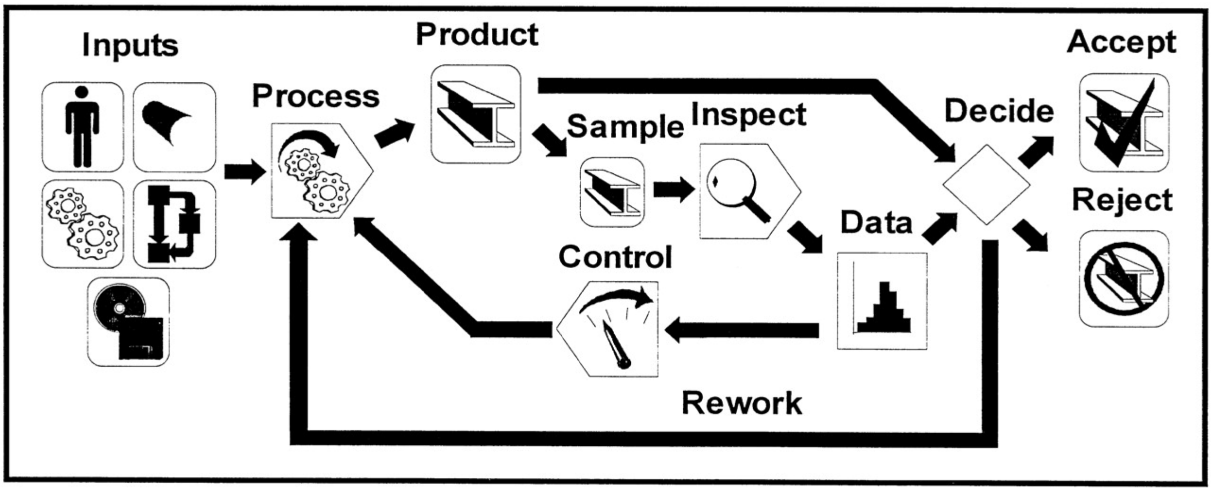

Figure 7-2: SQC inspection process. Source: (Hinckley, 1997)

To summarize, a comparison between judgment inspection and SQC inspection together with corresponding advantages and disadvantages aims to be given in Table 7-2.

Table 7-2: Pros and cons between judgement and SQC inspection

Inspection method	Advantages	Disadvantage
Judgment inspection	- Applicable for warehouse, less factory oriented. - Provides feedback for production process	- Judgment inspection can only performed after production process.
Statistical quality control (SQC) inspection	- Relies on sampling inspection. - Reduces the amount of inspection activities. - Provides feedback for production process	- Less applicable for a warehouse, more factory oriented.

One of the biggest disadvantages of quality inspection is that it is not 100% effective due to the possibility of human errors. 100% inspection is only 80% effective (Pesante, Williges, & Woldstad, 2001). This means that 20 percent of the defectives are not intercepted at inspection. Because quality is of such importance and based on the pros and cons, this alternative is narrowed to judgment inspection. Table 7-3 aims to show the advantages and disadvantages of alternative 2.

Table 7-3: Containment actions: Pros and cons method 2

Method	Advantages	Disadvantages
M2: Inspection method	- preventive instead of containment. - Inbound goods are inspected. - Only good quality products are shipped.	- No description of what to do when poor quality products are found. - Time and cost consuming method.

7.1.3 Supplier Corrective Action Request (SCAR)

Supplier Corrective Action Request (SCAR) model is developed by Keysight Technologies (2015) and is a “systematic approach to request investigation of a problem that already happened and request root cause analysis and resolution from supplier to prevent recurrence” (Keysight Technologies, 2015, p. 3). Only the first three steps are relevant for this research. Step 2 in the model is Containment Action which is performed after the problem verification. Containment action, according to Keysight Technologies (2015), is necessary to limit a problem extent while continue normal operation. Containment action is used until the root cause is determined and a sufficient corrective action is implemented. The containment area has to cover: production, finished goods, customers, incoming material, and warehouse storage. Note that affected date code or serial number should be known (Keysight Technologies, 2015).

Keysight Technologies (2015) state the following containment action activities (Keysight Technologies, 2015, p. 8):

- Stoppage of production or shipment
- Segregation goods on pass or fail
- Additional visual control
- Informing customer about the problem
- Informing operators about the problem
- Check on similar product or processes if there is a similar risk.

An example is given by Keysight Technologies (2015) to illustrate the containment action. First a problem is identified and described specifically using 5W2H (Who, What, When, Where, Why, How, How Much). Figure 7-3 illustrates this example.

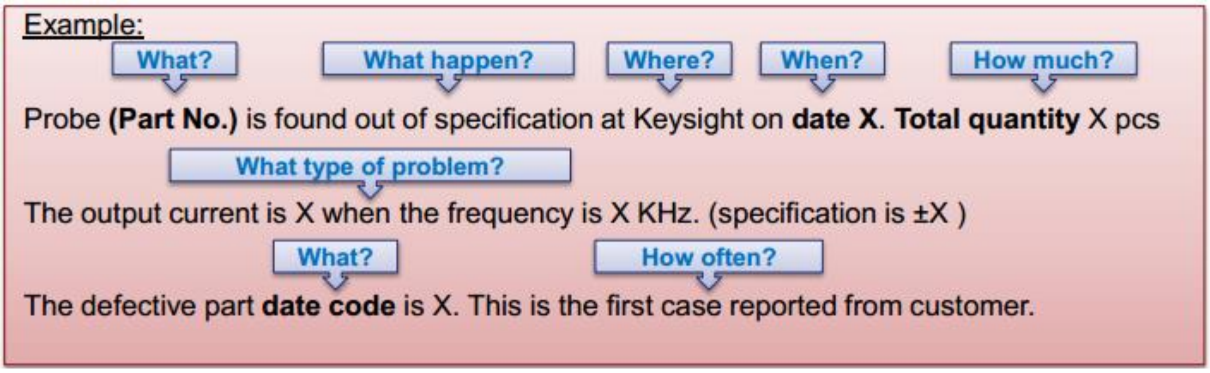

Figure 7-3: Example containment action. Source: (Keysight Technologies, 2015, p. 6)

After the problem verification, 100% screening is done for below area’s to identify poor quality products:

- Supplier’s production (xx pieces)
- Warehouse inventory (xx pieces)
- Customer’s inventory including production (xx pieces)

Results (based on this example): xx pieces out of total xx pieces are found with defection, the reject rate is xx %. Confirmed the affected date code is xx. Rejected parts are sent back for further failure analysis (FA). FA is the process of determining the cause of failure by collecting and analyzing data. FA can be done by several methods, some of them aims to be given in Table 7-4 (Keysight Technologies, 2015).

Table 7-4: Examples of failure analysis. Source: (Keysight Technologies, 2015, p. 10)

Visual Inspection	Physical Testing	Electrical Testing
Bare eye inspection	Drop test	Voltage measurement data
Optical microscope	Bending test	Resistance measurement
X-ray microscope	Pull test	

Finally Keysight Technologies (2015) lists a SCAR response guideline, the guidelines for the first three steps is listed below in Table 7-5.

Table 7-5: SCAR response guidelines. Source: (Keysight Technologies, 2015, pp. 26, 27)

Process Step	Criteria
S1: Problem Verification	- Provide Clear and Precise problem statement - Method and condition to duplicate and verify the problem reported
S2: Containment Action	- Select proper screening area. If no containment action please provide justification. - Screening area including: Producion, finished goods inventory (FGI), and remaining units with customer - information is needed: a) Method: Type of screening is done in respective area selected above b) Results: Reject quantity and rate c) Responsible person name d) Date of the action taken
S3: Failure Analysis	- Briefly summaries the failure analysis (FA) conducted and the results (Including visual inspection, Electrical testing, and Physical testing - Attach FA report as evidence if available

Table 7-6 aims to show the advantages and disadvantages of alternative 3.

Table 7-6: Containment actions: Pros and cons method 3

Method	Advantages	Disadvantages
M3: Supplier Corrective Action Request (SCAR)	- Detailed method. - Structured method with process steps. - Uses methods like 5W2H and FA.	- Not mentioning costs. - More factory based than warehouse based.

7.1.4 Process of customer quality issues

Barsalou (2015) developed a Step-By-Step guide for Root Cause Analysis in which containment is described as well. Containment should be based on the issue and varies between random sampling to 100% inspection of parts in production, inventory, transit, and at the customer's location. The Plan-Do-Check-Act (PDCA) cycle can be used, as presented in Figure 7-4, since shipping hundreds of defective items to the customer is far from optimal (Barsalou, 2015).

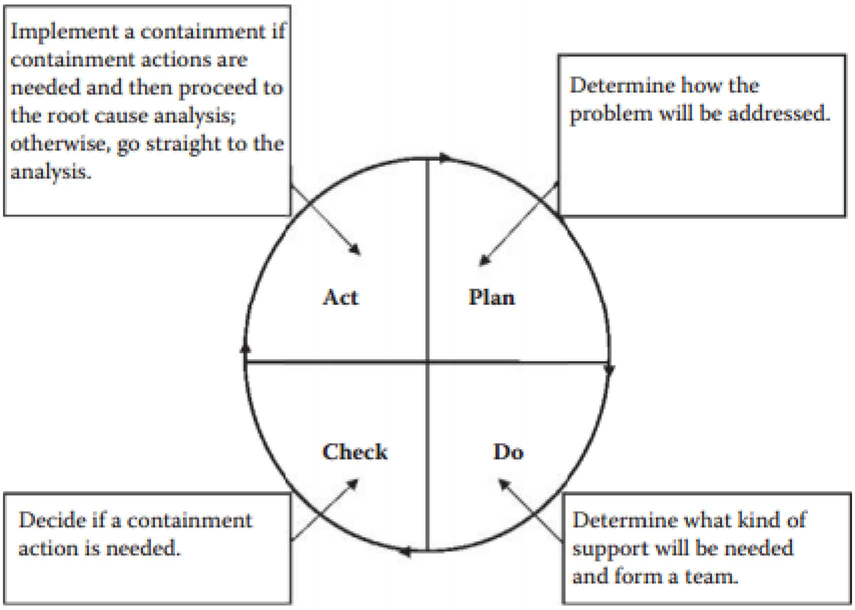

Figure 7-4: Plan-Do-Check-Act (PDCA) cycle for containment actions. Source: (Barsalou, 2015)

According to Barsalou (2015), an 8D report is usefull for a root cause analysis resulting from quality failures. The 8D report does not identify the root cause of the failure, but provides a systematic structure for immediate and preventive actions to be carried out. 8D is used in problem solving and uses eight disciplines (steps). An example of an 8D report can be found in Appendix I: Examples from Barsalou (2015). When a failure is detected, an 8D should be made based on the following steps (Barsalou, 2015):

D1: Use a team approach.
D2: Describe the problem.
D3: Implement and verify the temporary fix.
D4: Use root cause analysis .
D5: Develop permanent solutions.
D6: Implement and validate a permanent solution.
D7: Prevent reoccurrence.
D8: Close the problem and recognize contributions.

A brief description about the process aims to be given below:
Before executing step D1, the 8D report's header information should be completed. Information such as part number, date of failure, supplier number, short and descriptive analyze of the problem, etc. have to be known (Barsalou, 2015).
The first step of 8D is forming a team. The members of the team must be representatives from all departments that are affected by the issue. A team leader should be assigned who ensures that all activities are carried out and the 8D report is updated. A champion is desired as well, who is a person in a management function with sufficient authority in order to help the team if the team encounter difficulties (Barsalou, 2015).
After the team is formed a brief explanation of the error should be given. Note that this is not the right place to list the root cause of the failure. The root cause of the failure should be identified later and only after an extensive investigation (Barsalou, 2015).
The next step is to determine if a containment action is necessary. A qualified person has to determine if a containment action is necessary as well as the type of containment. A containment action can vary between inspecting parts in stock or recall parts which are at the end customer. After the determination, the containment action can be implemented. It is necessary to explain how checked

parts are identified in order to give feedback to the customer when good parts arrive. Otherwise, the customer may check all incoming goods even after the inspection of the supplier. The number of parts checked and the inspection results has to be recorded (Barsalou, 2015).
After the root cause is determined, corrective actions have to executed and monitored. Additionally, FMEA, control plans, standards, and procedures are updated in order to prevent that the failure occurs again (Barsalou, 2015).
The final steps are congratulating the team and closing the 8D report (Barsalou, 2015).

Barsalou (2015) stated several key points and procedures in the process of customer quality issues, which can be combined into guidelines. The guidelines are based on Plan-Do-Check-Act, 8D report, and corrective actions (Barsalou, 2015):

- An approach for solving the problem needs to be identified.
- Form an interdisciplinary team that has the skills to solve the problem.
- The type of resources and support required must be identified.
- Decide if containment actions are necessary. If containment actions are needed, determine the resources, support and actions required to execute the containment action.
- If containment actions are necessary, then implement the containment actions.
- Identify the root cause of the failure, and corrective actions should be described. Trials should be performed to ensure that the corrective actions are effective.
- Use the PDCA cycle for corrective actions and implement these actions.
- When implementing the corrective actions, look for opportunities to implement preventive actions for other parts or processes.
- Preventive actions must be taken in order to prevent that the failure will occur again
- Congratulate the team and close the 8D report.

Lessons learned should be considered at the end of the root cause analysis. One option for large companies is a central lessons learned database, or to ensure all designs, standards, and drawings are updated based on the lessons learned (Barsalou, 2015). Finally, Barsalou (2015) gives an example to illustrate the containment action process. This example is given in Appendix I: Examples from Barsalou (2015). Table 7-7 aims to show the advantages and disadvantages of this alternative.

Table 7-7: Containment actions: Pros and cons method 4

Method	Advantages	Disadvantages
M4: Process of customer quality issues	- Detailed description of containment actions. - Using PDCA, 8D and corrective actions. - Clear examples. - Continuous improvement. - Additive checking	- Much documentation needed. - Not mentioning costs.

7.2 Benchmark study

In order to improve this research and to propose improvements for the current situation, extra information about the existing problems and processes is needed. Because the mix of problems are rather specific in the current situation, we are not only acquiring knowledge from the literature. Another mean for finding a solution for Scania´s problems related to containment is to perform a benchmark study. Two companies are used in our benchmark study:

- Method 5: Benchmark company A
- Method 6: Benchmark company B

Section 7.2.1 aims to define benchmarking and identifies nine types of benchmarking. Section 7.2.2 explains the benchmark process. In Section 7.2.3 and Section 7.2.4, two benchmark companies are analyzed and Section 7.2.5 aims to give an overview of the mutual similarities and differences between the two benchmark companies.

7.2.1 What is benchmarking?

Benchmarking is the process of learning from others, the activity of comparing methods and / or performance with other processes. The aim of comparing is to learn and / or assess performance. The basis of benchmarking is based on the idea that "(a) problems in managing processes are almost certainly shared by processes elsewhere, and (b) there is probably another operation somewhere that has developed a better way of doing things" (Slack, Chambers, & Johnston, 2007, p. 587). In the last years, benchmarking has established its position as an improvement tool for organizations, to improve the performance and competitiveness in business life (Kyrö, 2003). After the benchmark, do not simply copy or imitate, but learn from the best and adapt lessons for the development of an improved performance (Ajelabi & Tang, 2010). Benchmarking can be done in many ways, depending on the focus of the benchmarking process. Table 7-8 aims to give a list of benchmarking types, the list is based on Bhutta & Huq (1999) and Slack et al. (2007):

Table 7-8: Types of benchmarking. Source: (Bhutta & Huq, 1999) (Slack, Chambers, & Johnston, 2007)

Type of Benchmark	Definition
Performance	Is the comparison between the levels of achieved performance in different operations.
Process	Is the comparison of methods and processes in order to improve the processes in an organization.
Strategic	Is the comparison of an organization's strategy with strategies of other organizations to help improve the capability to deal with external environment changes.
Internal	Is the comparison of performance made between departments of the same organization, solely to find and apply best practice information.
External	Is the comparison between an operation and other operations which are part of a different organization.
Competitive	Is the comparison between the 'best' competitors in the same market.
Non-competitive	Is the comparison between organizations which don't compete in the same market.
Functional	Is the comparison of a particular function in the industry.
Generic/Practise	Is the comparison of processes against the best process operators.

A benchmark study is rather a combination of several types of benchmarking, and based on the relevance to a specific context (Ajelabi & Tang, 2010).

7.2.2 Benchmark process

The benchmark process can be seen as a continuous process which consists out of five steps:

Step 1: **Plan the study.** The first step that has to be performed in the benchmarking process is to determine what has to be identified (Bhutta & Huq, 1999). The aim of our benchmark study is to get insight in how other companies are managing product quality in global supply chains. It is preferred that a warehouse is included in this global supply chain.

Step 2: **Form the benchmarking team**. The second step is forming a benchmark team. Normally the teams develops a plan that includes the benchmark approach, team member's roles and responsibilities, project milestone and a realistic completion date (Bhutta & Huq, 1999). Because I am performing this research alone, step two of the benchmark process isn't relevant for this benchmark study.

Step 3: **Identifying partners**. After the team is created, potential benchmarking partners / companies that are considered by the business to be 'world class' in that process are identified. These partners can be competitors, but also non-competitors (Bhutta & Huq, 1999). In our benchmark study, we use two non-competitors.

Step 4: **Collect and analyze information**. According to Bhutta & Huq (1999), step four is the most important step in the benchmarking process. The data is collected, analyzed and turned into useful information that can be compared with one's own. The aim of data collection goes further than just collecting, data collection should be geared toward understanding the 'enablers' of best-practice performance. After the data collecting, the data has to be analyzed. When analyzing the results, it is important to understand the data in order to be able to identify strategies for improvement (Bhutta & Huq, 1999).

Step 5: **Adapt and improve**. The final step in the benchmarking process concerns adapting the other companies' best practise and implement useful improvements. Do not confuse adapting with copying, since best practices learned from others must be adapted into organizations' culture, technology and human resources (Bhutta & Huq, 1999). Step 5 of the benchmark process is combined with the literature study to propose an improvement of the current situation.

7.2.3 Company A: Scania Parts Logistics

The first benchmark company is Scania Parts Logistics. Scania Parts Logistics is responsible for the distribution of all Scania parts around the globe. The focus is on the development of an optimal distribution structure in order to provide customers with a first-class parts service. The assortment consists of more than 100,000 different part numbers and from the central warehouse, more than 1,500 delivery points in more than 100 countries are delivered. The business mission is to provide logistics services to Scania's customers and distribute parts within agreed lead times, at agreed costs and with the agreed service level.

Scania Parts Logistics is chosen as a benchmark company since they are delivering parts to the end customers. Because the customer of Scania Parts Logistics is the end customer, the parts must be of high quality and without any deviation. Therefore, good product quality in the warehouse is extremely important.

Global Supply Chain

The heart of Scania Parts Logistics is located in Opglabbeek, Belgium and joined by seven regional warehouses in the UK, Spain, Austria, Poland, Italy, Sweden and Norway. Additionally, Parts Centres are located in Asia, South America and South Africa. The distribution structure is shown in Appendix J: Distibution structure Scania Parts Logistics.

Warehouse

The warehouse in Opglabbeek is the central warehouse of Scania Parts Logistics. The storage area is 60,600 m^2. The total site surface is 115,000 m^2 with a total building surface of 66,500 m^2. Today, more than 450 employees are working in the warehouse. Scania Parts logistics is a fully manual operated warehouse and no automatic equipment is present. There are no automatic cranes, guided vehicles or conveyers. This conventional handling is more reliable and flexible.

Quality

Scania Parts Logistics has a documented quality, environmental and management system that meets the requirements set out in ISO 9000, ISO 14001 and the local laws on working environment. Monitoring and measurement take place continuously in various processes in Scania Parts Logistics in order to continuously maintain a uniform high quality level. Scania Parts Logistics undertake to:

- Demand continuous improvements and to work towards more capable processes.
- Take preventive and corrective actions based on deviations in relation to chosen method.
- Make everyone aware of the quality status and involve everyone in the improvement process.

The Q-team of Scania Parts Logistics is responsible to act on product quality deviations which:

- Cause the end customer dissatisfaction.
- Are considered to find the cause of the dissatisfaction of the end customer, which can be discovered in the Scania Production Units, at Part Logistics, during product audits, during lab testing, etc.
- Cause production obstructions.

Each member of the Q-team has the authority to:

- Act fully on behalf of his/her organization in order to achieve a 24 hour lead time to introduce a quick Exemption From Requirements (EFR) solution.
- Issue EFR and approve (if responsibility is given by development manager).
- Forward matters to responsible line organization or other Q-teams.

Containment action
Scania Parts Logistics has its own Q-team. Each morning a Q-team meeting is scheduled and eQuality reports are discussed. It occurs occasionally that a PRU detects a technical deviation and inform Scania Parts Logistics about the deviation. In this way, the stock at Opglabbeek can be checked and sorted in order to prevent any distribution of poor quality parts towards the end customer.

It differs from case to case if a sorting action is necessary. It depends on the impact of the technical deviation, the amount of eQuality reports, the amount of parts with the deviation and the amount of customers who receives the poor quality part. According to Scania Parts Logistics, a written routine for a sorting actions is impossible.

If a sorting action is necessary, then it has to be clear where the clean cut is in order to know what has to be sorted or not. Together with the supplier and with delivery notes, the clean cut is determined. Secondly, a decision have to be made if the total stock is inspected or if a random sample is sufficient. Due to the large scale of the warehouse, a random sample check is preferred. However, if the impact of the deviation is big, then a 100% sorting action is performed.

In some cases the Q-team of Scania Parts Logistics performs the sorting action, because they do have the expertise and the required tools. But sometimes it is faster, cheaper or more practical if the manufacturing supplier performs the sorting action at the warehouse. It could even be the case that it is faster, cheaper or more practical if the parts are returned to the supplier. If the sorting action is performed at Scania Parts Logistics, the parts are collected at the Q-area and checked. Together with the manufacturing supplier, a checking instruction is made. There is no routine for checking instructions, due to the large scale of different part numbers and due to unlimited amount of technical deviations. The checking instructions differs from case to case. Based on the amount of parts that has to be checked, a decision is made about having a distribution stop. If all parts have to be checked, then a distribution stop is made.

If an Engineering Change Order (ECO) has been performed at a product, then the first three incoming shipments are inspected by a random check. If an ECO has been performed on a part related to critical parts (i.e., breaking or steering), then the first three incoming shipments are 100% inspected. Just to make sure that only good quality parts are in stock in the warehouse.

If the manufacturing supplier is responsible for the technical deviation, then all costs related to the containment action have to be paid by the manufacturing supplier. The supplier even has to pay for the required time needed for the Q-team to find the parts in stock in the warehouse.

Currently, a radio-frequency identification (RFID) system is implemented in the shipping zone of Scania Parts Centre. The system will secure that the right amount will be loaded into the right truck in order to minimize the logistical deviations. Next to this, some shipments have high technological devices in order to get relevant data about vibrations and weather conditions. These devices are important to determine if the packaging material is sufficient in order to minimize product deviations. The RFID as well as the high technological devices are new, and no relevant data is available yet.

Table 7-9 aims to show the advantages and disadvantages of the containment approach of benchmark company A.

Table 7-9: Containment actions: Pros and cons method 5

Method	Advantages	Disadvantages
M5: **Benchmark company A**	- Preventive actions. - Containment actions. - Track and trace system	- No systematic approach. - Many consultations with manufacturing suppliers.

7.2.4 Company B: Provider of power plants

Confidential.

7.2.5 Similarities and differences between benchmark companies

Similarities

- Goods are classified according to criticality.
- Inbound goods inspection, 100% goods inspection for 'critical' items and random sample inspection for 'less critical' products.
- Both benchmark companies have a sufficient and reliable track and trace system in order to keep track of products and easily find a clean cut.
- Quality teams are present in both benchmark companies. The personnel from the quality teams are high skilled and have expertise.
- A separate quality area is present in both warehouses. Goods inspection and sorting actions are performed in the quality areas, as well as rework or repair activities.

Differences

- Company A has every morning a meeting to discuss eQuality reports in order to know if there are parts in the warehouse with a possible deviation. Company B does not have meetings about product quality.
- Company A has a fully manual operated warehouse, in contradiction to company B which is more than half automated. Only large products are manually handled.
- Company B has a special incoming goods inspection team located in the warehouse.

7.3 Methods and criteria

Based on the literature study performed in Section 7.1, four methods are derived and two additional methods are derived from the benchmark study performed in Section 7.2.

7.3.1 Methods

Table 7-10 aims to give a summary of the six methods with the corresponding advantages and disadvantages.

Table 7-10: Summary of methods containment action

Method	Advantage	Disadvantage
M1: Damage-control	- Applicable for public warehouse. - Take photographs of the damaged goods. - Good description of costs involved.	- Not very detailed description on how to organize containment activity.
M2: Inspection	- Preventive instead of containment. - Inbound goods are inspected. - Only good quality products are shipped.	- No description of what to do when poor quality products are found. - Time and cost consuming method.
M3: SCAR	- Detailed method. - Structured method with process steps. - Uses methods like 5W2H and FA	- Not mentioning costs - More factory based than warehouse based.
M4: Customer Quality	- Detailed description of containment actions. - Using PDCA, 8D and corrective actions. - Clear examples. - Continuous improvement. - Additive checking.	- Much documentation needed. - Not mentioning costs
M5: Benchmark A	- Preventive actions. - Containment actions. - Track and trace system	- No systematic approach. - Many consultations with manufacturing suppliers.
M6: Benchmark B	- Good track and trace system. - Preventive actions. - Containment actions.	- Time and cost consuming method due to incoming goods inspection. - Sometimes having no goods on stock, because 'NOT OK' parts are returned to supplier.

7.3.2 Criteria

After the identification of six containment methods, selection criteria is composed for judging the containment methods. In consultation with management (Head of Customer Supplier Interface) four criteria's are determined:

Criteria 1: Usefulness
Usefulness refers to the degree how suitable the containment method is for Scania. A green check mark refers to a method that can easily be implemented by Scania, while a red ex refers to a method that needs changes.

Criteria 2: Speed
Speed refers to the degree how fast the proposed containment method is. A green check mark refers to a fast method, while a red ex refers to a slow method.

Criteria 3: intelligibility

Intelligibility refers to the degree how clear the containment method is. A green check mark refers to a method which is easy to understand, while a red ex refers to a method which is not easy to understand.

Criteria 4: Quality
Quality refers to the degree how adequate the proposed method is. A green check mark refers to a high quality method, while a red ex refers to a low quality method.

The manufacturing supplier is always responsible for the quality of its products, and the containment costs are paid by the supplier. Therefore, cost is not seen as a criteria.

The next step is comparing the six methods by using a decision matrix. In it, the green check marks are methods where the criteria is satisfied, while the red exxes indicates methods that do not satisfy the criteria. In consultation with management (Head of Customer Supplier Interface) each of the six methods are scored.

Table 7-11: Decision matrix, containment actions

methods \ criteria	C1: Usefulness	C2: Speed	C3: Intelligibility	C4: Quality	Total
M1: Damage-control	✗	✓	✗	✗	✗✗
M2: Inspection	✗	✗	✗	✓	✗✗
M3: SCAR	✓	✓	✗	✗	-
M4: Customer Quality	✓	✗	✓	✓	✓✓
M5: Benchmark A	✗	✓	✓	✓	✓✓
M6: Benchmark B	✗	✗	✓	✓	-

The decision matrix (Table 7-11) aims to conclude that method 4: Customer Quality and method 5: Benchmark A are the most suitable containment methods for Scania.

7.4 Summary Chapter 7

Based on a literature review and a benchmark study, six methods are identified for containment actions. These six methods are:

1. *Damage-control:* Five damage-control procedure steps, where minor repairs could be performed at the warehouse and critically damaged products should be shipped to a repair centre or scrapped.
2. *Inspection:* Inbound goods inspection at warehouse.
3. *SCAR:* Supplier Corrective Action Request (SCAR) is a containment model using 5W2H (ask the questions who, what, when, where, why, how, and how much). After the problem identification, 100% screening is done to identify poor quality products.
4. *Customer Quality:* Process of customer quality issues is a containment model using Plan-Do-Check-Act (PDCA), 8 disciplines (8D), preventive and corrective actions.
5. *Benchmark A:* Method used by the first benchmark company. Containment actions by having meetings, 'clean cut' determinations, and consultations with the manufacturing supplier.
6. *Benchmark B:* Method used by the second benchmark company. Containment action by shipping 'NOT OK' parts back to the manufacturing supplier.

The first four methods: damage control, inspection, SCAR, and customer quality are derived from reviewing the literature. The last two methods: benchmark A and benchmark B are derived from a benchmark study.

In consultation with management (Head of Customer Supplier Interface) each of the six methods are judged with the following four criteria:

1. Usefulness: Refers to the degree how suitable the containment methods is for Scania.
2. Speed: Refers to the degree how fast the containment method is.
3. Intelligibility: Refers to the degree how clear the containment method is.
4. Quality: Refers to the degree how adequate the containment methods is.

A decision matrix aims to conclude that method 4: Customer Quality and method 5: Benchmark A are the most suitable containment methods for Scania.

The next chapter contains a discussion about culture, preventive actions, and finally containment actions.

8 Discussion

This chapter aims to discuss the results retrieved from a literature review and a benchmark study. Section 8.1 aims to discuss cultural differences between Scania and its suppliers. Subsequently, Section 8.2 aims to discuss the preventive actions derived from a literature review. Finally, Section 8.3 aims to discuss containment actions derived from a literature review and a benchmark study.

8.1 Culture

After all, Scania feels that no one is responsible for the quality of the products in NBF. A cause of this lack of responsibility is the cultural differences between Scania and its suppliers outside of Europe. In order to find these differences, literature based on the Hofstede and Inglehart & Welzel was consulted. The scope of suppliers outside of Europe was narrowed down to three countries (Brazil, China, and India). Sweden represents Scania, since Scania is a Swedish company.

As shown in Figure 5-1, the three countries that represents the suppliers outside of Europe have all low scores on individualism. According to Kimura (2003), this aims to a low achievement of responsibility and that individuals do not take global issues personally.

Additionally, Bloch (1986) states that an open culture is necessary in order to solve problems related to individual responsibilities that conflict with corporate purpose. Key element is, for example, openness. Openness in culture should foster a willingness to communicate freely in all layers of the organization. However, Figure 5-2 shows that companies located in Asia and Latin America are located in the lower-left (poor) side of the cultural map. Traditional and survival values indicate a more closed organizational culture in contradiction with self-expression and secular-rational values. Despite of this, in the cultural value map of Inglehart & Welzel Sweden is located in the upper right corner. So it can be argued that Scania's culture differs a lot from its supplier's culture, which leads to responsibility issues.

8.2 Preventive actions

Following the adage "prevention is better than cure", a literature study is performed to prevent that 'NOT OK' products enter the supply chain of NBF. By scrutinizing eQuality reports, five alternatives are identified and judged by four criteria using a decision matrix. For the sake of completeness, the alternatives, criteria, and decision matrix are described and shown below.

The five alternatives are:

1. Specification: Extra specification control between Scania as an organization, Scania Purchase department, and the manufacturing supplier.
2. Audit: A tighter audit control at the manufacturing supplier.
3. Personnel: More clear work instructions and personnel training at the manufacturing supplier.
4. Inspection: 100% outbound goods inspection at the manufacturing supplier.
5. Packaging: Pay extra attention to packaging NBF products.

The five alternatives are judged by the following four selection criteria (where scores range from 1 to 5):

1. Cost: Refers to the degree how costly the alternative is. A high value refers to a low cost alternative and a low value refers to a costly alternative.
2. Speed: Refers to the degree how fast the alternative can be implemented. A high value refers to a fast implementation and a low value refers to a slow implementation.

3. Difficulty: Refers to the degree how much expertise is needed for the alternative. A high value refers to a simple alternative and a low value refers to a difficult alternative.
4. Quality: Refers to the degree how adequate the alternative is. A high value refers to a high quality alternative and a low value refers to a low quality alternative.

A decision matrix helps to find the most suitable alternative (in consultation with management (Head of Customer Supplier Interface) all five alternatives are scored).

Table 8-1: Decision matrix of the five alternatives

Alternatives \ Criteria	C1: Cost	C2: Speed	C3: Difficulty	C4: Quality	Total
Weights:	0.25	0.50	0.75	1.00	
A1: Specification	5	3	2	3	7.25
A2: Audit	4	1	3	4	7.75
A3 Personnel	3	2	1	2	4.5
A4: Inspection	1	5	5	5	11.5
A5: Packaging	2	4	4	1	6.5

It might appear that the decision matrix indicates that alternative 4: Inspections is better than the others. Alternative 4 has on three of the four criteria the highest possible score, including the three most important criteria (viz., criteria 2, 3, and 4). And in addition to this, the score of alternative 4 is quite higher than the score of the second best alternative. Based on this, it can be said that alternative 4 is indeed the best alternative.

However, despite of the fact that alternative 4 has the highest score in the decision matrix, alternative 1 and 2 seems to be important as well. Alternative 1 and 2 score a like and both provide high quality, low cost solutions. Alternative 2: Tighter audit process is the second best alternative on the most important criteria (viz. criteria 4), and alternative 1: extra specifications control is the third best alternative on the most important criteria. Subsequently, the two alternatives have the highest scores on criteria cost. Summarizing, the following three alternatives in order of importance are proposed: Inspection, Audit, and Specification.

Purchase department is responsible for supplying required material, equipment, and services. Therefore, Purchase department is given responsibility to monitor NBF suppliers more tightened in order to prevent that 'NOT OK' products enter the complex and extensive supply chain of NBF.

8.3 Containment actions

After preventive actions are derived from the literature, methods are identified for containment actions. Based on a literature study and a benchmark study, six methods are identified and judged by a decision matrix. For the sake of completeness, the methods, criteria, and decision matrix are described and shown below.

The six methods are:

1. Damage-control: Five damage-control procedure steps, where minor repairs could be performed at the warehouse and critically damaged products should be shipped to a repair centre or scrapped.
2. Inspection: Inbound goods inspection at warehouse.
3. SCAR: Supplier Corrective Action Request (SCAR) is a containment model using 5W2H (ask the questions who, what, when, where, why, how, and how much). After the problem identification, 100% screening is done to identify poor quality products.

4. Customer Quality: Customer Quality is a containment model using Plan-Do-Check-Act (PDCA), 8 disciplines (8D), and preventive and corrective actions. When implementing corrective actions, look for opportunities to implement preventive actions for other parts or processes.
5. Benchmark A: Method used by the first benchmark company. Containment actions by having meetings, 'clean cut' determinations, and consultations with the manufacturing supplier.
6. Benchmark B: Method used by the second benchmark company. Containment action by shipping 'NOT OK' parts back to the manufacturing supplier.

The six methods are judged by the following four selection criteria:

1. Usefulness: Refers to the degree how suitable the containment method is for Scania.
2. Speed: Refers to the degree how fast the containment method is.
3. Intelligibility: Refers to the degree how clear the containment method is.
4. Quality: Refers to the degree how adequate the containment methods is.

A decision matrix helps to find the most suitable alternative (in consultation with management (Head of Customer Supplier Interface) all six methods are scored).

Table 8-2: Decision matrix of the six methods

methods \ criteria	C1: Usefulness	C2: Speed	C3: Intelligibility	C4: Quality	Total
M1: Damage-control	✗	✓	✗	✗	✗✗
M2: Inspection	✗	✗	✗	✓	✗✗
M3: SCAR	✓	✓	✗	✗	-
M4: Customer Quality	✓	✗	✓	✓	✓✓
M5: Benchmark A	✗	✓	✓	✓	✓✓
M6: Benchmark B	✗	✗	✓	✓	-

It might appear that the decision matrix indicates that method 4: Customer Quality and method 5: Benchmark A are the most applicable methods to Scania.

However, since each of the six methods requires a documentation system which is rather extensive, we opt for an adaption that uses the best elements of each of the six methods. Table 8-3 aims to show the strength of each method which are used to improve the current situation.

Table 8-3: Strengths of containment methods

Method	Strengths
M1: Damage-control	It is obligatory to take photographs of the damage to give a clear understanding of the damage. All costs involved should be reported to the supplier.
M2: Inspection	100% re-check repaired parts.
M3: SCAR	Clear understanding about the containment area: production, finished goods, customers, incoming material, and warehouse storage.
M4: Customer Quality	Systematic containment process using: 8D, PDCA, and corrective actions. When performing the containment action, look for opportunities to implement preventive actions (additive sorting).
M5: Benchmark A	After an ECO, the first three incoming shipments are 100% inspected. This is done to make sure that only good quality parts are stored in the warehouse.
M6: Benchmark B	Classification of products with additional Dynamic Modification Rules for incoming goods inspection.

Containment actions performed by the manufacturing supplier is not seen as an alternative due to speed issues. The supplier is located (too) far away from the warehouse and if the containment action contains many infected products, then the manufacturing supplier doesn't have the required personnel nearby to perform the sorting activity. However, in a later stadium or if the infected inventory is tremendous, then in consultation with Purchase (SQA Zwolle) the manufacturing supplier could perform the sorting action.

Shipping the goods back towards the supplier instead of checking the stock is not seen as an alternative either. The reason for this is out of stock possibilities and speed issues, since it take some time to replace the stock. Next to this, if the stock is replaced fast, then there is still no guarantee that the stock contains only good quality parts. However, in a later stadium or if the infected inventory is tremendous, then in consultation with Purchase (SQA Zwolle) the manufacturing supplier could exchange the infected inventory.

8.4 Containment process Scania

This section aims to propose a suitable containment process for Scania, based on the current situation at Scania and the strengths of the containment methods derived from reviewing literature and a benchmark study. As described in Section 3.5, the current situation at Scania is working but needs improvements, especially due to the expected growth of NBF. The most important containment improvements in relation to the current situation are described in the next section.

8.4.1 Containment improvements

Based and adapted from the strengths of the six methods described in Chapter 7, five practical containment recommendations can be proposed in relation to the current situation.

1. eQuality report should not only be sent to the manufacturing supplier but also to NBF organization. Because the information flow is in the current situation not similar as the goods flow (as explained in Section 4.2.2), the NBF organization is not notified regarding the technical deviation. According to Chopra & Meindl (2007) and Habib (2011) the goods flow should be same as the information flow. The eQuality report should therefore also be sent to the NBF organization, to keep them informed about any possible 'NOT OK' products present in inventory. In other words, if an eQuality is issued about a technical deviation, then there should be a notification sent automatically to NBF organization.

2. In case the manufacturing supplier cannot 100% guarantee where the 'clean cut' is, inspect the whole inventory stored in the warehouse. This is because of the assumption that the whole stock is infected.

3. If parts are blocked in the warehouse, note the reason why the parts are blocked. On 23-05-2013, more than 33,000 parts were blocked in the NBF warehouse without knowing the exact reason.

4. NBF organization is responsible for the logistics before a containment action is requested. As soon as a containment action is requested, Purchase (SQA Zwolle) is responsible for the containment action. Despite the fact that the new warehouse located in Hasselt contains a quality department (e.g., TKDQ of KD), Scania Production Zwolle is still involved in organizing a containment action. TKDQ does not has a relation with Purchase department and Scania Production Zwolle has (e.g., SQAs are present in Zwolle). Purchase has to be involved due to their relationship with suppliers and should has the responsibility about performing the containment action.

5. Finally, after a containment action, always 100% inspect the first ok delivery from the manufacturing supplier. Due to the principle 'right from me', Scania assumes that suppliers

manufacture 'OK' parts. However, unfortunately this is not always the case. Therefore after a sorting activity in the warehouse, the next delivery should be 100% inspected as well. Just to be sure that only 'OK' parts are stored in the warehouse.

8.4.2 Containment guidelines

Combining the information retrieved from the literature study and benchmark study, the following information is proposed to have regarding organizing a sorting activity in the NBF:

eQality report: All necessary information for organizing a containment action in NBF, can be updated continuously through eQuality report.

- **Part number**: The part number has to be known in order to gather the right products for the sorting activity.
- **Delivery note or / and batch number or / and parts lot number of 'NOT OK' products.** If the delivery note or / and batch is known, then only the infected batch needs to be checked. Otherwise, the whole stock has to be checked. Keep also in mind the parts that are in transit. If the delivery note is known, a supplier number isn´t necessary, because a delivery note is linked with a particular supplier.
- **Manufacturing supplier number**: Some parts have the same part number, but are manufactured by other suppliers. For a sorting activity, only the parts from the specific manufacturing supplier needs to be sorted. If a delivery note is not known, the supplier number is necessarily.
- **Technical deviation**. Understand the problem, because it has to be clear what the deviation is. A clear and easy description of the deviation should be given in order to perform the sorting activity. Photos of 'OK' parts and 'NOT OK' parts should be included if deviation is not clear.
- **Amount of parts that has to be checked**. This is needed in order to able to determine the amount of time needed to perform the sorting activity. If necessary, personnel can be hired to help with the sorting activity. The amount of parts that has to be checked, should be stated in the delivery note. However if a delivery number is not present, or the Material & Transport coordinator cannot find a clear clean cut, or the manufacturing supplier cannot 100% guarantee which batch is infected, then the whole stock is 100% inspected.
- **Additive sorting**. If the specific part had some deviations in the past, these changes could be checked as well. In consultation with supplier, checking instructions and instructions what to do with 'NOT OK' parts are provided.
- **Distribution stop**. Stop shipping possible 'NOT OK' parts, NBF organization (i.e., Material & Transport coordinator NBF) is responsible for blocking parts in NBF.
- **Dual source**. It has to be known if the part is dual sourced or not. If the part is dual sourced and if necessary, the order of the dual supplier could be raised to prevent having backorders. Notify the Material & Transport coordinator NBF, if the part is dual sourced. This can be checked by delivered part homepage (material control website).
- **Distribution structure**. Customers who also received parts from the same infective batch has to be informed about the technical deviation. The NBF organization has this knowledge, since they are responsible for logistics. The NBF organization has also the responsibility to inform the other Scania addresses.
- **Personnel**. Determine the amount personnel needed and subsequently train and prepare personnel in order to perform the sorting action.
- **Checking instructions**. Checking instructions are necessary in order to understand what has to be checked. Checking instructions has to be made in consultation with the manufacturing supplier. The manufacturing supplier needs to approve the checking instructions for one important reason, namely: if the parts receive another deviation after the sorting, then the manufacturing supplier can't blame Scania for the deviation regarding bad checking

instructions. Because of this it is desired that the manufacturing supplier determines the checking instructions.
- **Rework instructions**. Instructions what to do with 'NOT OK' parts. If necessary, rework instructions are necessary in order to understand how rework has to be done. Rework instructions has to be made in consultation with the manufacturing supplier for the same reason as with the checking instructions. Normally, rework is done by a 3PL (e.g., IJssel Technology), because Scania doesn't has the tools. If rework is necessary, then re-check the reworked parts in order to be sure that the parts are good.
- **Separating**. The 'OK' / 'NOT OK' parts have to be separated. Determine in cooperation with the manufacturing supplier what has to be done with 'NOT OK' parts (e.g., 'NOT OK' parts can be reworked at sight, reworked at a 3PL, sent back to supplier, or scrapped).
- **Marking**. It has to be known how parts are marked after the sorting process to prevent that unchecked parts get mixed with checked parts. After a 100% (visual) inspection, the pallets have to be marked. If the parts are 'OK', then the pallets receive a '100% TQIP control' sticker. And if the parts are 'NOT OK', then the pallets receive a 'red-disapproval' paper. The 'red-disapproval' paper and the '100% TQIP control' sticker are both presented in Figure 8-1.

A. 'red-disapproval' paper

B. '100% TQIP control' sticker

Figure 8-1: 'Red-disapproval' paper and a '100% TQIP control' sticker

- **First 'OK' delivery**. The first 'OK' delivery has to be known from the warehouse of NBF towards the customer and the first 'OK' delivery from the supplier towards the warehouse of NBF.
- **Feedback**. Feedback should be given towards the customers to keep them informed about the sorting process and when 'OK' parts can be expected. This can be done by eQuality report or mail.
- **Costs.** Costs involved in the containment process are allocated towards the manufacturing supplier. Appendix N: Cost summary shows a systematic cost calculation for supplier related deviations. This cost summary is used at Scania Engines.

8.4.3 Containment process

The containment process can be described following a flowchart. Figure 8-2 shows the proposed actions before the containment process starts. As can be seen, the eQuality report is sent to the manufacturing supplier and to NBF organization simultaneously. The eQuality report is updated continuously by the issuer, the manufacturing supplier, or the NBF organization. The NBF organization is just as usual responsible for the logistics, and therefore inform the other customers about the deviation. The customers of NBF and the manufacturing suppliers have to check their own inventory. From the moment that a containment action is requested by the NBF customer, NBF manufacturing supplier, or NBF organization, responsibility for the containment process is given to Purchase (SQA Zwolle).

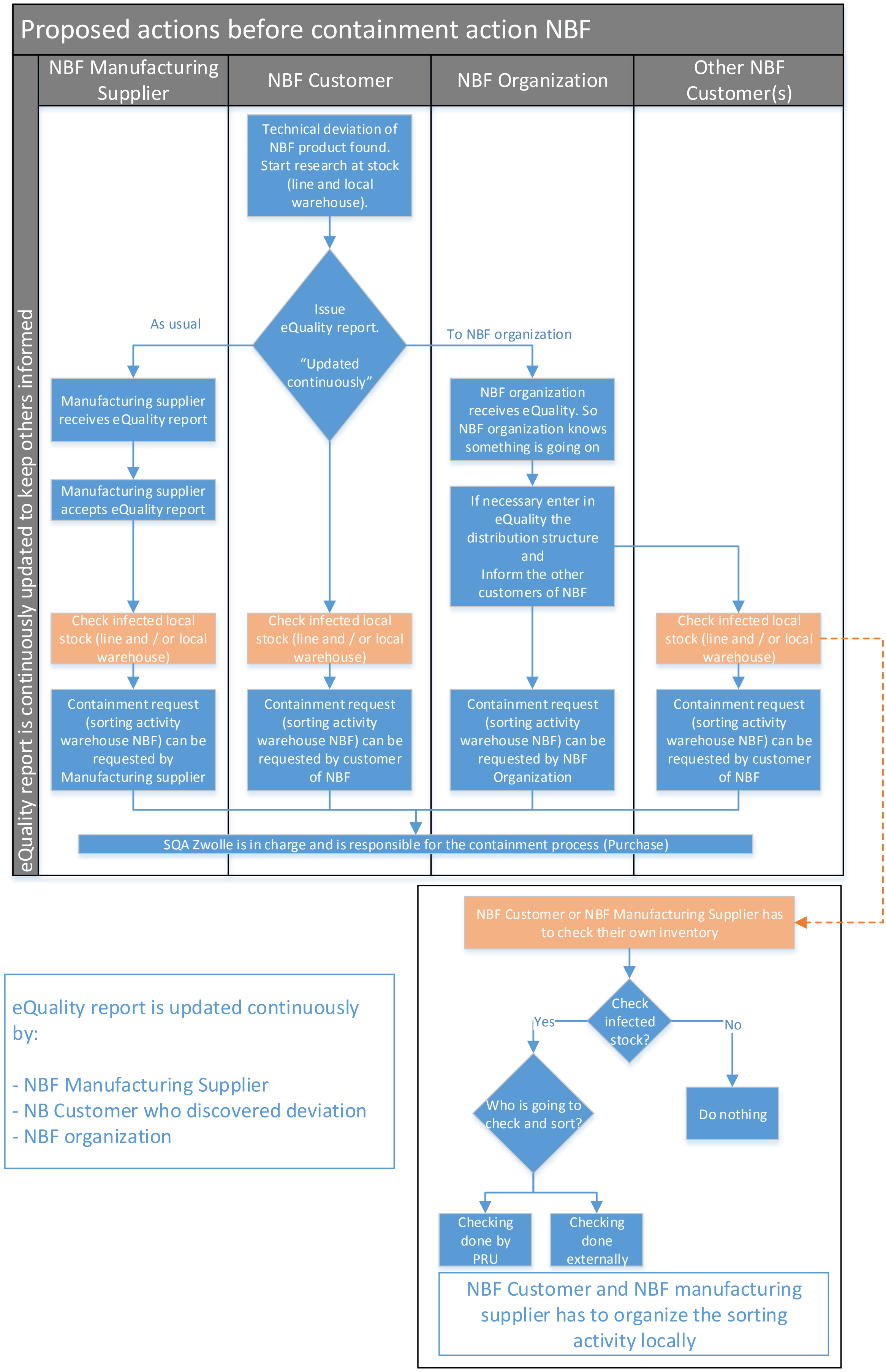

Figure 8-2: Proposed actions before containment process

Subsequently, Figure 8-3 shows the proposed containment process applicable for Scania. As can be seen, whenever the manufacturing supplier isn't 100% certain where the clean cut is the inventory is 100% inspected. The NBF organization stops the distribution and notes why the stock is blocked. Finally, the first ok delivery form the manufacturing supplier is 100% inspected in order to be sure that only 'OK' parts are stored in the warehouse.

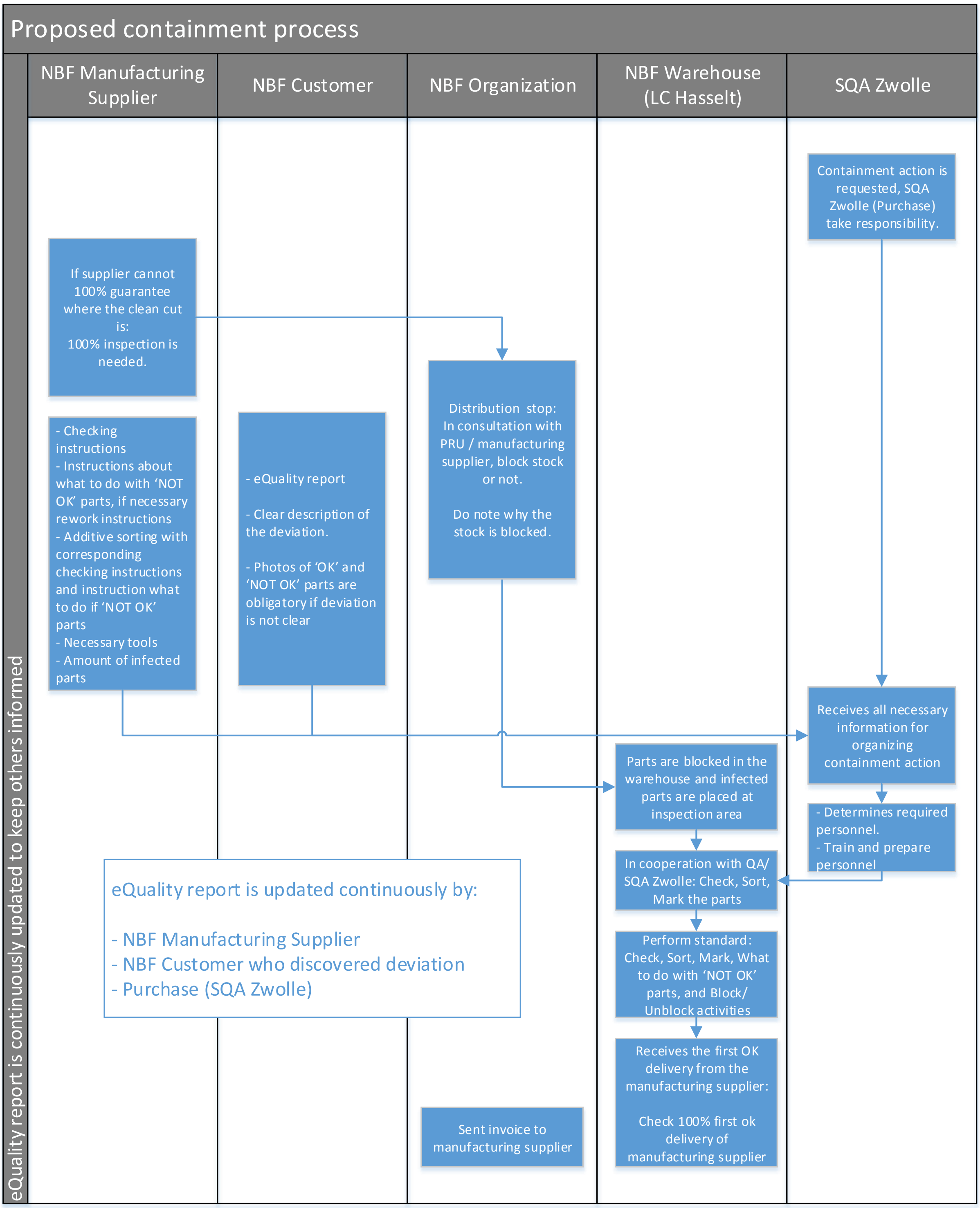

Figure 8-3: Proposed containment process

A simplified version is given in Figure 8-4 and shows who is responsible during the containment process. The NBF organization is responsible for the logistics and has to inform other PRUs which received infected parts. After the requested containment action, Purchase (SQA Zwolle) is responsible for the containment process.

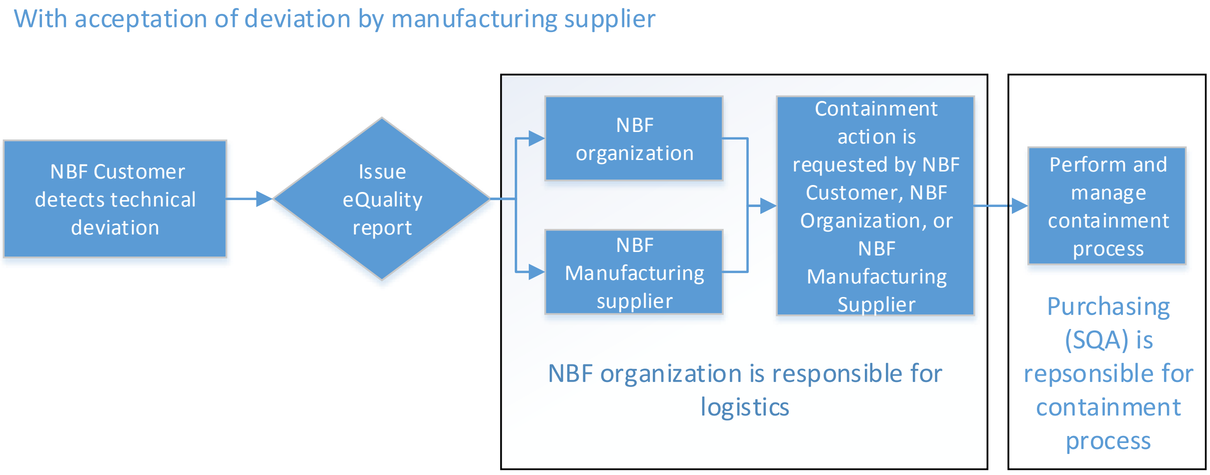

Figure 8-4: Simplified version of responsibilities during containment process

To be able to implement this in the quality handling process, I propose that eQuality should be improved. Normally, only two players are linked to an eQuality report: the issuer and the manufacturing supplier. However, in the proposed situation (with an NBF supplier), more players are involved. In the beginning the issuer, NBF manufacturing supplier, and NBF organization are linked to the eQuality report. Subsequently, after a containment action is requested: the issuer, NBF manufacturing supplier, and Purchase (SQA Zwolle) are linked to the eQuality report, Figure 8-5 aims to show the process.

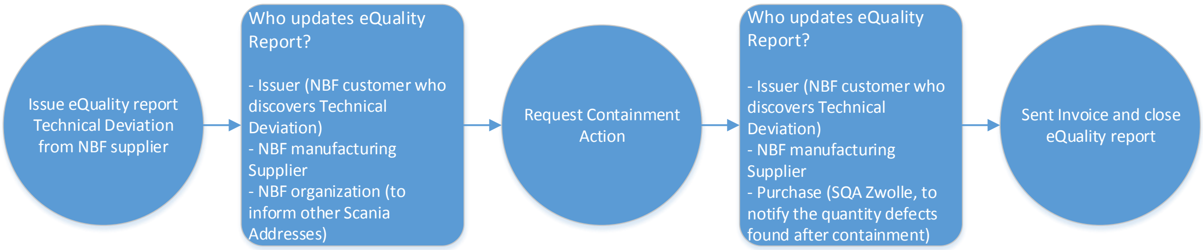

Figure 8-5: Access to eQuality report

8.4.4 eQuality improvements

In the proposed situation, when creating an eQuality report for a technical deviation, always select the manufacturing supplier. The reason for this is because the NBF organization is automatically linked with the eQuality report.

Because the eQuality report is created for the manufacturing supplier, it can be said that NBF organization could be eliminated from the eQuality prepage. But this is not the case, since NBF organization is still responsible for logistical deviations. In a standard report, one has to fill out the standard form: “create new eQuality”. Figure 8-6 shows the “create new eQuality prepage”. When issueing a logistical deviation, NBF organization can still be chosen.

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Figure 8-6: Webpage of standard form: "create new eQuality prepage"

For the new proposed containment process, the eQuality system should slightly be improved. Because NBF organization should also get a notification when creating a new eQuality report for a NBF supplier. When creating a new eQuality report for a technical deviation, eQuality should automatically show that NBF is involved in the situation and that the local MP is automatically assigned to NBF. In this way, NBF organization receives a notification about the technical deviation. Figure 8-7 aims to show this situation.

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Figure 8-7: Webpage of standard form: "create new eQuality"

After NBF organization receives the notification, it is necessary to enter if other Scania addresses also received possible 'NOT OK' parts. If other Scania addresses received possible 'NOT OK' parts, then the NBF organization has also the responsibility to inform the other Scania addresses.

If a containment action is requested by the issuer, NBF manufacturing supplier, or NBF organization, then Purchase (SQA Zwolle) is given responsibility for the containment process. Purchase gets authorization to edit the eQuality report and adds how many 'NOT OK' parts were identified during the containment action.

The figure below aims to show the proposed improved eQuality report.

- Text in red aims to provide the changes needed to improve the current system.
- Text in blue aims to give extra information about the changes.
- Text in black is the current situation in eQuality report.

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Figure 8-8: Proposed improved eQuality report

8.5 Summary Chapter 8

This discussion chapter highlights the results retrieved from a literature review and a benchmark study. Let us specify the results for culture, preventive actions, and containment actions.

Culture
Countries of NBF suppliers aim to have a low achievement of responsibility and therefore individuals do not take global issues personally. Additionally, these societies have a more closed culture. However, creating a more open culture, by fostering a willingness to communicate freely in all layers in of the organization is necessary in order to solve problems related to individual responsibilities that conflict with corporate purpose.

Preventive actions
In order to monitor NBF suppliers more tightened, three alternatives are proposed to Scania:

- Specification: Extra specification control between Scania as an organization, Scania Purchase department, and the manufacturing supplier.
- Audit: A tighter audit control at the manufacturing supplier.
- Inspection*:* 100% outbound goods inspection at the manufacturing supplier.

Purchase department is given responsibility to monitor NBF suppliers more tightened in order to prevent that 'NOT OK' products enter the complex and extensive supply chain of NBF.

Containment actions
Since each of the six containment methods requires a documentation system which is rather extensive, we opt for an adaption that uses the best elements of each of the six containment methods. Based on the strengths of the six methods, five practical containment recommendations in relation to the current situation are proposed.

1. eQuality report should not only be sent to the manufacturing supplier but also to NBF organization.
2. In case the manufacturing supplier cannot 100% guarantee where the 'clean cut' is, inspect the whole inventory stored in the warehouse.
3. Note the reason why parts are blocked in the warehouse.
4. NBF organization is responsible for the logistics before the containment action. As soon as a containment action is required, Purchase (SQA Zwolle) is responsible for the containment process.
5. After a containment action, always 100% inspect the first ok delivery from the manufacturing supplier.

Combining the information retrieved from the literature review and the benchmark study, containment guidelines are determined together with flowcharts which represent the proposed containment process. Before the containment process is requested, NBF organization is responsible for the logistics and has to inform other PRUs which received infected parts. As soon as a containment action is requested, Purchase (SQA Zwolle) is responsible for the containment action.

Conclusions, recommendations, and ideas for further research are given in the next chapter.

9 Conclusion and recommendations

The main objective of this research at Scania Production Zwolle is to find methods in order to improve current quality assurance in the North Bound Flow (NBF). The overall conclusion is described in Section 9.1. Subsequently, recommendations are given in Section 9.2. Finally, Section 9.3 suggests areas for further research.

9.1 Conclusion

The current situation at Scania is working but needs improvements, especially due to the expected growth of NBF. This research was initiated to answer the main research question:

"Who is responsible for managing the quality of the products in North Bound Flow (NBF) when there could be parts in the NBF with a technical deviation and how can Scania safeguard the quality of these parts?"

In the current situation, containment actions are organized with 'ad-hoc' solutions which result in a mix of problems. The problems that Scania as a global organization experience are more general problems and can't be influenced. The problems that NBF customers, Purchasing, and NBF organization experience are more in detail and can be influenced. Seven problem areas were identified by analyzing the current situation, namely: information, organization, containment, communication, supply chain / logistics, responsibilities, and remainder. However, the problem areas don't stand alone, all problems are connected with each other. To be able to identify the underlying causes of the problems, a problem knot was created. Based on the problem knot and due to time limitations, we focused on the following four major problems:

- Cultural differences between Scania and NBF supplier lead to responsibility issues.
- Manufacturing supplier ships a 'NOT OK' part in the supply chain of NBF.
- Lack of internal knowledge about the existence of NBF.
- Lack of a systematic way of organizing a containment action.

Due to the strong connections in the problem knot, solving these four issues automatically affect other problems (problem areas) in a positive way. In order to solve these four issues, literature is reviewed and a benchmark study is performed. The four problems are categorized in the following three sections: culture, preventive actions, and containment actions. Next to that, let us dwell upon the responsibilities involved.

Culture

Cultural differences are present in the NBF and results in responsibility issues. Based on Hofstede (2010) Sweden has a much higher value on IDV and a much lower value on PDI and MAS than Brazil, India, and China. Subsequently, NBF suppliers have more traditional and survival values and therefore they have a less open culture. This leads to responsibility issues. Creating a more open culture, by fostering the willingness to communicate freely in all layers of the organization is necessary to solve problems related to individual responsibilities that conflict with corporate purpose.

Preventive actions

Due to the complex and extensive global supply chain of NBF, it is important that 'NOT OK' parts doesn't enter the supply chain. By scrutinizing eQuality reports, the most common technical deviations were identified. Based on this, five alternatives were identified. After a Multi-Criteria Decision Analysis (MCDA), a decision matrix is conducted.

In order to monitor NBF suppliers more tightened, three alternatives are proposed to Scania:

- Specification: Extra specification control between Scania as an organization, Scania Purchase department, and the manufacturing supplier.
- Audit: A tighter audit control at the manufacturing supplier.
- Inspection*:* 100% outbound goods inspection at the manufacturing supplier.

Containment action
If 'NOT OK' parts enter the supply chain of NBF, then a containment action is required in NBF. After reviewing the literature and a benchmark study, six containment methods are determined. Despite of the fact that a decision matrix helps to indicate which method is the most applicable to Scania. A combination of the strengths of all six methods and the current situation is proposed. Five practical containment recommendations can be proposed in relation to the current situation:

1. eQuality report should not only be sent to the manufacturing supplier but also to NBF organization. In this way the information flow is the same as the goods flow and the NBF organization can inform customers who also received parts from the infected batch.
2. In case the manufacturing supplier cannot 100% guarantee where the 'clean cut' is, inspect the whole inventory stored in the warehouse.
3. Note why parts are blocked in the warehouse. This aims to give the NBF organization a better understanding of why parts are unavailable for supply.
4. NBF organization is responsible for the logistics before the containment action is requested. As soon as a containment action is required, Purchase (SQA Zwolle) is responsible for the containment process.
5. Finally, after a containment action, always 100% inspect the first ok delivery from the manufacturing supplier.

Finally, based on the five improvements, containment guidelines are determined (Section 8.4.2) together with flowcharts which presents the proposed containment process (Section 8.4.3). Before the containment process, NBF organization is responsible for the logistics and has to inform customer who also received parts from an infected batch. As soon as a containment action is requested by NBF customer, NBF supplier, or NBF organization, responsibility is given to Purchase (SQA) for containment action.

Responsibilities
In order to address the main research question. Let us dwell upon the responsibilities for preventive actions and containment actions specifically.

As for *preventive actions*, Purchase department is responsible for supplying required material, equipment, and services. Therefore, Purchase department is given responsibility to monitor NBF suppliers more tightened in order to prevent that 'NOT OK' products enter the complex and extensive supply chain of NBF.

Before the *containment process* is requested, NBF organization is responsible for the logistics and has to inform customers who also received parts from an infected batch. As soon as a containment action is requested by a NBF customer, NBF manufacturing supplier, or the NBF organization, responsibility is given to Purchase (SQA Zwolle) for the containment process.

9.2 Recommendations

Below, let us dwell upon the recommendations for the three categories (e.g., culture, preventive actions, and containment actions). Subsequently, general recommendations are given.

9.2.1 Culture

Create a more open culture by fostering the willingness to communicate freely in all layers in the organization. In this way, problems related to individual responsibilities that conflict with corporate purpose are solved easier.

9.2.2 Preventive actions

Due to the complex and extensive supply chain, it is important to prevent that 'NOT OK' products enter the supply chain. Below, three recommendations are given for preventive actions.

- Have a 100% visual outbound goods inspection at NBF suppliers.
- Extra specification control between Scania as an organization, Scania Purchase department, and the manufacturing supplier to close the gaps identified in our gap analysis.
- Tighter audit control for NBF suppliers.

Purchase department is given responsibility to monitor NBF suppliers more tightened in order to prevent that 'NOT OK' products enter the complex and extensive supply chain of NBF.

9.2.3 Containment actions

Now that recommendations are given for preventive actions, it is essential that containment actions are present when having 'NOT OK' products in NBF. Below, five recommendations are given for containment actions.

Equality report should be sent to the manufacturing supplier and to the NBF organization.
In case of technical deviations, eQuality should be sent to the manufacturing supplier and to the NBF organization. In this way, the NBF organization knows about the possible 'NOT OK' products stored in the warehouse.

Without clean cut, inspect 100%
If the manufacturing supplier cannot 100% guarantee where the 'clean cut' is, we propose to inspect the whole inventory of that specific part. This is perhaps a high cost activity, but the costs can be charged to the supplier. Next to this, FIFO is not always done correctly. So inspecting the whole inventory is the best way to be certain if parts are 'OK' or 'NOT OK'.

Note the reason of blocked parts in warehouse
NBF organization does already record which inventory in the warehouse is available and not. However, the reason why parts are blocked is not always known. We propose to note also the reason why parts are blocked. In this way, NBF organization has a better understanding why parts are unavailable for delivery.

Give responsibility to Purchasing (SQA Zwolle) for containment process
Because the mission of Purchasing is to provide value to their customers by supplying required material, equipment, and services to the right quality, delivery, and costs, Purchasing is aimed to give responsibility for the containment process. As soon as a containment action is requested in NBF, we propose that Purchase (SQA Zwolle) is given responsibility to manage this well.

Before the containment process is requested, the NBF organization is responsible for the logistics and has to inform other Scania addresses who received parts from the infected batch.

Inspect 100% first ok delivery of manufacturing supplier

100% inspect the first ok delivery from the manufacturing supplier. Due to the corrective actions the goods are slightly changed and therefore have to be checked. In this way, Scania has more control over the quality of the parts stored in the warehouse.

9.2.4 General recommendations

In addition to the recommendations on culture, preventive actions, and containment actions, four general recommendations are listed below.

Inform customers NBF about NBF

This research aims to indicate the lack of information and knowledge about NBF. This research or Appendix M can be used to inform the customer of NBF about NBF. In this way, the customers have an information document about the supply chain of NBF, warehouse, existing problems, and containment actions.

Systematic containment process

We recommend to use the containment process as described in this research. Based on a literature study and benchmark study performed in Chapter 7, the current containment process is changed and improved. The guidelines described in Section 8.4.2 together with the flowcharts in Figure 8-2 and Figure 8-3 can be used as a systematic approach for containment actions in NBF. In the proposed containment process, NBF has the responsibility to inform Scania addresses who also received infective parts and Purchase (SQA Zwolle) is given responsibility to coordinate the containment process

Change and improve eQuality report

We propose to change and improve the eQuality reports. If QA/SQA issues an eQuality, and the supplier is from NBF, then automatically NBF organization should receive the eQuality report as well. The proposed changes in eQuality are presented in Section 8.4.4.

Cost summary

Finally, we propose to use an enhanced version of the current engine cost template which can be completed and charged to the manufacturing supplier. The manufacturing supplier is responsible for the quality of its parts and therefore charged for the costs. An example is provided in Appendix N: Cost summary, the template is used in Scania Engine. The template should at least include administrative costs, handling costs, inspection costs, processing damaged goods costs, and personnel costs.

9.3 Further research

This research has addressed the issue of managing product quality in the North Bound Flow. Learning from this research and based on the problem knot given in Figure 4-6, five recommendations are proposed for further research:

Since this research has the focus on NBF, I propose some sort of similar research for the South Bound Flow (SBF). In contradiction to NBF, the flow of goods in SBF is going south to Brazil, see Figure 9-1. Perhaps with minimal changes the outcome of this research can be used for SBF as well.

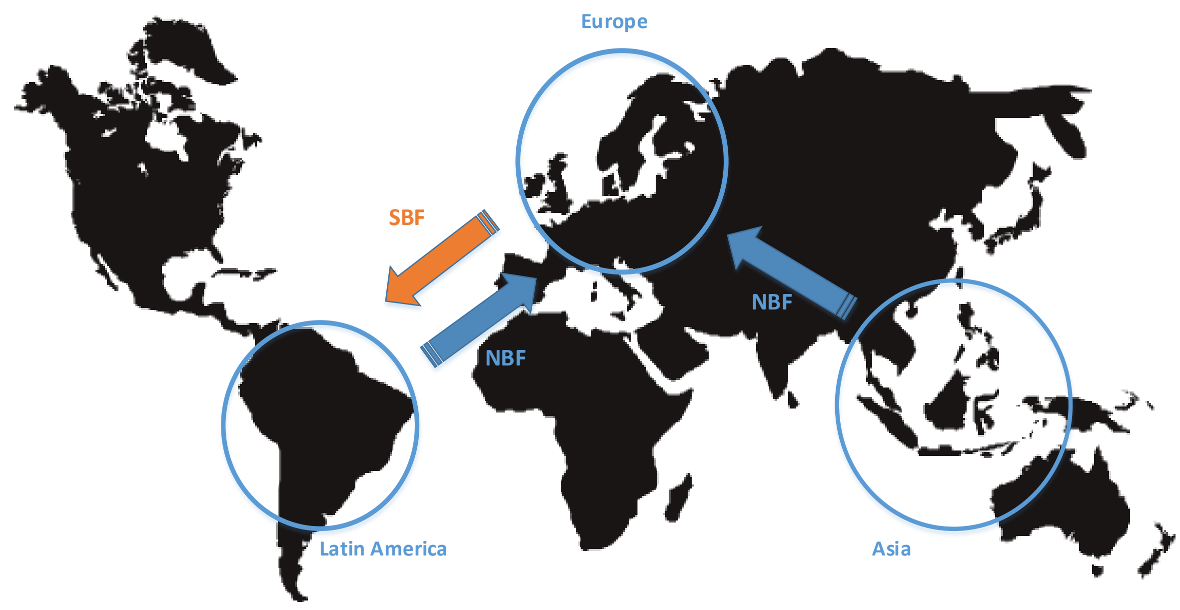

Figure 9-1: NBF and SBF

Track and trace is the second recommendation for further research. Because of the global and complex supply chain of Scania, the need for goods-centric tracking and tracing of logistics items is increasing (Shamsuzzoha, Ehrs, Addo-Tenkorang, Nguyen, & Helo, 2013). Next to this, the need for visibility in the supply chain and recording the movements of products from manufactures to retailers is increasing as well (Choi, Yang, Cheung, & Yang, 2015). For example, radio-frequency identification (RFID), tag data processing and synchronization (TPDS) methods, etc., are widely used for monitoring the flow in the logistics chain (Choi, Yang, Cheung, & Yang, 2015) (Shamsuzzoha, Ehrs, Addo-Tenkorang, Nguyen, & Helo, 2013). Yet, Scania doesn't use such innovative track-and-trace system, therefore I propose further research in the field of track and trace systems.

My third recommendation for further research is about warehousing. In the current situation, warehousing was outsourced to a third party logistics (3PL). During my visit at the warehouse in Ridderkerk, I noticed that the aim of the 3PL is to charge Scania for as many square meters as possible. Because the warehouse of NBF is now moved from Ridderkerk to Hasselt and managed by Scania instead of a 3PL, my recommendation for further research is space optimization in the warehouse. The literature provides some interesting topics (Gu, Goetschalckx, & McGinnis, 2010) (Bartholdi & Hackman, 2002) (Koster, Poort, & Wolters, 1999) (Mantel, Schuur, & Heragu, 2007) (Ratliff & Rosenthal, 1983) (Goetschalckx & Ratliff, 1991). I propose the following papers about warehousing that can be investigated, as shown in Table 9-1.

Table 9-1: Recommendations for further research on warehousing

Recommendations about warehousing topics for further research	Recommended papers
Warehouse design	Gu, J., Goetschalckx, M., & McGinnis, L. F. (2010). Research on warehouse design and performance evaluation: A comprehensive review. *European Journal of Operarions Research, Vol. 203*, 539-549.
Design of the fast pick area	Bartholdi, J. J., & Hackman, S. T. (2002). *Warehouse & Distribution Science Release 0.1.2.*
Shaping a warehouse	Koster, M. d., Poort, E. v., & Wolters, M. (1999). Efficient orderbatching methods in warehouses. *International Journal of Production Research, Vol. 37, No. 7*, 1479-1504.
Optimal Order Picking	Ratliff, D. H., & Rosenthal, A. S. (1983). Order-Picking in a Rectangular Warehouse: A Solvable Case of the Traveling Salesman Problem. *Operations Research, Vol. 31, No. 3 (may-Jun)*, 507-521.
Storage configuration	Mantel, R. J., Schuur, P. C., & Heragu, S. S. (2007). Order oriented slotting: a new assignment strategy for warehouses. *European Journal of Industiral Engineering, Vol. 1, No. 3*, 301-316.
Optimal lane depths	Goetschalckx, M., & Ratliff, D. H. (1991). Optimal Lane Depths for Single and Multiple Products in Block Stacking Storage Systems. *IIE Transactions, Vol. 23, No. 3*, 245-258.

The forth recommendation for further research is about the problem that manufacturing suppliers produces a 'NOT OK' product. Yet, due to the importance that a manufacturing supplier delivers a good quality product. I propose some further research on (for example) a 'funded head' (Justice, 2009) at the suppliers of NBF. According to Justice (2009), a 'funded head' is an employee of Scania working at as specific manufacturing supplier in order to make sure that the supplier manufactures a good quality product. Scania's pays a portion of the salary of the 'funded head' employee. Some of the advantages of the manufacturing supplier is lower cost than hiring own personnel, manufacture less 'NOT OK' products and therefore receives less eQuality reports. One of the biggest advantage of Scania is having less 'NOT OK' products in NBF which can result in less production stops.

The final recommendation for further research is about an incoming goods inspection in the warehouse with Dynamic Modification Rules as described at benchmark company B. It might be beneficial for Scania to classify the products and make additional incoming inspections rules. However, note that the incoming goods inspections is not the same as the outbound goods inspection at the manufacturing supplier.

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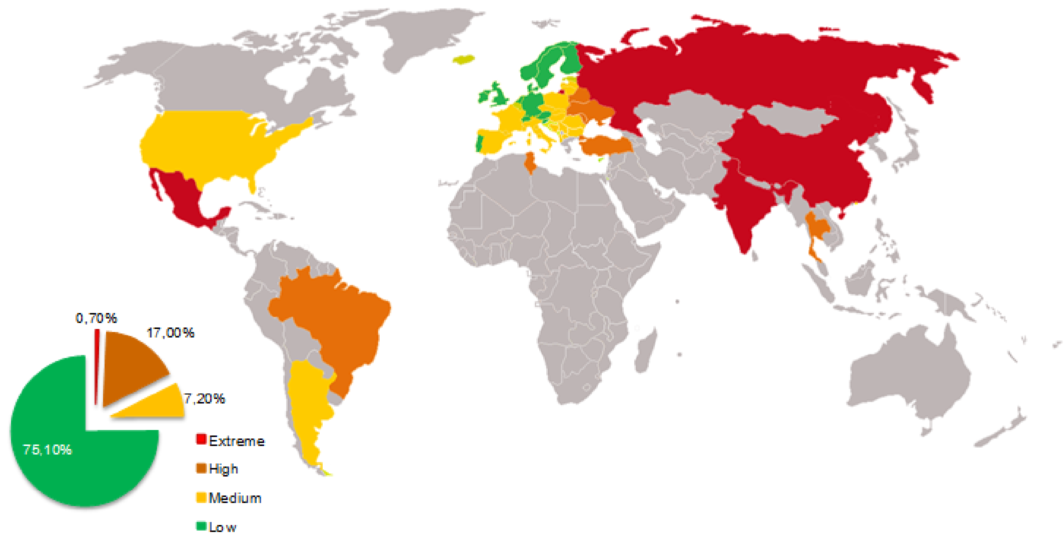
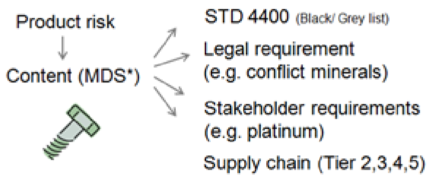
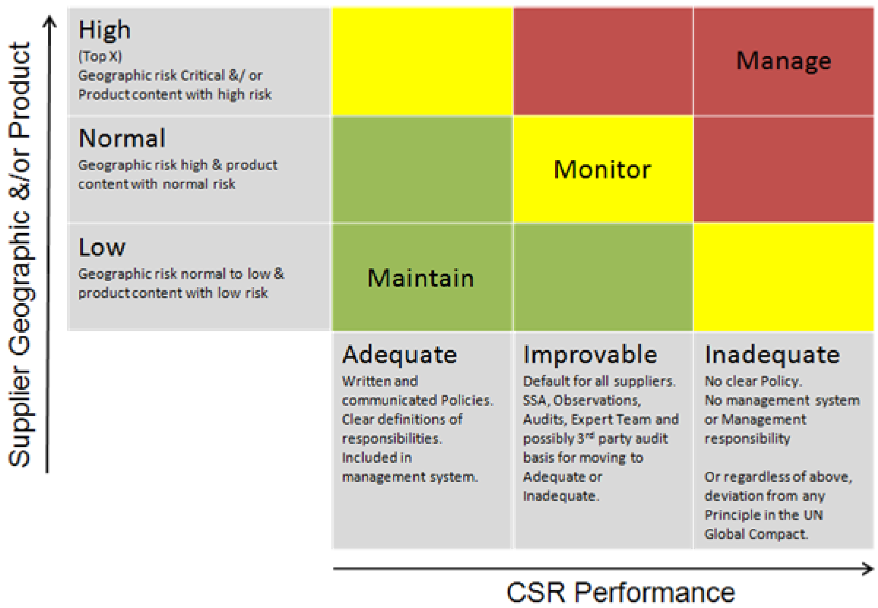
Appendix A: Sustainability Risk Analysis

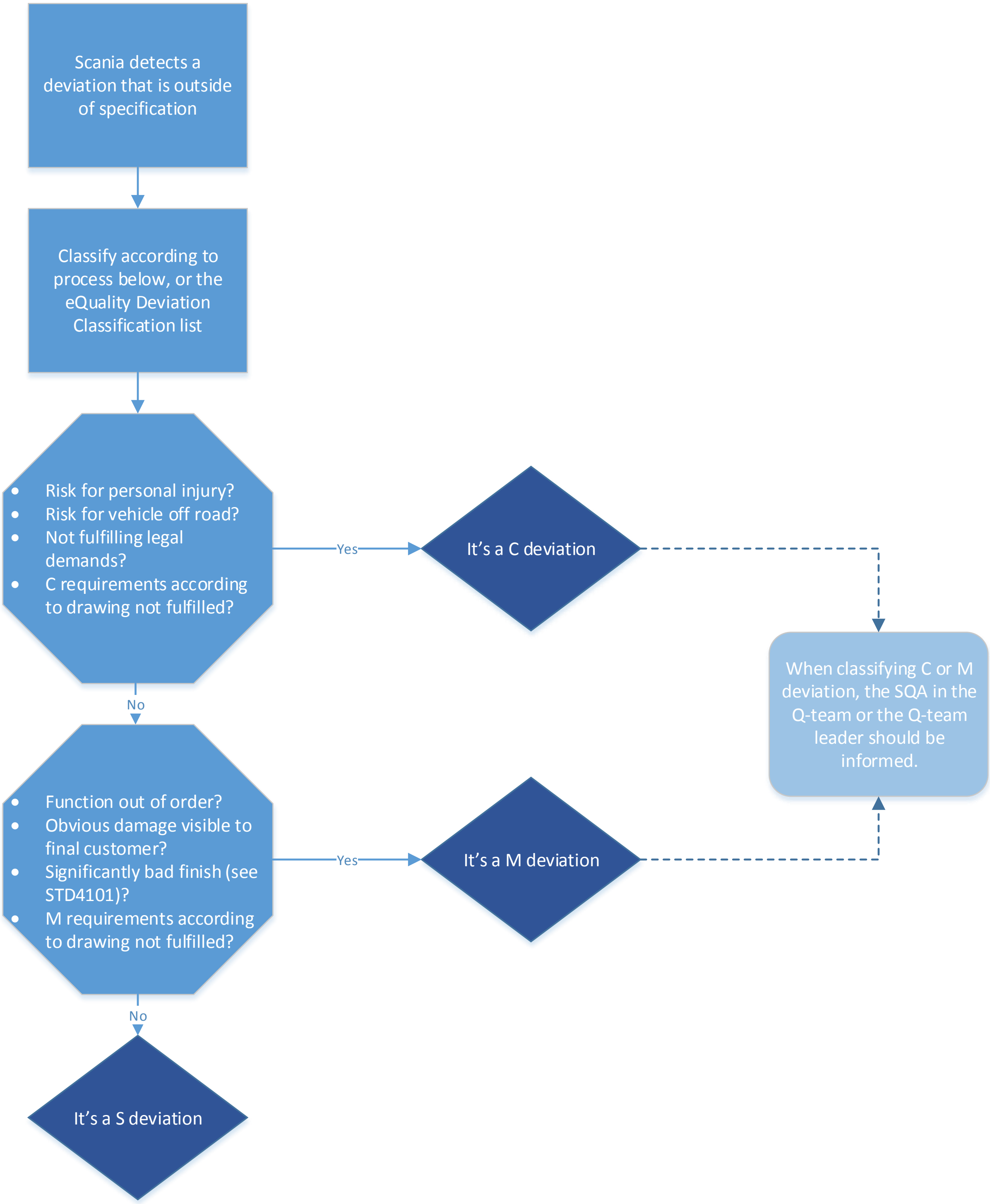






Appendix B: eQuality classification of technical deviations

The flowchart below can be used to classify technical deviation consequences.

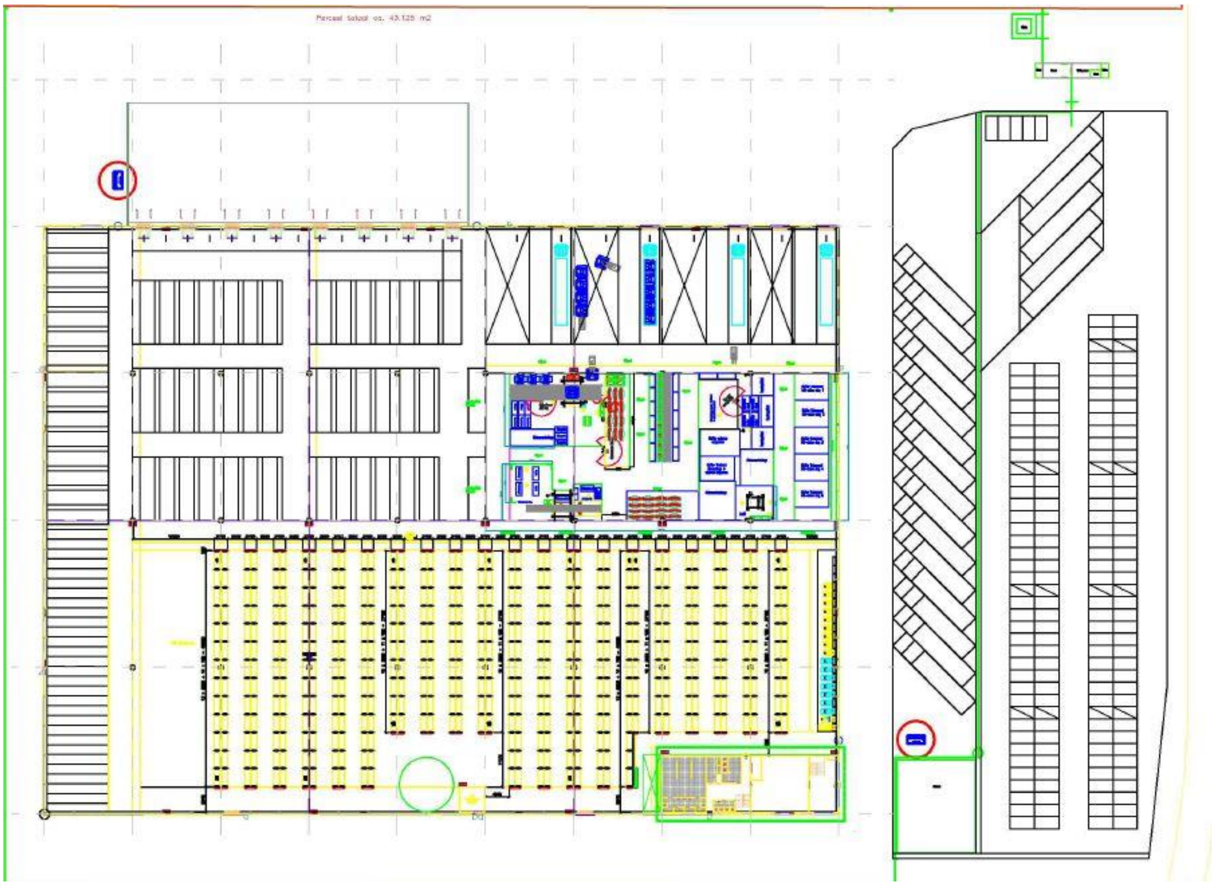


The list below can be used to classify technical deviation consequences.

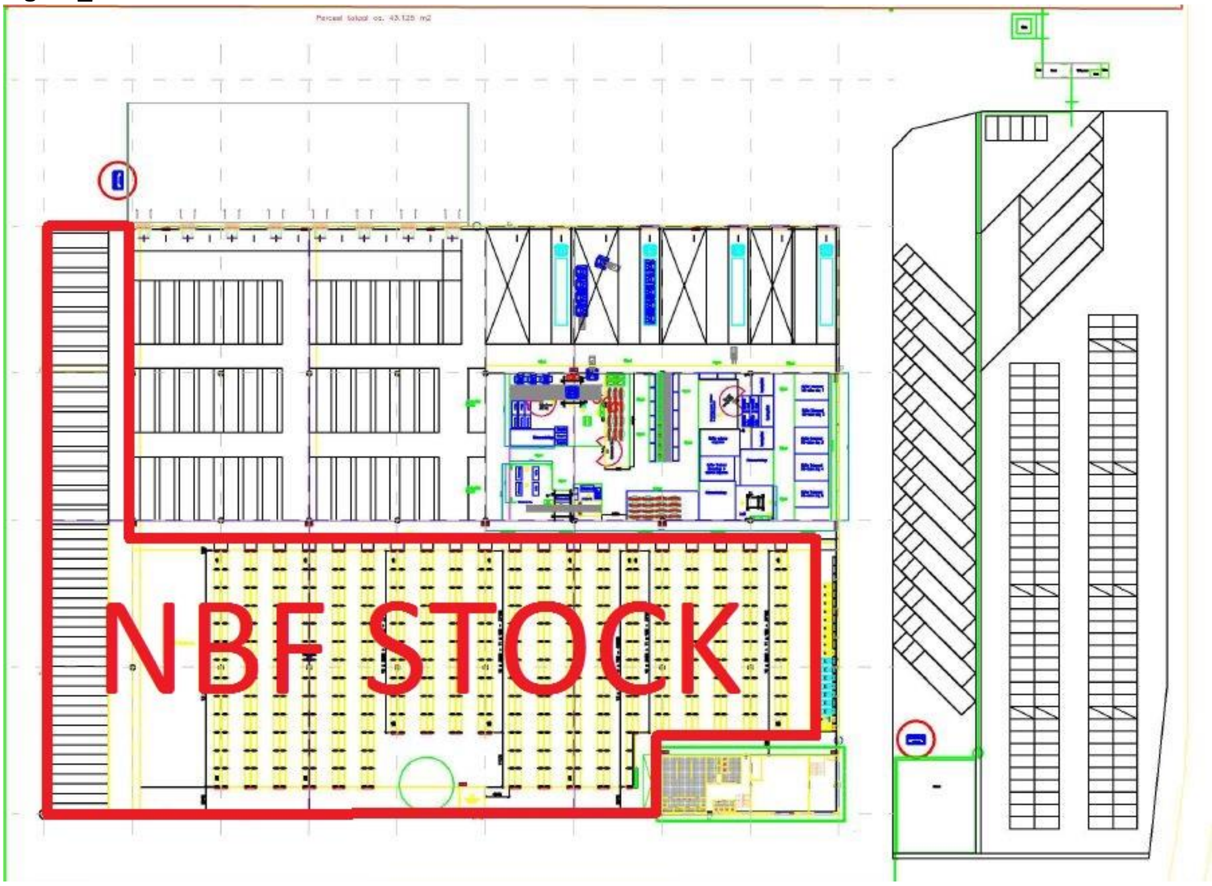
Classification		Score
Safety	Personal injury	C
	Fire risk	C
	Traffic Safety	C
Environment	Emissions	M
	Leakage/AC, oil	C
	Noise, external	M
	Reuse/recycling, marking	M
Uptime	Reliability / Urgent visit to repair shop, stop on the road - VOR	C
	Access / Standstill due to service and service-intervals	M
(Engine) Performance	Power train (optimised, harmonised, synchronised)	M
	Moment curve / Response	M
	Vibrations	M
Driver environment / Comfort	Noise, internal	M
	Manoeuvre force	M
	Drivers comfort	M
Economy	Fuel cost	M
	Service life	M
Repair and Maintenance cost	Maintenance	M
	Repair, Ease to service	M
	Repair Technique	M
Load capacity	Weight and position	M
	Road holding qualities	M
	Suspension	M
	Structural strength	C
Others	Appearance / Lacquer, Gap	M
	Special market requirements	C
	Documentation requirements	C
	Legal requirements	C

Appendix C: Floor map LC Hasselt, the Netherlands

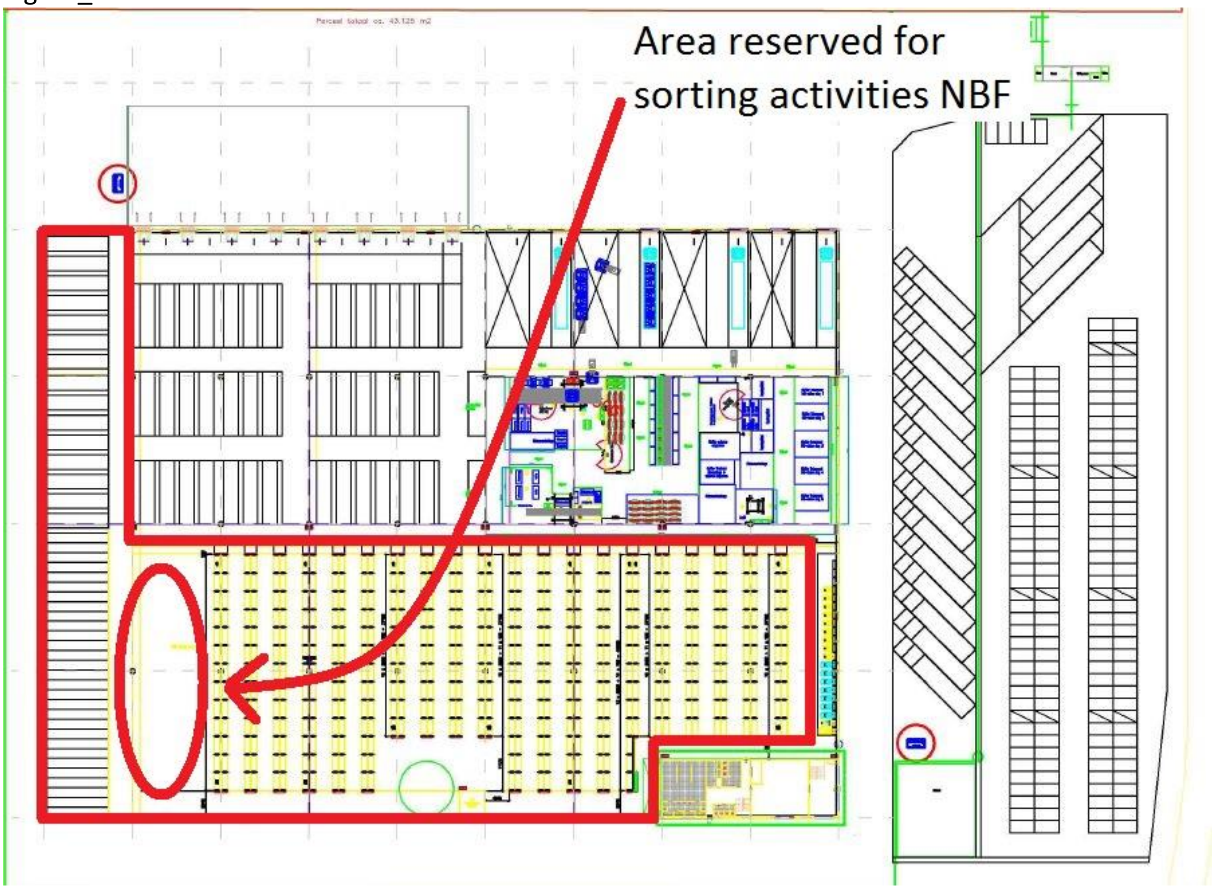
Figure_i:



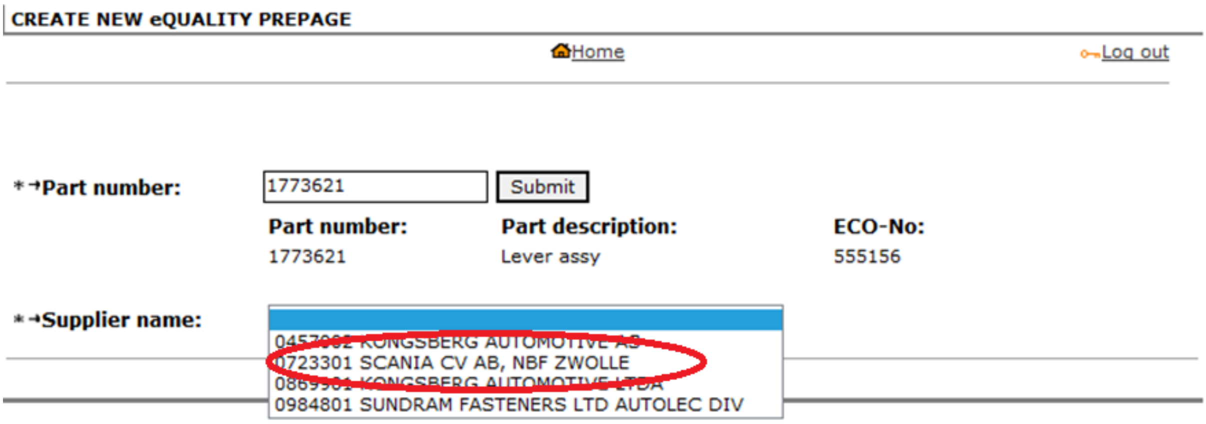
Figure_ii:



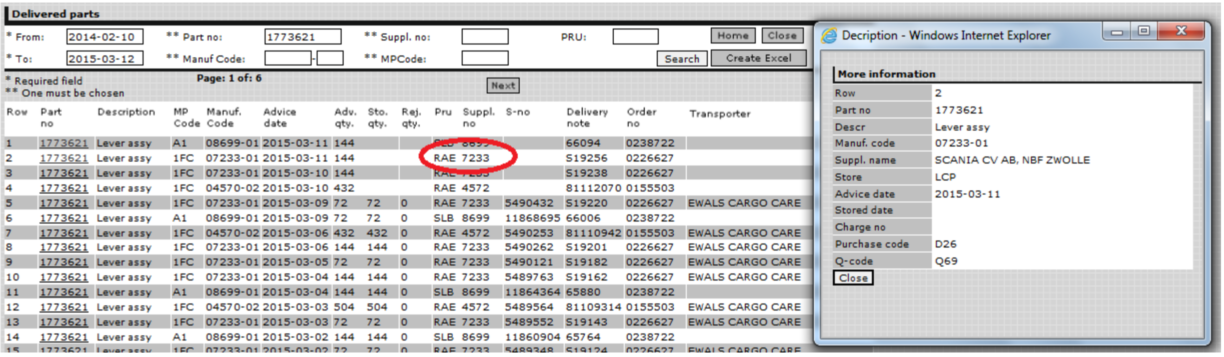
Figure_iii:



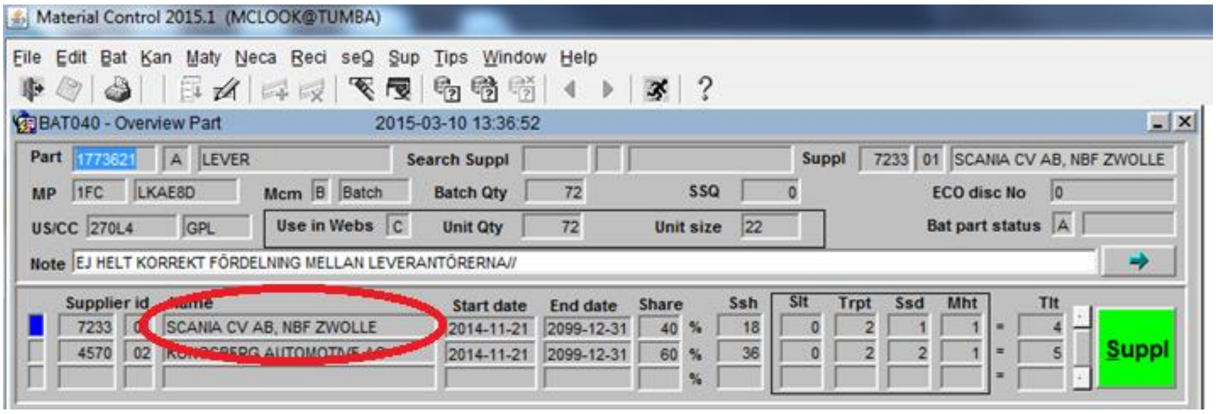
Appendix D: Supplier North Bound Flow (NBF)



Look in eQ2 portal to see if supplier is NBF



Look in delivered part homepage to see if supplier is NBF



Look in Mona production system (Material Control) to see if supplier is from NBF.

Look at label on pallet to see if the supplier is NBF.

Appendix E: Survey

Survey: North Bound Flow (NBF) suppliers

My name is Jurgen Bremmer and I'm a graduate intern at Scania Production Zwolle at the Q team of Martijn Smit.

I am doing my Master thesis at Scania about the North Bound Flow (NBF) and my main research question is:

"Who is responsible for managing the quality of the products in North Bound Flow (NBF) when there could be parts in the NBF with a technical deviation and how can Scania safeguard the quality of these parts?"

The NBF (North Bound Flow) organization is located in Zwolle and enables the Scania production units (PRUs) in Europe to use suppliers from outside Europe. The responsibility is to collect the part demand from its customers (Scania PRUs, Scania Parts, and Scania Knock Down), make delivery plans on supplier level and finally send call offs to the suppliers. The lead times are very long because the suppliers are located outside of Europe. Therefore NBF uses a warehouse (located in the Netherlands) to keep inventory.

Because the NBF has a complex supply chain with suppliers located outside of Europe, I want a deeper understanding about those suppliers and the sourcing process.

Completing the survey will take about 15 minutes, and the layout is as follows:

1. Supplier roles
2. Supplier interfaces
3. Sourcing strategy

If you have any questions, don't hesitate to contact me:
Tel: +31 6 28 30 92 46
Mail: Jurgen.bremmer@scania.com

Remember:
Complete this survey regarding suppliers from the NBF!
Suppliers outside of Europe!

Supplier roles

According to the literature, there are four different supplier roles: which role do suppliers in NBF have according to you? (First some information is given, please answer in the second table).

Role	Description	Responsibilities during product development
Partner **(Full service provider)**	Relationship between equals; supplier has technology, size, and global reach.	Entire subsystem. Supplier acts as an arm of the customer and participates from the pre-concept stage onward.
Mature **(or Adult)** **(Full-System Supplier)**	Customer has superior position; supplier takes major responsibility with close customer guidance	Complex assembly. Customers provides specifications, then supplier develops system on its own. Supplier may suggest alternatives to customer.
Child	Customer calls the shots, and supplier responds to meet demands.	Simple assembly. Customer specifies design requirements, and supplier executes them.
Contractual **(or Commodity)**	Supplier is used as an extension of customer's manufacturing capability.	Commodity or standard part. Customer gives detailed blueprints or orders from a catalogue, and supplier builds.

Suppliers in the NBF can be seen as (place an 'X' in the right quadrant(s)):

If some suppliers have a partner role and other suppliers have a Mature role, then place a 'X' at Partner and Mature.

Role	Suppliers in the NBF can be seen as:
Partner **(Full service provider)**	
Mature **(or Adult)** **(Full-System Supplier)**	
Child	
Contractual **(or Commodity)**	

If you want to give some extra information, then you can use this space:

…….

Supplier Interfaces

According to the literature, there are four different interfaces based on how a customer can access its suppliers' resources:

(First some information is given, please answer in the second table).

Interface Category	Characteristics	Customer Benefits Productivity	Customer Costs Productivity	Customer Benefits Innovativity	Customer Costs Innovativity
Interactive	Joint development based on combined knowledge of use and production.	Open-ended exchange allows full consideration of direct and indirect costs for both parties.	Investments in knowledge of how best to make use of existing resources.	Supplier learning about user context opens up the gamut of solutions offered.	Requires investments in joint developments and learning.
Translation	Directions given by customer based on user context and functionality required.	Supplier can propose efficient solutions that provide its own and well as the customer's productivity	Supplier may reap benefits that are not shared with customer.	Supplier has some leeway to propose innovative solutions.	Supplier may not know enough about customer context to innovate radically
Specified	Precise directions given by customer on how the supplier should produce.	Supplier can pool together similar orders; economies of scale and scope can be attained.	Supplier's resource base "locked in." Limited possibilities to influence specifications.	Minimal (supplier can propose changes to blueprints).	Suppliers used as capacity reservoir. Development of supplier resources may suffer.
Standardized	No Directions. No specific connection between user and producer contexts.	Cost benefits from supplier economies of scale and scope, as well as learning curve effects.	Adaptation to standardized solutions may create indirect costs elsewhere.	None.	No direct costs. Allows only indirect feedback to suppliers based on sales figures.

The interface with suppliers in the NBF can be seen as (place an 'X' in the right quadrant(s)):

If you have partner and mature suppliers, place a 'X' in the column of Partner and a 'X' in the column of Mature.

Interface Category	Partner	Mature	Child	Contractual
Interactive				
Translation				
Specified				
Standardized				

If you want to give some extra information, then you can use this space:

…….

Sourcing strategies
Kraljic matrix: in which quadrant are suppliers from NBF located, according to you?
(First some information is given, please answer in the second table).

Impact on business can be defined in terms of the volume purchased, percentage of total purchase cost, or impact on product quality or business growth.

Supply risk / supply market complexity can be defined as the complexity of the supply market gauged by supply scarcity, pace of technology and/or materials substitution, entry barriers, logistics cost or complexity, and monopoly or oligopoly conditions.

	Classification of purchase items	
High **Impact on business (internal issues)**	**Leverage: Best deal** (High profit impact, low supply risk) • Unit cost management important because of volume usage. • Substitution possible. • Competitive supply market with several capable suppliers.	**Critical: Cooperation** (High profit impact, high supply risk) • Custom design or unique specification. • Supplier technology important. • Changing source of supply difficult or costly. • Substitution difficult.
Low	**Routine: Efficiency** (Low profit impact, low supply risk) • Standard specifications or 'commodity'-type items. • Substitute products readily available. • Competitive supply market with many suppliers.	**Bottleneck: Supply continuity** (Low profit impact, high supply risk) • Unique spécification. • Supplier's technology important. • Production-based scarcity due to low demand and/or few sources of supply. • Usage fluctuation no routinely predictable. • Potential storage risk.
	Low **Supply Risk / supply market complexity (external issues)**	**High**

Suppliers in NBF can be classified as (place an 'X' in the right quadrant(s)):
If you have partner and mature suppliers, place a 'X' in the column of Partner and a 'X' in the column of Mature.

Classification:	Partner	Mature	Child	Contractual
Leverage				
Critical				
Routine				
Bottleneck				

If you want to give some extra information, then you can use this space:
…….

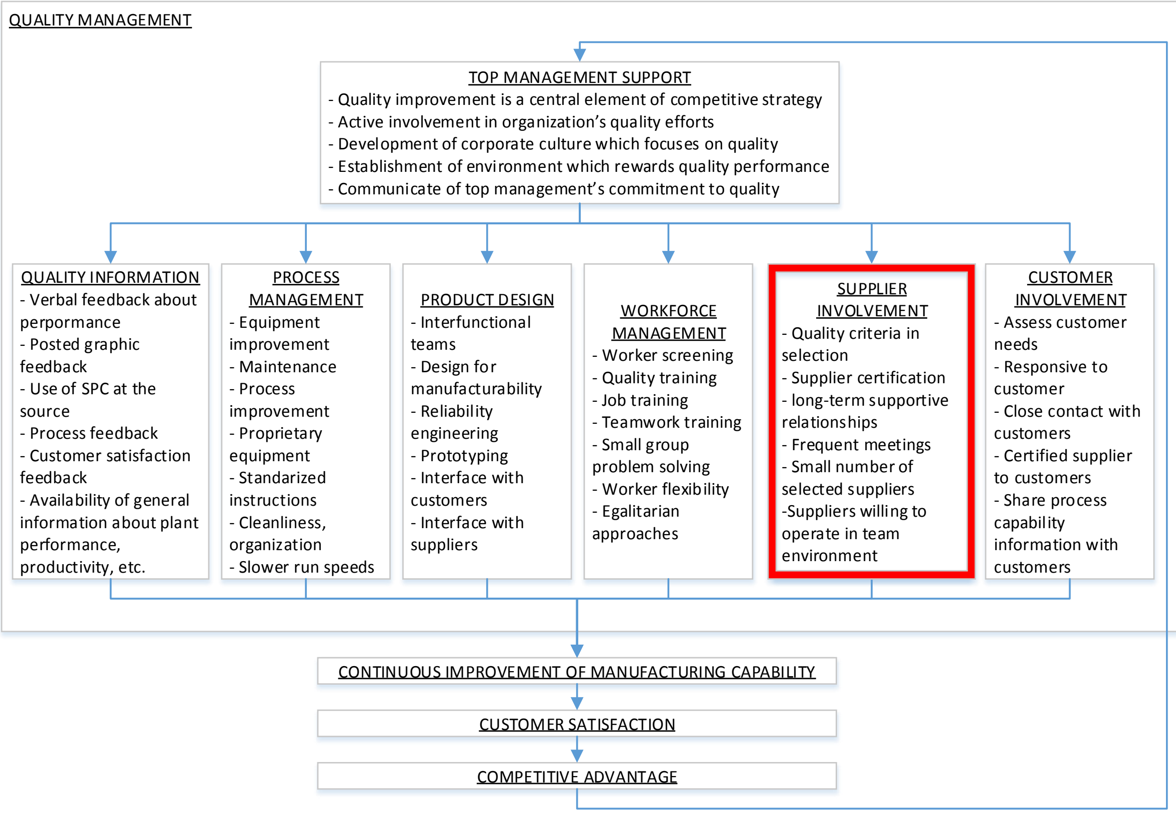
Appendix F: Interface categories

Interface Category	Characteristics	Customer Benefits Productivity	Customer Costs Productivity	Customer Benefits Innovativity	Customer Costs Innovativity
Standardized	No Directions. No specific connection between user and producer contexts.	Cost benefits from supplier economies of scale and scope, as well as learning curve effects.	Adaptation to standardized solutions may create indirect costs elsewhere.	None.	No direct costs. Allows only indirect feedback to suppliers based on sales figures.
Specified	Precise directions given by customer on how to produce.	Supplier can pool together similar orders; economies of scale and scope can be attained.	Supplier's resource base "locked in." Limited possibilities to influence specifications.	Minimal (supplier can propose changes to blueprints).	Suppliers used as capacity reservoir. Development of supplier resources may suffer.
Translation	Directions given by customer based on user context and functionality required.	Supplier can propose efficient solutions that provide its own and well as the customer's productivity	Supplier may reap benefits that are not shared with customer.	Supplier has some leeway to propose innovative solutions.	Supplier may not know enough about customer context to innovate radically
Interactive	Joint development based on combined knowledge of use and production.	Open-ended exchange allows full consideration of direct and indirect costs for both parties.	Investments in knowledge of how best to make use of existing resources.	Supplier learning about user context opens up the gamut of solutions offered	Requires investments in joint developments and learning.

Adapted from:

Araujo, L., Dubois, A., & Gadde, L. E. (1999). Managing Interfaces with Suppliers. *Industrial Marketing Management, Vol. 28.* , 497-506.

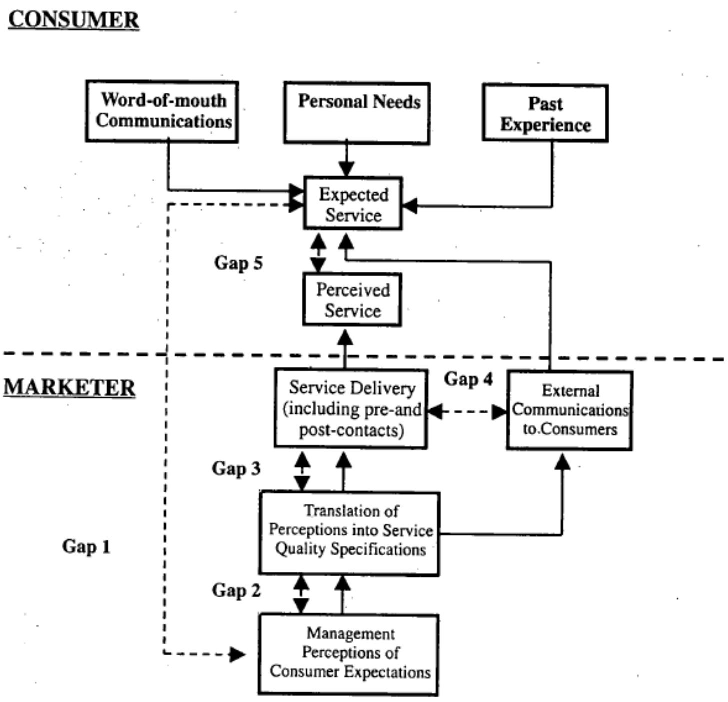
Appendix G: Quality Management



Adapted from:

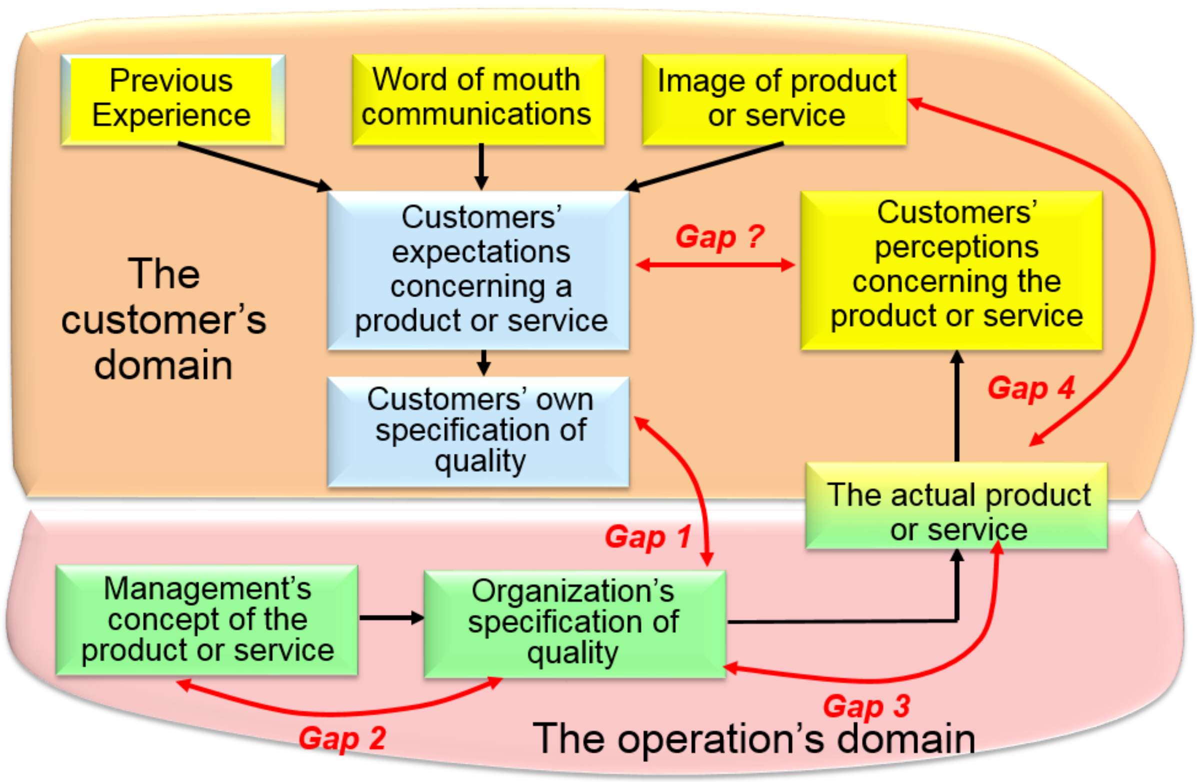
Flynn, B. B., Schroeder, R. G., & Sakakibara, S. (1994). A framework for quality management research and an associated measurement instrument. *Journal of Operations Management, Vol. 11, Adapted in revised form December 1993*, 339-366.

Appendix H: Service / Product Quality Model



Adapted from:

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing, Vol. 49*, 41-50.



Adapted from:

Slack, N., Chambers, S., & Johnston, R. (2007). *Operations Management, fifth edition.* Harlow, England: Prentice Hall.

Appendix I: Examples from Barsalou (2015)

Example of an 8D report

Report No.: **Customer Claim No.** **Supplier 8D No.:**	**Part No.:**
	Complaint:
(1) Team	**Opened on:** **Version date:**
(2) Problem Description	
(3) Immediate Containment Action	**Resp./Date**
(4) Root Cause	
(5) Planned Corrective Action	**Resp./Date**
(6) Implemented Corrective Action	**Resp./Date**
(7) Actions to Prevent Reoccurrence **P-FMEA** **D-FMEA** **Control Plan** **Procedures**	**Resp./Date**
(8) Congratulate the Team	**Closed on**

Example 1 to illustrate containment action

The operator of a production machine discovers a defective component in a batch of material that had been produced during a previous manufacturing process. The machine operator informs a quality engineer, who quickly calls together the supervisor of the two manufacturing departments; the three decide that it is possible for a defective part to go undetected, so a containment action is needed. The quality engineer informs the warehouse to quarantine all parts, and the supervisor of the department that made the mistake sends three people to the warehouse to begin checking parts. A root cause analysis is started by the quality engineer while the inspection is taking place.

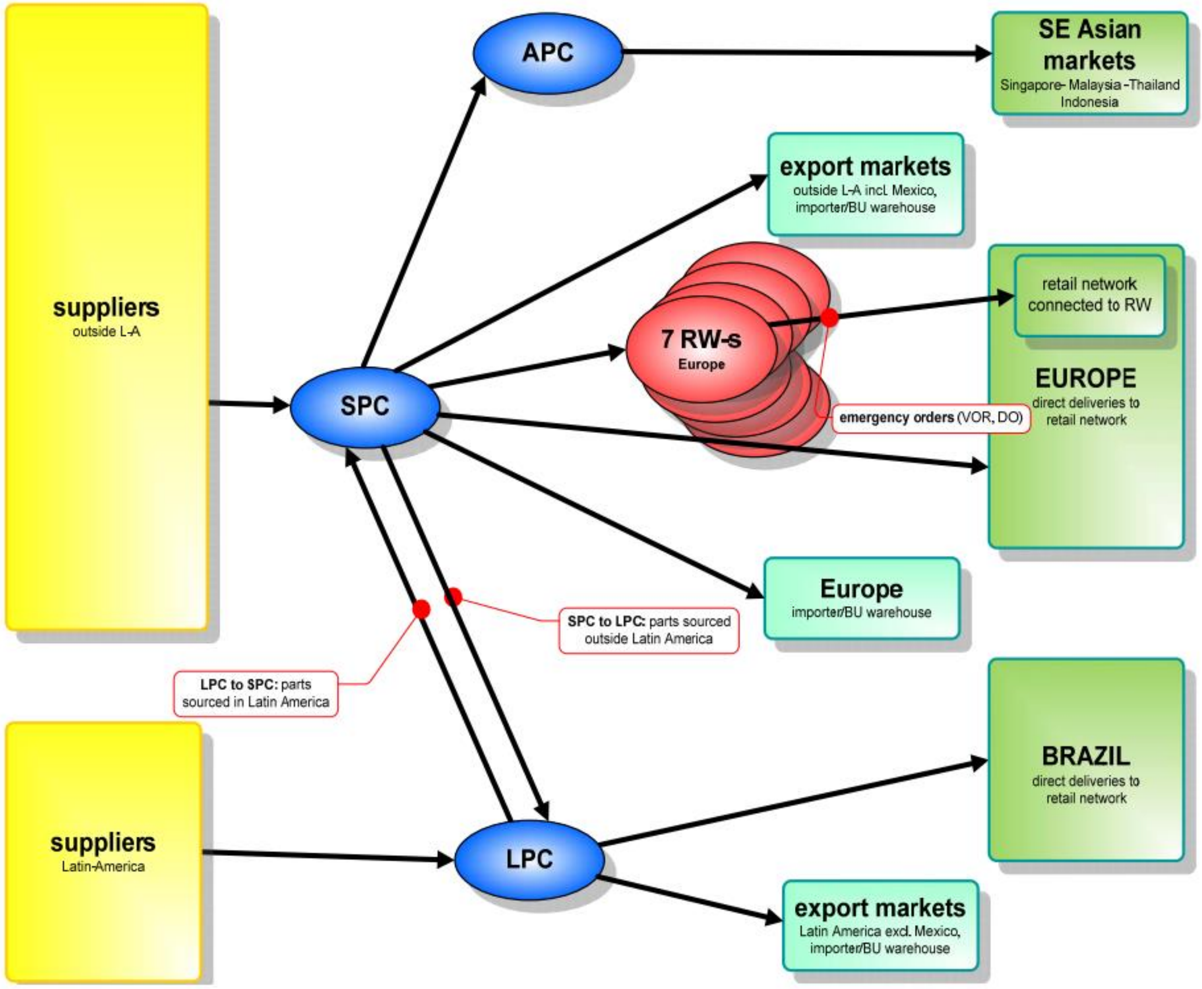
Example 2 to illustrate containment action

A customer issues a quality complaint because two units were found to be missing bolts. The supplier initiates an 8D report to document the activities pertaining to the failure (Figure 14.2). The inventory was checked, and the use of quality tools led the team to conclude that a new worker failed to install the bolts. Although this was a human error, an automatic check was installed in the process to ensure an assembly with missing bolts could not be shipped to the customer again. The work instruction, process failure modes and effects analysis (P-FMEA) and control plan were found to lack this point, so they were updated.

All three examples are adapted from:

Barsalou, M. A. (2015). Root Cause Analysis, A Step-By-Step Guide to Using the Right Tool at the Right Time. 6000 Broken Sound Parkway NY, suite 300, Boca Raton: CRC Press, Taylor & Francis Group, A productivity Press Book, page 47, 111, 112, and 113.

Appendix J: Distibution structure Scania Parts Logistics



Appendix K: Interview templates

Production Units

Introduction of the assignment.

1. What is your function related to the NBF?
2. What is the current situation when there is a part with a technical deviation? (Flier, NBF, Supplier?)
3. Is this a systematic way of working?
4. What problems do you experience?
5. The way you handle a technical deviation from NBF, is this a solid / adequate way? -> Why?
6. What do you miss when there is a technical deviation with a NBF part?
7. What do you expect from the NBF organization?
8. Can you give an example that went very good? And why did it go very good?
9. Can you give an example that went very bad? And why did it go very bad?

10. Can you show me an Equality report of a NBF part?
11. Did you manage this with Aart Flier? or with NBF? or directly with the supplier? –> why? (standard?)
12. Who takes the decision?
13. Is there a systematic way of writing equality reports?
14. Were there any problems with this particular item?

Go to the line (same product as from the eQuality)

16. Where are the pallets with NBF parts located at the line?
17. Where are the pallets with NBF parts located in the factory?
18. Where do you find a technical deviation (e.g. at line or at warehouse) ?
19. When do you find the technical deviation?
20. How do you find the technical deviation?
21. What is the first action taken when finding a technical deviation (e.g. do they throw the part away)?
22. When is it a problem when you find a technical deviation?
23. Which impact on the line has a technical deviation of a NBF part?
24. Does the production experience problems when there are technical deviations at a NBF part?
25. Are there dummies of NBF parts?
26. What happens with the part with a deviation?
27. How fast is this happening?

28. How fast should the deviation be reported?
29. How fast is the deviation reported?
30. What is the process of reporting?
31. Is there a delay in the process? -> Why?
32. When do you discover it is from NBF?

33. How important are the parts from NBF?
34. What is the share, dual sourcing?
35. Are all parts from NBF equally important?
36. Do you expect the same service from NBF parts as from parts from supplier nearby? -> Why?

37. When the deviation is found, how is the checking / sorting process regulated?
38. Where are the parts checked / sorted?
39. How are they checked / sorted?
40. How fast is the checking / sorting process?

41. How is rework done?
42. where is rework done?

43. Is the checking / sorting / reworking process in cooperation with the supplier? -> why?

Purchasing department:

Introduction of the assignment

1. What is your function related to the NBF?
2. What is the current situation when there is a part with a technical deviation? (Flier, NBF, Supplier?)
3. Is this a systematic way of working?
4. When does production inform you about a technical deviation?
5. Are you only informed with deviations of NBF which have a very large impact?
   Are you always informed? -> Why?
   Where is the line of informing or not informing?
6. What problems have you experienced?
7. Why was this a problem?
8. The way you handle a technical deviation from NBF, is this a solid / adequate way? -> Why?
9. What do you miss when there is a technical deviation with a NBF part?
10. What do you expect from the NBF organization?
11. Can you give an example that went very good? And why did it go very good?
12. Can you give an example that went very bad? And why did it go very bad?
13. Can you show me an Equality report of a NBF part?
14. Did you manage this with Aart Flier? or with NBF? or directly with the supplier? –> why? (standard?)
15. Who takes the decision?
16. Is there a systematic way of writing equality reports?
17. Were there any problems with this particular item?

Warehouse Ridderkerk:
Introductie

Introductie master thesis

Vragen

1. Wat organiseert Schenker voor Scania/NBF?

Magazijn

2. Hoe is de goederen ontvangst geregeld?
3. Hoe worden de goederen verpakt voordat ze worden opgeslagen?
4. Hoe worden de goederen opgeslagen?
5. Hoe worden de goederen terug gepakt?
6. Hoe wordt er voor gezorgd dat de kwaliteit van de producten niet in gevaar komt?
7. Hoe is de track and trace in het magazijn? (e.g. labels, systemen, etc?)

Transport

8. Hoe worden de goederen verscheept naar de klanten?
9. Hoe worden de goederen verpakt voor de verzending naar de klanten?
10. Indien goederen verscheept worden naar Brazilië, worden deze anders verpakt dan voor transport binnen Europa? (e.g. i.v.m eventuele zee containers?)
11. Hoe is de track and trace voor transport? (e.g. labels, systemen, etc?)

Sorteeracties

12. Hoe wordt Schenker gecontacteerd voor sorteer acties binnen het magazijn?
13. Hoe organiseert Schenker een sorteer actie? (e.g. met wie communiceert Schenker?)
14. Wat regelt Schenker voor een sorteer actie?
15. Welke problemen ondervindt Schenker bij het organiseren van een sorteer actie?
16. Wat mist Schenker voor het organiseren voor een sorteer actie? (e.g. contact persoon, informatie, etc?)
17. Wat gaat er goed bij een sorteer actie ?

Appendix L: Benchmark template (draft)

Global supply chain

For the benchmark company it is preferred to have a global supply chain, since it has to have the complex supply chain with associated problems (e.g. long lead times, culture, etc).

Warehouse

For the benchmark company it is preferred to have a warehouse, since NBF has a warehouse too. It is not obligatory, since the benchmark company could have an adequate solution without the use of a warehouse.

Quality

Because quality is very important for Scania, the benchmark company should also have high quality products.

Containment

How are containment activities organized at the benchmark company regarding to:

- *When:* When is a containment action organized, and who decides this?
- *How:* How can the customer organize a containment action?
- *Routine:* Is there a written routine for organizing a containment action?
- *Checking instructions:* Is there a systematic way of how checking instructions for parts are made? For is responsible for making the checking instructions?
- *Responsibility:* Who is responsible for the quality of the parts, who is responsible for setting up the containment action?
- *Contact person:* Who is the contact person for the customers as well as for the suppliers?
- *Who is going to perform the containment action:* Who is going to do the sorting activity? People from benchmark company, supplier, Randstad? Expertise or low skilled employees?
- *Delivery stop:* Who decides a delivery stop at the warehouse when there are parts with a possible technical deviation?
- *Tools:* Who is going to arrange the necessarily tools and space for the sorting activity?
- *Marking:* How to mark the pallets that are sorted?
- *Track and Trace:* How is the track and trace in the benchmark company?
- *Special organization:* Is there a special organization in the benchmark company for the containment action, or for this goods flow (e.g. like NBF organization at Scania).
- *Quality:* Is quality department located in the warehouse?
- *Expertise:* Expertise involved in containment action?
- *Costs:* Who is paying for all involved costs?

Appendix M: Information document North Bound Flow (NBF)

Information Document North Bound Flow (NBF)

North Bound Flow (NBF)

The North Bound Flow, hereafter referred to as NBF, is the goods flow from suppliers outside of Europe (e.g. Asia and Latin America) towards Europe, Figure 0-1 gives an indication. It is called NBF since the suppliers are mainly located in the south of the world (e.g. Asia and Latin America) and the customers are located in the north of the world (Europe). It can be said that the products are going upwards to the north, in other words, the North Bound Flow.

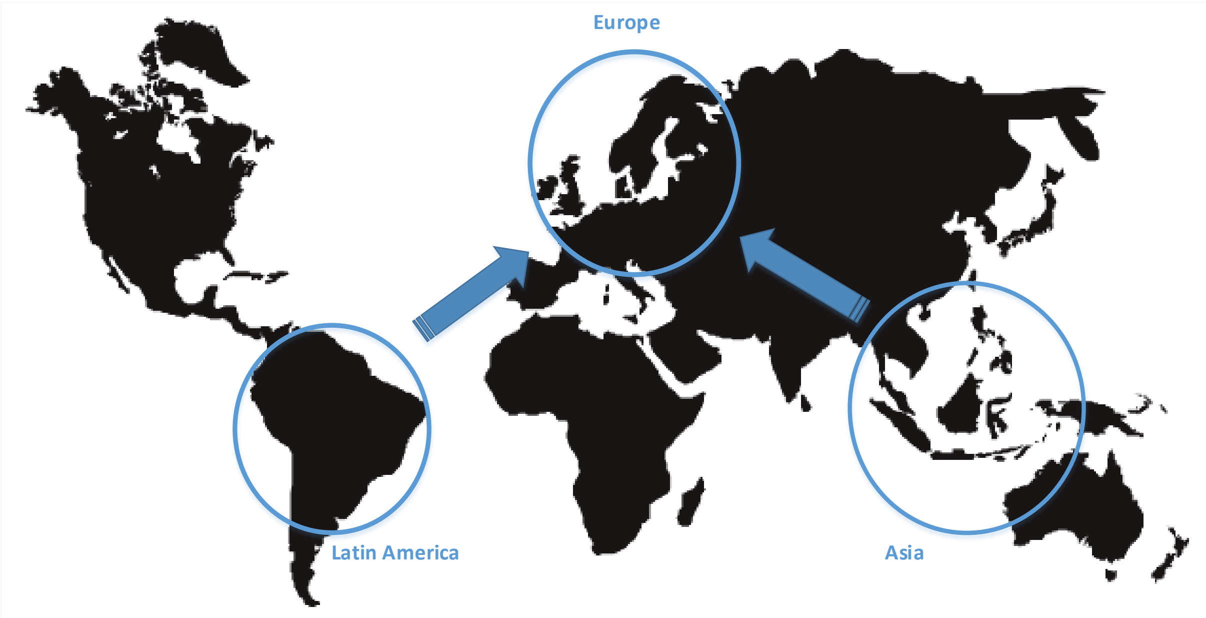


Figure 0-1: North Bound Flow

The NBF organization, which is located in Zwolle in the Netherlands, enables the customers of NBF to use suppliers outside of Europe. The NBF organization is responsible for receiving goods from suppliers, storing the goods, and ship the goods to its customers, in other words, they are responsible for the logistics. The business mission of NBF is to enable its customers to work with goods from suppliers that are located outside of Europe.

The scope of NBF starts from the moment that goods leave the supplier and the scope of NBF ends when the goods arrive at the final customer (e.g. Scania Production Unit), Figure 0-2 gives an indication.

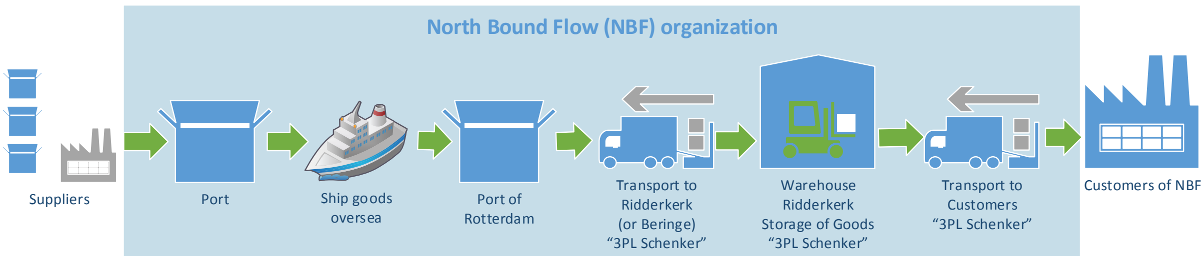


Figure 0-2: Scope NBF

Customers and Suppliers North Bound Flow (NBF)

The NBF organization has ten customers which are, except for Truck Chassis São Paulo, all located in Europe. Table 0-1 gives an overview of the customers of NBF.

Table 0-1: Customers of NBF

Continent	Country	City	Scania
South America	Brazil	São Paulo	Truck Chassis
Europe	Sweden	Södertälje	Truck Chassis
			Engine
			Transmission
		Oskarshamn	Cabs
	The Netherlands	Zwolle	Truck Chassis
			Knock Down (KD)
		Meppel	Production
	France	Angers	Truck Chassis
	Belgium	Opglabbeek	Part Logistics

Scania Part Logistics and KD are more special than the other customers of the NBF organization. Scania Part Logistics takes care of the global distribution of all Scania spare parts within their network of dealers and distributors. Scania Part Logistics support the global retail network by securing a high availability of Scania spare parts. The assortment covers truck and bus spare parts, but also vehicle related services. In addition to complete vehicles, Scania also produces KD products for several specific markets. KD trucks are disassembled into components, packed and sent to (simple) assemble plants elsewhere in the world, mainly in Russia, Asia and Africa. Hereafter, the components are locally assembled to a Scania truck. Good product quality of the components and completeness of these components packages are crucial in this type of production. The products from NBF for KD as well as for Part Logistics are at the start of a new supply chain.

North Bound Flow (NBF) has around 100 suppliers located across the globe, supplying around 400 different parts. The suppliers are mainly located in Asia and Latin America, the figure below shows the distribution structure.

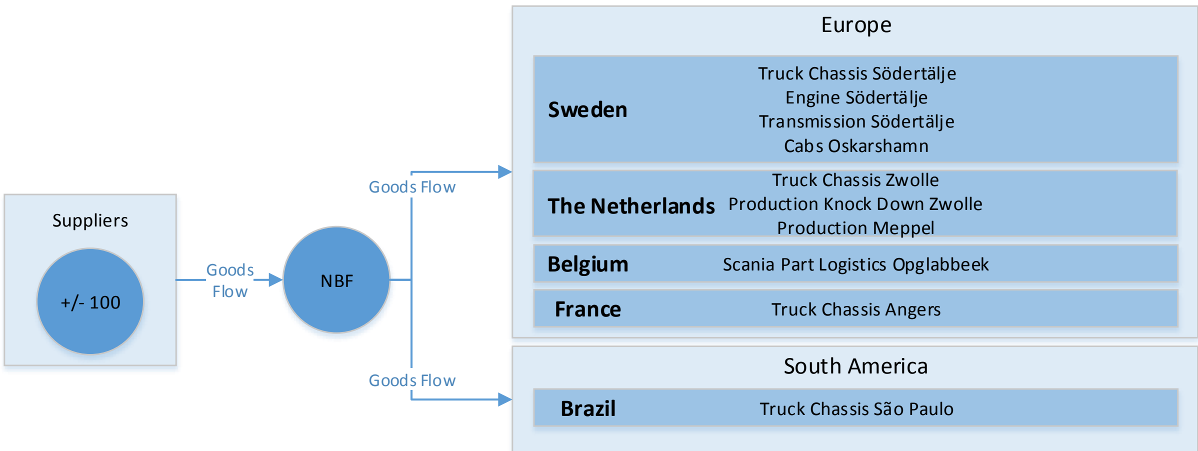


Figure 0-3: Suppliers and customers of NBF

Warehouse NBF

Goods are being shipped from the supplier to the warehouse across the ocean in large container ships. These long distances are at the basis of some challenges for the logistics system of Scania, in terms of: extensive lead times, forecasting demand, large batches, and the usage of safety stock. For price advantages, compensating extensive lead times, and the requirement of forecasting the demand, NBF uses a warehouse located in Hasselt in the Netherlands. The biggest advantage of having this warehouse is that customers can be supplied by suppliers oversea as fast as suppliers located within Europe.

The goods received from the suppliers can be packed in four ways, wrapped in carton, packed in a box of plastic blue, packed in a larger box of plastic green or the goods are packed in a green wooden box. In some cases, some goods have to be repacked into other boxes. Because the NBF organization has a safety stock policy of four to six weeks, there are more than one million parts in stock in Hasselt. The large batches received from the suppliers, are stored and distributed in smaller quantities to the customers of NBF. From the moment that the products arrive at the warehouse, the suppliers loses control over its products. In other words, the suppliers don’t have the knowledge which products are distributed to which particular customer. The NBF organization is responsible for collecting the part demand from Scania PRUs, Scania parts logistics and KD, make delivery plans on supplier level and finally send call offs and dispatch advice to the suppliers.

Appendix N: Cost summary

Scania Engines Södertälje uses a systematic cost calculation for supplier related deviations. The figure below shows an example.

Suplier	AUTOTECH INDUSTRIES		
EQ.nr	Q222710		
Cost calculation for supplier related deviations			
Type of cost	**Description**	**Sum SEK**	**Explanation**
Administrative	Administrative costs	2 000	The cost of the administrative handling of a deviation.
Direct	Rejected parts	165	The cost of the rejected parts.
	Sorting and rework	0	The cost for sorting and/or reworking.
Consequence	Delivery delay of Scania product due to supplier deviation	0	The cost of extra handling due to the disturbance of inter-factory flows.
	Not direct run	0	The cost of extra handling of engines in assembly, repair and logistics processes.
	Sequence change	0	The material for an assembly line is prepared according to the sequence in the production plan. Sequence changes involves extra handling for planning and logistics.
	Stop line, entire PRU	0	Costs for line stop. Whenever a stop occurs in an assembly line, the entire line is idle, which affects hundreds of people. The cost is calculated according to the extent of the specific line stop.
	Stop line, DE (D12 assembly line only)	11 270	
	Stop line, DE (V8 assembly line only)	0	
	Extra Freight	0	The invoice from third party if the deviation has caused the need of extra freight costs.
	Travel expenses (delivery stop)	0	In the case of a delivery stop, the deviation might lead to travel expenses for containment actions at internal or external customers.
Amount to be claimed		**13 435**	