MASTER

Inter-firm knowledge exchange in the after-sales service supply chain using supplier expertise within OEM organizations

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Inter-Firm Knowledge Exchange in the After-Sales Service Supply Chain: *Using supplier expertise within OEM organizations*

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Subject headings: Supply Chain Management, After-sales Service, Knowledge Exchange
“Knowing is not enough; we must apply. Willing is not enough; we must do”

*Johann Wolfgang Von Goethe (1749-1832)*

*German writer, scientist, philosopher and politician*
Abstract
In this master thesis project a single case study with embedded units is executed at Philips Healthcare. The goal of this study has been to create better insight in how inter-firm knowledge exchange in the after-sales service supply chain has to be organized. Especially, integrating the expertise of suppliers into the Original Equipment Manufacturer (OEM) organization was studied. A conceptual model has been developed during that can generate useful insights for OEMs to identify and analyze the processes related to knowledge exchange with suppliers in the after-sales period. Furthermore, it was elaborated on how OEMs should change their organization in order to successfully exchange knowledge with their supply base. Based on this, a specific proposal has been offered to Philips Healthcare on how to embed the study’s findings in its current organization.
Preface and Acknowledgements
This report is the result of my master thesis project, which is executed in fulfillment of the master Innovation Management (IM) at the Eindhoven University of Technology (TU/e). The master thesis project is executed in cooperation with Philips Healthcare, where I worked as an intern within the Service Purchasing team from December 2011 until August 2012. During this time I had the opportunity to develop my knowledge on purchasing, supplier management and after-sales and service management.

From Philips Healthcare I would like to thank my primary supervisor Eveline Hogenes for creating the opportunity to join Philips Healthcare to execute this project and for the discussions and help during the project. Furthermore, I would like to thank Bert Mollen for his inspiring input. Besides, I owe many thanks to all employees who participated in my research project. Especially the members of the Service Purchasing team who were available for input and feedback whenever needed.

From the TU/e, I would like to thank my primary supervisor Dr. Wendy van der Valk for her guidance and support during the project. I also would like to thank my second supervisor, Dr. Hans Berends, for his help and feedback on the different deliverables of this project. They provided me with useful new insights to tackle certain issues throughout the research. I wish both supervisors the best of luck in their new jobs at Tilburg University and VU University.

Finally, I am very grateful to my family and friends who supported me throughout my studies and during this master thesis project. Special thanks go to my parents and sister, who supported me in all possible ways during my life as a student.

Arjan Koemeester
August 2012
Management Summary

In recent years, a shift was identified toward after-sales service delivery by Original Equipment Manufacturers (OEMs). Customers increasingly expect high up-times of the systems delivered by OEMs. Moreover, with after-sales services OEMs can gain large financial benefits. Another reward of after-sales services for OEMs is the creation of competitive advantage. Services are less visible and more labor intensive and are therefore more difficult to copy by competitors (Oliva & Kallenberg, 2003; Cohen et al., 2006). The delivery of after-sales services is very complex because many different disciplines are involved that have to act comprehensively with each other to create customer value. OEMs should be able to deliver field service engineers, spare-parts and customer care activities, such as helpdesks, at any moment in time to reach a high level of customer value (Saccani et al., 2007). Therefore, knowledge exchange within after-sales service supply chains can be expected to be much more complex because of the different topics that are involved. Research of the Aberdeen Group (2006) has shown that cooperation with suppliers (through supply management and the purchasing function) is one of the best strategies to create better service performance. More specifically, it was stated that best-in-class companies systematically share knowledge over the supply chain to improve the after-sales service performance. The objective of this study is to create better insight in how inter-firm knowledge exchange in the after-sales service supply chain has to be organized. To reach this objective, the following research question is defined:

What should an OEM change in its organizational processes to proactively obtain information from its after-sales service suppliers and transform this information into useful knowledge for its internal and external stakeholders?

Research methodology

In order to answer the research question, a single case study with embedded units (Yin, 2003) was executed at Philips Healthcare (PH). PH is among the top three manufacturers of medical equipment worldwide and the company is struggling with the exchange of knowledge with its suppliers in the after-sales period. Based on orientation interviews, several topics were extracted for which knowledge exchange in the after-sales service supply chain is required. Since, in practice, knowledge exchange differs for each of these topics, a detailed study should have been executed for each topic individually. However, because of time limitations the case study was limited to two embedded units; these included the topics:

- Repair feedback;
- Disaster management.

These two topics were selected because of the current attention they receive within the organization (i.e. several people are involved on these topics). Besides, the two topics are dissimilar in their underlying processes and impact. Repair feedback is an example of knowledge exchange that can be organized in a structural manner and that is used for improvements in the reverse (repair) supply chain, having no direct impact on the end-customer of PH. Disaster management, on the other end, is only executed if a certain disaster has occurred and therefore much more ad-hoc organized. Moreover, insufficient disaster management may have a direct impact on the end-customer of PH, since a lack of spare-parts implies longer downtimes of the systems in the field. These dissimilarities make it possible to generalize the findings because a wider range of issues can be covered.

For the data collection in this case study, a combination of interviews and document analysis were used. Given the research topic, it made sense to look at the topic from both the buyer and the supplier
perspective. Therefore, interviews were held at both PH (buyer) and its suppliers who were involved in the studied cases. For the determination of the direction for redesign, a mid-term presentation was held with stakeholders of the project. These stakeholders include the project supervisors, members of the service purchasing team and additional people from PH.

Findings
Based on the data collected during the research, five improvement areas were identified that play a role in both repair feedback and disaster management. These main improvement areas can help PH to improve its overall performance on knowledge exchange with the supply base. They include:

- Ad-hoc organization of external communication;
- Company culture is too much focused on innovation instead of after-sales service;
- Low internal transparency;
- Unclear processes (both internal and external);
- Unclear utility of knowledge exchange within Philips Healthcare.

Improving these five areas seems to be essential for PH to create successful knowledge exchange with its supply base. However, because of time limitations in this study, a redesign could only be developed for a sub-set of these areas. Moreover, it was decided that the focus of the redesign will be on the creation of a change plan for repair feedback. It was shown that the current processes for this type topic do not seem to be successful. The main reason for this is that the goal of exchanging repair feedback is not clear for suppliers, because of the lack of a detailed identification within PH of where the repair feedback will be used for. Therefore, it was decided to focus on the improvement areas utility creation, improvement of internal transparency and improvement of external communication.

For this, a redesign has been developed that explicitly takes the requirements of the different stakeholders of PH. Moreover, it was advised to unite the different departments in a ‘repair feedback team’ instead of separate entities. Service purchasing is involved to combine the different requirements for knowledge exchange. However, the SAM is still responsible for the interaction with the supplier.

To test the applicability of the redesign, a workshop was organized in which people from different involved departments of PH (SPS, IS-OPS, Purchasing and different BU’s) as well as several suppliers, were invited to identify their capabilities of repair reporting. Together several steps were taken to determine the requirements for repair feedback from suppliers. Because of the cross functional set up of the workshop different views were found that others had not thought of yet. Interaction between the different functions is needed to clarify the requirements towards the supply base. It can be concluded that component and trend analysis should be considered as the main applications for repair feedback. However, different sessions like this are required to investigate in greater detail which functions have to be responsible for certain issues.

Recommendations
It was found at PH that it is difficult to exactly define the needs that have to be achieved with knowledge exchange. In order to better define the utility of knowledge exchange, several recommendations are given:

- Determine the exact applications for which repair feedback can deliver the most added-value.
- Execute component and trending analysis for repair feedback.
- Improve the focus on after-sales service within the organization.
Internal transparency is an important requirement for successful inter-firm knowledge exchange. To improve the internal transparency, several recommendations are given:

- Use cross-functional discussion sessions to find out the main problems and motives of other functional areas.
- Define exact roles and responsibilities for the knowledge exchange activities. Before asking suppliers to exchange information, it should be made clear who is responsible for what part of the exchange activities.
- When a disaster has occurred, the experiences of that disaster should be secured in a Business Continuity Plan.

In order to create valuable knowledge that can be compared for different suppliers, it is important that communication with the supply base is organized in a structured manner. To better structure the external communication, the following recommendations should be taken into account:

- Standardize the way in which purchasing managers communicate with suppliers on critical information.
- Create more discussion between suppliers and the focal firm to determine the requirements of knowledge exchange.
- Study the possibilities of standardized coding for repair activities.
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<th>Full Form</th>
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<tbody>
<tr>
<td>BCP</td>
<td>business continuity plan</td>
</tr>
<tr>
<td>BoM</td>
<td>Bill of Material</td>
</tr>
<tr>
<td>CCP</td>
<td>Customer Critical Part</td>
</tr>
<tr>
<td>Defoa</td>
<td>Defect On Arrival</td>
</tr>
<tr>
<td>DMR</td>
<td>Device Master Record</td>
</tr>
<tr>
<td>EMEA</td>
<td>Europe, Middle East and Africa</td>
</tr>
<tr>
<td>EoP</td>
<td>End of Production</td>
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<tr>
<td>GCS</td>
<td>Global Customer Service</td>
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<tr>
<td>FDA</td>
<td>Food and Drugs Administration</td>
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<tr>
<td>FMEA</td>
<td>Failure Mode &amp; Effect Analysis</td>
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<tr>
<td>FRU</td>
<td>Field Replaceable Unit</td>
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<tr>
<td>FSE</td>
<td>Field Service Engineer</td>
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<td>FSL</td>
<td>Forward Stocking Location</td>
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<tr>
<td>IS</td>
<td>Imaging Systems</td>
</tr>
<tr>
<td>IS-OPS</td>
<td>Imaging Systems Operations</td>
</tr>
<tr>
<td>iXR</td>
<td>Interventional X-ray</td>
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<tr>
<td>LDC</td>
<td>Local Distribution Center</td>
</tr>
<tr>
<td>MR</td>
<td>Magnetic Resonance</td>
</tr>
<tr>
<td>NFF</td>
<td>No Failure Found</td>
</tr>
<tr>
<td>NPI</td>
<td>New Product Introduction</td>
</tr>
<tr>
<td>PH</td>
<td>Philips Healthcare</td>
</tr>
<tr>
<td>PO</td>
<td>Purchase Order</td>
</tr>
<tr>
<td>PPA</td>
<td>Purchase Part Approval</td>
</tr>
<tr>
<td>RDC</td>
<td>Regional Distribution Center</td>
</tr>
<tr>
<td>RfQ</td>
<td>Request for Quotation</td>
</tr>
<tr>
<td>SAM</td>
<td>Supplier Account Manager</td>
</tr>
<tr>
<td>SCRA</td>
<td>Supplier Change Request Assessment</td>
</tr>
<tr>
<td>SPS</td>
<td>Service-parts Supply Chain</td>
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<tr>
<td>SQA</td>
<td>Supplier Quality Assurance</td>
</tr>
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1 Introduction

After-sales services include a set of activities to provide the customer with an increased value of its purchased product. Although firms have already been providing a form of customer service for a while, these services were not considered valuable to the company (Baines et al., 2009). This view has been changed radically in recent years as OEMs recognized that service delivery can bring several rewards. The largest advantages can be gained through financial rewards. Services show a higher profit margin compared to product offerings. Research has shown that firms earn 45% of its profit from after-sales service whereas it only counts for 24% of overall revenues (Cohen et al., 2006). Moreover, services are considered a more stable source of income then their related products, as services tend to be less sensitive for economic cycles (Baines et al., 2009). Another reward of after-sales services is the creation of competitive advantage. Services are less visible and more labor intensive and are therefore more difficult to copy by competitors (Oliva & Kallenberg, 2003; Cohen et al., 2006). The third reward can be found in the field of marketing because service offerings influence both first-time and repeat buying decisions, especially in B2B environments. Providing services positively influences overall customer satisfaction, trust, seller’s perceived reliability and the willingness of the buyer to adopt new products. Moreover, by providing services, a company can get a better understanding of the customer’s needs compared to its competitors. This knowledge can help to meet those needs by differentiating the product portfolio. Another reason why services can be used as a marketing instrument is because customers focus more and more on core competences and products are growing in their technological complexity. Customers therefore have the tendency to outsource their services to OEMs (Mathieu, 2001; Baines et al., 2009).

The shift towards after-sales service delivery as an integrated part of a product is already the case in many other markets for complex technical systems, such as wafer scanners, luggage handling systems, and large-scale computers. These systems require high availabilities as they are used in primary processes of the customers and downtimes are very expensive. This has impact on the required service level that has to be provided by the manufactures of these systems to keep the systems running. Research of the Aberdeen Group (2011) shows that ‘customer demand for faster service’ is the primary pressure for a company to increase its service level. An earlier study of the Aberdeen Group (2006) is showing best practices to achieve a higher service level. Among these best practices (as shown in Table 1) cooperation with suppliers (through supply management and the purchasing function) is one of the best strategies to create better service performance. More specifically, it was stated that best-in-class companies systematically share knowledge over the supply chain to improve the after-sales service performance. Suppliers can add value by giving visibility into the availability and quality of spares. This can help to make more informed make-or-buy decisions and reduce inventory levels (Aberdeen Group, 2006).

<table>
<thead>
<tr>
<th>Market Drivers</th>
<th>Best-in Class Strategies</th>
</tr>
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<tbody>
<tr>
<td>1. Customer satisfaction issues</td>
<td>1. Integrate service organization more closely with supply management functions</td>
</tr>
<tr>
<td>2. Corporate profitability mandates</td>
<td>2. Integrate service parts planning and execution more closely with field service optimization efforts</td>
</tr>
<tr>
<td>3. Escalating inventory carrying costs</td>
<td>3. Restructure service organization with higher-level oversight and accountability</td>
</tr>
<tr>
<td>4. Excess inventory / stock-outs</td>
<td>4. Purchase and/or upgrade technology solutions to automate portions of the process</td>
</tr>
<tr>
<td>5. Competition from other OEMs</td>
<td>5. Outsource service parts management to third-parties</td>
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The concept of knowledge exchange within supply chains has already been studied in literature (e.g. Moberg et al., 2002; Myers & Cheung, 2008).
These studies all confirm the importance of knowledge sharing between the different actors in the supply chain as shown in Figure 1. Knowledge exchange makes supply chains more efficient which results in lower cost and higher speeds. Moreover, more effective organizations are created due to higher quality of their delivery to the field (Myers & Cheung, 2008). Several dimensions are found that influence knowledge exchange in the supply chain. These can be separated into information, organizational and relationship related dimensions (Moberg et al., 2002). Although these dimensions may be applicable to after-sales service supply chains as well, the focus of the current studies on knowledge exchange within supply chains are all on traditional supply chains. Johnson & Mena (2008) identified that there are no frameworks available in literature for the management of after-sales service supply chains. However, the after-sales service supply chain is significantly different from traditional supply chains. That is, after-sales services include a set of activities to provide the customer with an increased value of its purchased product. The delivery of after-sales services is very complex because many different disciplines are involved that have to act comprehensively with each other to create customer value. OEMs should be able to deliver field service engineers, spare-parts and customer care activities, such as helpdesks, at any moment in time to reach a high level of customer value (Saccani et al., 2007). Therefore, knowledge exchange within after-sales service supply chains can be expected to be much more complex because of the different topics that are involved.

The objective of this study is to create better insight in how inter-firm knowledge exchange in the after-sales service supply chain has to be organized. To reach this objective, the following research question is defined:

What should an OEM change in its current supplier management processes to proactively obtain information from its after-sales service suppliers and transform this information into useful knowledge for its internal and external stakeholders?

Since clear definitions are the starting point for all research, it is important to define the exact concepts of ‘inter-firm knowledge exchange’, ‘after-sales service’ and ‘after-sales service supply chain’ in order to answer the above research question. The definition for inter-firm knowledge exchange used in this study is adapted from Graham et al. (2006):

“Inter-firm knowledge exchange is collaborative problem-solving between organizations that involves interaction and results in mutual learning through the process of planning, producing, disseminating, and applying existing or new methods in decision-making.”

This definition addresses the importance of not only transferring information, but actually use that information and apply it within the after-sales service supply chain. The following definition for after-sales, as adapted from Baines et al. (2009) will be used in this study.

“After sales-service is the offering of ‘bundles’ of customer focused combinations of goods, services, support, self-service and knowledge in order to add value to core product offerings”
This definition shows that after-sales service is a combination of goods and services. Finally, since the focus of this study is on the integration of the supply chain for after-sales services, the following definition for after-sales service supply chains, as adapted from Johnson & Mena (2008), will be used in this study:

“After-sales service supply chains include the flow of information, processes, capacity (people, equipment and facilities), products, services, and funds from the earliest supplier to the ultimate customer.”

Thus, it is indicated that different resources are involved in after-sales service. The different types of resources require interaction between the different parties within the after-sales service supply chain.

To investigate the presented research question, a case study is executed at Philips Healthcare. Philips Healthcare is an OEM of capital goods within the complete cycle of care. An important part of the business contains the production of Imaging Systems. This business group produces technologies that create images from all parts of the body, each with different accuracy. Philips Healthcare notices a shift towards after-sales service delivery as an integrated part of its product offering. This shift is influenced by the current state of the global healthcare market. One of the major factors that pull the healthcare industry towards a more customer-centric view is the increasing global population and higher life expectancy. Illustrative is the increasing number of people in emerging economies, who have access to healthcare. Moreover, these people increasingly demand higher quality. Another important factor is that, in mature economies, the costs related to healthcare are increasing towards unsustainable rates.

The contribution of this study will be twofold. First, a theoretical contribution will be made by showing the importance of inter-firm knowledge exchange in the after-sales service supply chain, as well as by the development of a conceptual model that to analyze buyer-supplier knowledge exchange in the after-sales service supply chain. Second, the deliverables for Philips Healthcare will be, in addition to the theoretical contributions, a proposal of how to embed the study findings in their current organization and an advice on how to go forward to create a more mature after-sales service organization.

The results of the study will be presented in a structured manner in the remainder of this document. In chapter 2, a literature review will be presented including a conceptual model. Chapter 3 presents the methodology used to test the findings from literature in practice. Chapter 4 shows an empirical exploration of the case study that was conducted at Philips Healthcare, followed by a detailed analysis in which the case study findings are tested against the conceptual model in chapter 5. Finally, chapter 6 will present the conclusions and recommendations of this study. Figure 2, displays the outline of the report.
2 Literature Review
This chapter provides insight in the findings of academic research on the knowledge exchange between original equipment manufacturers (OEMs) and their suppliers in the after-sales service supply chain for capital goods. Emphasis will be put on the identification and exploration of debates and gaps concerning this topic. In particular, attention is given to the interaction between buying and supplying firms by means of inter-firm knowledge exchange. From this, a conceptual model is derived that describes the factors influencing the knowledge exchange between buyers and suppliers. This chapter is structured as follows: Section 2.1 elaborates on the after-sales service supply chain. In section 2.2 the subjects related to knowledge exchange are defined. Then in section 2.3 the conceptual model will be presented. The chapter will be finished by a reflection in section 2.4.

2.1 The after-sales service supply chain
This section describes how the OEM has to organize its after-sales service supply chain in order to deliver high-quality service to its customers. Sub-section 2.1.1 seeks for an integrated definition of the after-sales service supply chain by combining the supply chains for goods and services. This is followed by an exploration of how after-sales service supply chains can be managed successfully in sub-section 2.1.2. The section concludes by investigating the role that suppliers of OEMs can play in the after-sales service supply chain in sub-section 2.1.3.

2.1.1 Combining services and goods
The concept of supply chain management was traditionally developed for manufacturing firms. That is, the designed models focus on the movement of goods from the supplier, through the manufacturing company to the customer. This indicates that manufacturing supply chains have in common their physical stream of products (Ellram et al., 2004). Compared with manufacturing supply chains, service supply chains are not focused on flows of physical products. Instead, physical products are rather seen as a resource to be able to carry out the service (e.g. test-tools and working equipment) (Baltacioglu et al., 2007). The activities in a service supply chain are much more focused on interaction with the end-customer since a key aspect of services is the continuous interactive process between buyer and supplier in the development, production and consumption phases (Van der Valk & Wynstra, 2010). The underlying goals of manufacturing and service supply chains are the same. Namely, to manage a stream of processes that take place between different firms in order to meet end-customer needs in a cost-effective way (Ellram et al., 2004). The focus of this research is on after-sales service, for which the supply chain structure is even more difficult. After-sales service is a special case because it combines delivery of products (e.g. spare-parts) and services (e.g. repair services, field maintenance). The production and delivery of such different items is practically impossible to be performed by a single firm. Instead, after-sales services require coordination of a large network of product and service providers.

2.1.2 Organizing the after-sales service supply chain
After-sales service supply chains are a combination of manufacturing and service supply chains, the available management frameworks for these types of supply chains could therefore be combined to create an after-sales service supply chain management framework. Figure 3 shows such a framework as proposed by Johnson & Mena (2008). It shows that the after-sales service supply chain management is an integrated process in which different actors employ activities. The OEM is in fact dependent on the other actors in the supply chain in terms of customer satisfaction, flexibility and productivity. Johnson & Mena (2008) found particularly the Information Flow Management to be important in supply chain
2.1.3 Role of suppliers in the after-sales service supply chain

OEMs that are trying to increase the involvement of suppliers in the after-sales service supply chain have to deal with the supplier quality paradox: suppliers that offer the best solutions may lose the most business since their repair activities are not required anymore. Moreover, a higher repair yield in the field reduces business for, for example, the logistics provider. It may become even more complicated when companies play multiple roles in the network (Lockett et al., 2011). For example, many suppliers of spare-parts are also providing repairs to these parts. This leaves them with a consideration between either sufficiently repair a broken part or sell a new product. Since, for most parts, it is difficult to predict failure, it is hard to forecast return flows. This requires high flexibility from the OEM, logistic providers and, for example, repair-suppliers. Mehdi Amini et al. (2005) have indicated that coordination between the multiple parties involved in the repair process is needed to assure effective reverse supply chain activities. However, many companies seem to have difficulties with this coordination. Required information is either not available or in the form of fragmented data points spread over several places in the organization or even spread over the different supply chain members. Information about what is repaired should therefore be communicated when the repaired products are returned back to the OEM.

2.2 Inter-firm knowledge exchange

In the previous section it was shown that the after-sales service supply chain is a very complex process in which many actors are involved. To coordinate such complex processes knowledge should be exchanged between the different actors in the supply chain. This section describes the concepts of inter-firm knowledge exchange. There has been a long theoretical debate about the differences between data, information and knowledge exchange. In sub-section 2.2.1 this discussion will be reviewed and shaped toward the inter-firm context of this study. In sub-section 2.2.2 a detailed description of the
activities that are involved in knowledge exchange is given. This is followed by an investigation on how the exchanged knowledge has to be applied in an organization in sub-section 2.2.3. From there, in sub-section 2.2.4, a conceptual model will be presented for the exchange of knowledge between organizations. This conceptual model describes the relationship between the different concepts of inter-firm knowledge exchange as well as the factors that influence the exchange of knowledge between organizations.

2.2.1 Defining concepts
Aamodt & Nygard (1995) have stated that there is no known way to identify data, information and knowledge as separate entities. Aamodt & Nygard (1995) have suggested a model to separate the concepts theoretically. This model is summarized and represented in Figure 4. It is notable in Figure 4 that the different concepts do not stand on their own, but are interacting with each other. Data is often identified as all the characters and signals that have, in itself, no meaning. By combining different data points, it can be transformed into information. For this transformation however, knowledge is required since the data has to be structured. Besides creation of information from data, information can also be combined to create new information. Information is therefore defined as interpreted symbols and symbol structures. Through learning, new information can be integrated into the existing body of knowledge. The knowledge of a firm grows through the integration of the acquired information as well as the interaction with its environment. Knowledge should therefore be identified as the body of integrated information that is potentially useful for decision making (Aamodt & Nygard, 1995).

Data, information and knowledge can all be transferred. The content being transferred for each of these concepts is very different in nature. However, since the content can be considered new to the buying firm (OEM) it will be indicated as ‘information’ in the remainder of this study. The term transfer is used to describe the process of obtaining information from the donor by the recipient firm. However, this would imply that the knowledge exchange is a one-way process that will end once the information has been transferred to the recipient firm without any extension towards creation of useful knowledge (Graham et al., 2006). In order to indicate a somewhat broader perspective, the knowledge exchange process is adopted. Knowledge exchange can be seen as the process of information transfer and knowledge creation. In order to be effective, interaction is required between buyer and supplier to create mutual learning (Graham et al., 2006). The process of knowledge exchange will be described in more detail in the next sub-section.

2.2.2 Exchange activities
The actual activities required for the exchange of knowledge can be seen as a three step process. This process is adopted from the work of Graham et al. (2006) and somewhat adapted to fit in the context of this study. The first activity in the exchange process is the actual transfer of information from the supplier to the buyer. Obtaining information can occur in many different ways. The right medium to use depends to a large extent on the information that is exchanged. Some information types require
personal contact. For other information types, more codified communication channels have to be used. In Table 2 an overview is given of the different communication methods that can be used in different situations.

<table>
<thead>
<tr>
<th>Table 2: Overview of communication channels</th>
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<tr>
<td><strong>Direct contact/personal communication</strong></td>
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<tr>
<td>Cross-functional teams</td>
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<tr>
<td>Discussion by telephone</td>
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<tr>
<td>E-mail</td>
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<tr>
<td>Face-to-face meetings</td>
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<tr>
<td>Personnel movement</td>
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<tr>
<td>Site visits</td>
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<tr>
<td>Training/education</td>
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<td>Drawings</td>
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<td>IT-systems</td>
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<tr>
<td>Reports</td>
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<tr>
<td><strong>Codified communication</strong></td>
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<tr>
<td>Drawings</td>
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<tr>
<td>IT-systems</td>
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<td>Reports</td>
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The second activity identified is the synthesis of the available information and knowledge. This involves what is often defined as knowledge creation. The real added value of knowledge exchange lies in the useful knowledge that is created from it. Berdrow & Lane (2003) have suggested that the creation of knowledge should be a result of the joint activities of buyer and supplier. That is, a process has to be created in which it is clear who is responsible for the synthesis of information. This may be the supplier, the buyer or a collaborative team with members of both organizations. This view is also identified by Oluić-Vuković (2001) who proposed two steps that describe the knowledge creation process. First the transferred information should be organized by cataloging, indexing, filtering, clustering and other techniques to reduce comprehensive amounts of information into an orderly number of categories, to identify relevant concepts and to find structures and patterns in the information. The second step is then to refine the knowledge by running extensive analyses that makes the knowledge more usable.

The third activity of knowledge exchange is to transform the knowledge in the form of (design) rules that can be used to map the knowledge and make it possible to apply in the supply chain. It has to be made sure that knowledge is presented in a clear, concise and user-friendly format (Graham et al., 2006). Figure 5 gives a good summary of the creation of knowledge through inter-firm collaboration. As shown on the horizontal axis, knowledge is often present at an individual level. Through different iterations of the exchange activities, this knowledge can be transferred through the organization and ultimately cross-organizational boundaries (Nonaka, 1994). After the knowledge exchange activities have taken place, the buying firm has to do something valuable with the created knowledge. This is identified as ‘application’ and will be discussed in the next sub-section.
2.2.3 Knowledge application
The concept of knowledge application can be seen as the ability of an organization to utilize the knowledge generated during the exchange activities. According to Song et al. (2005) successful knowledge application is determined by several factors:

- Individuals require knowledge from different sources to make suitable decisions;
- A long-term orientation is required for appropriate and correct decision making;
- To ensure the supply of knowledge from different sources sufficient budget should be available;
- Formal reward systems should be in place for individuals who successfully apply knowledge
- IT-systems increase the timely availability of accurate and comprehensive information.

According to Graham et al. (2006), three types of knowledge use can be distinguished. First, there is the conceptual use of knowledge which describes changes in the understanding of individuals (i.e. learning). The second is instrumental use, which describes changes in the practical behavior of individuals. Third, there is strategic use, which describes attaining of a power positions by manipulating the knowledge. If more knowledge is required to use it properly, a feedback loop has to be created that allows for re-starting knowledge exchange activities. It should be made clear that the input of (external) knowledge is not only limited to the first phase of knowledge application. When knowledge can be used in different phases of knowledge application, it will create a more effective diffusion of knowledge (Graham et al., 2006).

2.3 Conceptual model
Based on the discussion in the previous sub-sections, the question rises whether it is possible to create a conceptual model that describes the inter-firm knowledge exchange process between buyers and suppliers within an after-sales service supply chain context. Several studies on inter-firm knowledge exchange had to be compared to find the similarities and differences between them. The findings of this analysis are represented in data-extraction form (Tranfield et al., 2003) and shown in Appendix 1. The underlying factors were captured within a single conceptual model as displayed in Figure 6. This model helps organizations to create a process of knowledge exchange that uses different types of information. In sub-section 2.3.1, the drivers underlying the characteristics indicated in the conceptual model will be identified and discussed in more detail. Sub-section 2.3.2 will investigate how the after-sales service context may influence these characteristics. This will give more clarity to how this conceptual model can help a firm to get inter-firm knowledge exchange in the after-sales service supply chain organized.

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Figure 6: Conceptual model - Buyer-Supplier Knowledge Exchange (Based on: Moberg et al., 2002; Fawcett et al., 2007; Modi & Mabert, 2007; Easterby-Smith et al., 2008)
2.3.1 Drivers behind knowledge exchange characteristics

For each of the identified characteristics of the knowledge exchange activities, the underlying drivers will be explained.

**Information characteristics**

The quality of the exchanged content can be identified by several drivers as displayed in Figure 7. Accurate content is created by exact measurements of activities. Therefore, more accurate information leads to better information (Moberg et al., 2002; Simatupang et al., 2002). Ambiguity occurs when the transferred content can be interpreted in different ways. Ambiguous information decreases the quality of the exchanged content since it is hard to understand what exactly is meant by the transferred content (Easterby-Smith et al., 2008). The relevancy is identified as the degree to which the exchanged content fulfills the expectations of the recipient. (Simatupang et al., 2002). Besides good agreements between the donor and recipient firms, the relevancy is also influenced by both the volume and format of the exchange. Nonaka (1994) states that only the exchange of relevant information allows the recipient firm to directly process that content. Tacitness is the degree to which information is in the heads of people and only transferable through personal contact or available as explicit data sheets and reports which can be transferred through IT-systems. Tacit content negatively influences the quality of information transfer since tacit information is hard to exchange. Timeliness refers to the timely availability of the transferred information. Timely availability has a positive effect on the information exchange because information is only valuable the moment that it is needed.

**Inter-firm relationships characteristics**

The status of a relationship can be influenced by several drivers, as shown in Figure 8. Competitive pressure occurs between the supply chain of the focal firms and the supply chain of other firms. High competitive pressure leads to implementation of more joint activities which positively influences the inter-firm relationship. (Modi & Mabert, 2007). Balanced power relations indicate that both the buyer and supplier are able to influence the relationship. There are often asymmetric power relationships, which is influenced by factors like the design holder of the exchanged product, and future business incentives for the supplier (Dyer & Singh, 1998). Asymmetry indicates that one party is depends on the willingness of the other. Therefore, balanced power relations are beneficial in relationships. Relationship intensity refers to the amount of interaction between buyer and supplier. It is positively influenced by the length of a relationship (Dyer & Singh, 1998). However, it depends on the goal of the inter-firm relationship whether a strong relationship is beneficial Terpend et al. (2008). Therefore, the effect of relationship intensity on inter-firm relationships cannot be generalized. This is indicated in Figure 8 by the (*) sign. Trust creates the security that the transferred information will not be used in other ways as agreed upon (Easterby-Smith et al., 2008). Therefore, trust positively influences a relationship. Early supplier involvement refers to the moment from which a supplier is contributing to a supply chain. Suppliers might produce for customers on a continuum between tailor made design and of-the-shelf products (Van Weele, 2005). The strength of the relationship follows the same pattern. When a supplier is responsible for the design of a product, the relationship will be stronger because collaboration is required in design and production. When there is only a relationship in
manufacturing or even only for off-the-shelf products, the relationship will be more arm-length of nature. This means that a larger involvement of the supplier in the design of the product, the better the inter-firm relationship.

**Buyer and supplier characteristics**

Five items were found that influence both buyer and supplier in the knowledge exchange process. These are displayed in Figure 9. Top-management involvement creates alignment between two firms on the strategies and objectives of the exchange activities (Inkpen, 1996). Increased top-management involvement on knowledge exchange may result in the allocation of more resources and thus increased exchange activities. Absorptive capacity is the degree in which a firm is able to recognize the value of certain knowledge and is able to communicate and use it. The higher this capacity is, the more knowledge can be exchanged (Easterby-Smith et al., 2008). IT-commitment could be seen as the willingness to simplify information transfer not to automate the knowledge exchange. After the transfer, still people are needed to give meaning to the information (Fawcett et al., 2007). IT-commitment can be considered to have a positive influence on both the buyer and supplier because it can create fast and accurate reports. The size of an organization or organizational-unit positively relates to the exchange of knowledge. That is, large organizations tend to have more resources available for the exchange process. Besides, larger organizations are more likely to have a diverse pool of information sources available. The degree of willingness of a company to share knowledge can also be described as the motivation to teach (Easterby-Smith et al., 2008). Besides the culture of the company, the motivation to teach is different for donor and recipient firms. For the donor, the motivation to teach is influenced by the degree of perceived risk that teaching the buying firm will result in the loss of competitive advantage. For the buying firm, the risk of receiving information that is not useful or of a low quality is present. The type of industry in which a firm is operating also has implications for its willingness to share. In highly competitive industries, this might be more difficult than in industries where mutual cooperation is common sense (Collins & Smith, 2006).

Besides the characteristics that are similar between donor (supplier) and recipient (buyer), it was found that the recipient firm also requires a central position in the supply network to be successful in knowledge exchange (see Figure 9). A central network position determines the ability of the buyer to gain a diversified set of information. That is, more network centrality improves the probability to acquire information from different actors (Dyer & Singh, 1998).

2.3.2 **Integrating after-sales service supply chains and inter-firm knowledge exchange**

The discussion on supply chains in section 1 indicates that the characteristics described in sub-section 2.3.3 might be influenced by the after-sales service context. That is, when the supply chain shifts from a pure product or service orientation towards an integrated product and service orientation (i.e. the after-sales service supply chain), the behavior of organizations will change on several aspects. These changes in behavior will happen both in the buyer- as well as in the supplier organization and influence the inter-firm relationship characteristics. Figure 10 shows the six variables. Each of the after-sales variables shown in this figure moderate on either the relation between supplier characteristics and inter-firm relationship characteristics (A), the relation between buyer characteristics and inter-firm relationship characteristics (B).
characteristics (B), or on both relations. The effect that each of these variables has on the after-sales period, and how these variables moderate the conceptual model will be discussed below.

The variety of resources that is present in after-sales service is specific for the after-sales service supply chain because of the different streams of resources that flow through that type of supply chains. That is, actors in the after-sales service supply chain have to be able to keep products functioning by ensuring availability of spare-parts, service engineers, repair procedures, etc. to the field (Johnson & Mena, 2008). Moreover, the reverse logistics operations, that ensure product recovery of all used products and components, have to be organized. All these activities require a continuous flow of information, from different sources. These different information types make it difficult to develop a standard process and therefore require from the buyer to get it on the desired level. Therefore, the variety of resources moderates relation B.

The divergence of the supplier objectives from the objectives of the buyer negatively influences the relationship between them. This is especially relevant in the after-sales period because the supplier has to deal with low volumes of products (and thus low order quantities). At the same time, after-sales service has large advantages for the OEM (buyer), both in financial terms as in terms of customer satisfaction (Cohen et al., 2006). Therefore, the divergence of goals moderates on both relation A and B.

The amount of turnover that is spent by the buyer decreases in the after-sales period (Modi & Mabert, 2007). When a certain part of a supplier is used in the production of new OEM systems, the flow of products from that supplier to the OEM is rather extensive. However, at a certain moment, the production of the OEM system will be phased-out and the supplier only has to deliver spare-parts and repair services. This will negatively affect relationship between the buyer and supplier because the buying firm will not be seen to be of strategic importance to the supplier, and therefore not interesting to invest time and resources in. Therefore, the amount of turnover spent by the buyer mainly moderates relation A.

The incentive for future business that is obtained by the supplier from the buying firm impacts the after-sales period because the perspective on new orders for a longer period of time makes it valuable for a supplier to invest in the activities of older products. The impact depends both on how long the current system will remain in production and whether the supplier will be picked to deliver parts for new product introductions of the OEM. Therefore, the incentives for future business moderate relation A.

The possibility that the supplier of the OEM is able to directly deliver spare-parts to the end-customer of the OEM will influence their relationship negatively. When standard (of-the-shelf) parts of the supplier are used in the systems of the OEM, its end-customer might be able to directly contact the supplier of these products and thus cutting out the intermediary role of the OEM. This results in a lower power position of the OEM, decreased level of inter-firm trust as well as a lower turnover of the OEM after-sales service organization. Thus, both the supplier (by going directly to the end-customer) and buyer (by a decreased level of power) change their behavior when there is a direct link between the supplier and the end-customer. Therefore, this variable influences both relation A and B.
Obsolescence of spare-parts typically occurs because of the gap in the product lifecycle duration of the supplier’s products and the lifecycle of the buyer’s systems, leading to difficulties in the availability of purchased products. In order to manage this properly, the supplier should regularly update the buyer on changes in its product portfolio. If this is not done so, the buyer might face problems in its spare-part availability, which will influence the relationship. Therefore, the obsolescence of spare-parts mainly moderates relation B.

2.4 Reflection
This chapter has presented a conceptual model that can be used for analysis of inter-firm knowledge exchange in the after-sales service supply chain. The framework describes how characteristics of buyers and suppliers, the characteristics of their relationship and the characteristics of the information that is exchanged influences the knowledge exchange activities. Moreover, it is stated that the application of knowledge, after the exchange of it, has to be integrated in the analysis. Six specific variables were defined that indicate the differences between knowledge exchange in production supply chains and after-sales service supply chains. These variables include the variety of resources, the (lack of) mutuality of goals, the amount of turnover spent by the buyer, the incentives for future business, the link between the supplier and the end-customer, and obsolescence of spare-parts.
3 Methodology

The focus of this research was to design a solution for a business problem by integrating scientific insights into a practical environment. Based on the theoretical framework, as presented in chapter 2, the setup of the empirical research was designed according to the reflective cycle (Van Aken et al., 2007). The aim of the reflective cycle is to learn from a specific project for similar future projects. This cycle, as shown in Figure 11, consists of several steps. The cycle starts at ‘choice of type of problem’ in which the research problem is identified. Section 3.1 elaborates on the type of problem that was studied in this research. Then, in ‘choice of case’ a case company was found where the problem defined in the first step is detected. For this research the selected case company was Philips Healthcare. Details on Philips Healthcare will be presented in section 3.2. The right side of Figure 11 shows the regulative cycle (Van Strien, 1997) as part of the reflective cycle. During the ‘problem definition’, which is discussed in section 3.3, a clear statement of the problem was found, based on the ‘problem mess’ that was presented at the company. In section 3.4 of this chapter the detailed design of the empirical research is discussed, taking into account the next steps of the regulative cycle; ‘analysis and diagnosis’, ‘plan of action’, ‘intervention’, and ‘evaluation’. After the regulative cycle has been successfully completed, the solution of the single project has to be generalized to make it suitable in a broader perspective. This is typically seen as the learning phase of the project and will be executed during the last two steps of the reflective cycle, in which a reflection takes place and technological rules (scientific output) are to be developed. These two steps were not executed within the scope of this master thesis project, because they need lots of time, effort and management support. Finally, section 3.5 will give a reflection on this chapter.

![Figure 11: The reflective cycle (Van Aken et al., 2007)](www.healthcare.philips.com)

3.1 Problem context

As stated in the introduction, the topic that was researched in this study focused on better cooperation between OEMs and their supply base in order to provide after-sales service to the end-customer. Since this was researched in a specific context, the healthcare industry, first some insight is given in the trends in this industry. In healthcare after-sales service has become of increasing importance recently, because the industry faces some major changes, both in developed and developing economies. These changes are discussed in sub-section 3.1.1. Then, the implications that these changes have for medical equipment suppliers are shown in sub-section 3.1.2.

3.1.1 The healthcare industry

The healthcare industry is facing some major trends in the global market place. Global population is increasing and continues to age. Illustrative is the increasing number of people in emerging economies, who have access to healthcare and are more and more demanding higher quality. At the same time, healthcare costs in mature economies are increasing towards unsustainable rates. As shown in Figure

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1 www.healthcare.philips.com
healthcare costs are an increasing element of the GDP of developed countries. The U.S. healthcare expenditures outweigh those of other countries by far. Porter & Teisberg (2006) argue that the major cause of these growing healthcare expenditures is the wrong type of competition within the industry. In the traditionally organized healthcare market, competition is different to that of other industries on several aspects. First, healthcare providers are mainly geographically organized and patients are automatically referred to the nearest hospital. This leads to large, diversified healthcare providers in which each medical specialism is operating in isolation. Second, performance of the different providers is not publicly available which makes it impossible for patients to compare and make a well-considered choice. Third, healthcare prices are often fixed by health insurers. This does not give any incentive to the care provider to reduce costs (Porter & Teisberg, 2006).

Due to economical and political uncertainty and regulatory changes in the recent years, the current market already shows a shift towards healthcare at sustainable rates. A study of the PwC Health Research Institute (2011) shows for example that insurers in the U.S. try to improve quality and competition by lowering the standard payments to healthcare providers. Instead, healthcare providers have the opportunity to ‘earn’ a bonus when meeting some performance metrics. These performance metrics are made publicly available giving patients the chance to choose their desired provider. Trends like these are not unique for the U.S. Healthcare market. The European market is facing similar changes.

3.1.2 Implications for healthcare suppliers

The above mentioned healthcare trends have some implications for healthcare providers and their suppliers, such as Philips Healthcare. First, although increased healthcare access in emerging economies implies larger healthcare markets, the technology demand from healthcare providers (and their patients) in these markets is typically lower than in mature economies. Instead, these countries ask for robust products with a lower level of technology to receive the best care for low cost. Suppliers respond to this by offering new medical devices in a value segment. Second, in mature economies, healthcare providers have to base their processes more and more on customer service and quality improvement. This requires higher uptimes of their system and higher and reliable throughput time (TPT) of the processes executed by using these medical devices. To achieve this, medical equipment suppliers play a key role. They can influence two factors: design and after sales service. Designing simpler patient access or modular tables that are compatible with different types of medical devices can for example increase the TPT of the medical equipment significantly (Porter & Teisberg, 2006). Failure of medical equipment and thus (longer) waiting times for patients has a direct (negative) influence on the performance of a
healthcare provider. When equipment is down, it has to be fixed as fast as possible. Therefore, after-sales service of the equipment supplier becomes extremely important to the healthcare provider.

### 3.2 Case company selection

Since Philips Healthcare is a supplier of medical equipment, and thus faces the problems described in the previous section, Philips Healthcare is considered to be a good case company in which this research can be executed. In this section, a description of the Philips Healthcare organization will be given. In subsection 3.2.1, the position of Philips Healthcare will be described including its position in the Philips Group. Then in subsection 3.2.2 an analysis of the exact context and affected stakeholders in the problem is given.

#### 3.2.1 Philips Healthcare

Philips Healthcare (PH) is one of the three business sectors of Royal Philips Electronics NV (Philips) that has been founded in 1891 as Philips & Co. by Anton and Gerard Philips in Eindhoven, the Netherlands. The first business of Philips was the production of light bulbs in which Philips grew out to be one of the world’s largest producers by 1900. In the first half of the 20th century the company became active in many fields. In 1918, Philips set up its first activities in the medical field by introducing a medical X-ray tube. After years of expansion and product differentiation, Philips changed its organization in the last three decades from an integrated product manufacturer towards a more research and development driven company. Much of its non-core activities are outsourced leaving only the value adding activities in-house.

At the end of 2011, Philips was active in 100 countries and had production activities at 124 sites in 26 countries. Their total workforce exceeds 121,000 employees and total revenue was €22.57 billion. The company is organized in three operating sectors which are represented in Figure 13. Consumer Lifestyle focuses on products that are used in daily life situations, such as household products and sound/vision equipment. Lighting provides lighting solutions for professional as well as consumer markets. Finally, healthcare offers solutions to meet the healthcare needs in hospitals as well as at home.

As shown in Figure 14, PH is active in all areas of the medical spectrum. Within Philips, the healthcare industry is seen as one of the most pressing global issue of this time. Therefore PH made major investments in the last decades to become a major player in the field. Now, together with Siemens and General Electric, Philips is one of the top three manufacturers of medical equipment worldwide.

With an EBITA of €1.14 billion over 2011 PH is the most profitable division of the Philips Group. PH currently employs approximately 38,000 employees. As shown in Figure 14, the United States is the largest market representing 45% of turnover. About 22% of sales are generated in emerging economies. The healthcare equipment industry is a regulated industry. Therefore, PH has to deal with compliancy issues monitored by the Food and Drugs Administration (FDA) in the US (and similar organizations in other countries).

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2 [www.philips.com](http://www.philips.com)
3 Annual report Royal Philips Electronics N.V. 2011
4 [www.healthcare.philips.com](http://www.healthcare.philips.com)
3.2.2 Case study stakeholders

PH is organized as a matrix organization. There are business groups which are supported by functional groups. These functional groups include Legal, IT, Marketing, Finance and Purchasing. Figure 14 shows the different business groups displaying their size according to the percentage of sales. This study is executed within a combination of the business groups Customer Services (GCS) and Imaging Systems (IS). IS produces different types of medical equipment that can create images from all parts of the body, each with different accuracy. Products are aligned in different Business Units (BU), including interventional X-ray (iXR), diagnostic X-ray (DXR), computed tomography (CT), magnetic resonance (MR), nuclear medicine (NM) and ultrasound imaging equipment (US). In the After-sales service organization of IS four functional areas are involved. Each of these functional areas will be discussed below to identify their roles and responsibilities. In Appendix 2 the organizational charts are shown.

Business unit

In a BU, all activities related to that specific product are executed. Such activities include R&D, regulatory affairs and lifecycle management. The BU has several responsibilities during the lifecycle of a product. These include the development and introduction of new products in the New Product Introduction (NPI) phase, production and delivery of the products to the end-users, and changes to the product designs if regular failures are detected or product improvements can be realized. The BU is also responsible for the service execution. The most important aspect of this is the determination of Field Replaceable Units (FRU). A medical system in the field includes predetermined FRUs, which is a combination of different components that can be replaced completely when broken down. The BU decides which components are combined in a FRU. Moreover, they decide whether a FRU is classified as repairable or consumable. This is done based on the (both financial and technical) features of the FRU itself and the costs involved in transportation and logistics. Based on these decisions, the other departments that are involved in the after-sales service organization have to organize their processes.

Service-parts supply chain

The Service-part Supply Chain organization (SPS) is responsible for logistics activities for service-parts & repair. This includes both the forward as well as reverse logistics. SPS is accountable for planning, ordering, warehousing and transport. Key focus of SPS lies on the availability of Customer Critical Parts

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5 Annual report Royal Philips Electronics N.V. 2011
(CCP). These parts are a subset of the system critical parts determined by the BU. CCPs are important because of several factors, such as their high failure rates and high costs. SPS has partnerships with three external service providers who carry out the main operational activities. Accenture is responsible for transactional issues, such as the creation of purchase orders (PO). UPS is responsible for worldwide transportation (forward and reverse) and warehousing in the forward stream of service-parts. Finally, Sanmina-SCI is responsible for defect warehousing and handling of repairs in the reverse stream of service-parts.

Imaging systems operations
Imaging systems operations (IS-OPS) is the production facility for the business group Imaging Systems and as such responsible for the production of the medical devices. Production mainly involves assembly activities as over 90% of the parts used in the OEM systems are purchased from external suppliers. Like SPS, IS-OPS is responsible for the planning and ordering of their materials. Besides the production of new systems, IS-OPS is also related to the after-sales service organization. Besides a small amount of service-parts that is directly sourced from suppliers and delivered to the warehouses of SPS, about 80% of all service-parts are delivered through IS-OPS. Within IS-OPS, value can be added to the service-parts. This happens in several ways. Service-parts are tested to secure their safety, different parts are assembled into one FRU or parts which are delivered in bulk by the supplier, are repacked as a single service item. When SPS needs a certain part, they place a PO at IS-OPS as if it is an external supplier to them. IS-OPS also has repair facilities in which failing parts from the field are repaired. Moreover, in this repair facility IS-OPS executes autopsy to do second opinions on repair activities of suppliers.

Purchasing
The IS purchasing department is organized around different commodity clusters. Some of these commodity clusters are dedicated to IS related parts; others are organized as a network of the different business groups within PH. In each commodity cluster, a Supplier Account Manager (SAM) is responsible for the relationships with individual suppliers. During the NPI phase, suppliers for the new product are selected. The selected suppliers are put on an approved supplier list. Suppliers have to meet certain strict criteria because of all the rules and regulations that are involved with the healthcare business. To assure that suppliers stay on the required quality level, they are assessed by Supplier Quality Assurance (SQA). SQA give each part of a supplier a risk qualification depending on the potential dangerous effects on patients, medical professionals and engineers working with the part. Both IS-OPS and SPS have their own operational buyers who actually place the orders at the supplier. Operational buyers can only purchase from suppliers on the approved supplier list, which is created by the purchasing department. For issues related to the after-sales period, such as repair or spare-part availability for SPS, dedicated service purchasers are responsible. These service purchasers operate in a department that is embedded within SPS; however they have a dotted line to purchasing as well (see Appendix 2). The service purchasing team has the goal to enable availability of spare-parts during the after-sales period while minimizing Total Cost of Ownership (TCO).

3.3 Problem definition
The goal of this research was twofold. In addition to giving insights in the process of inter-firm knowledge exchange in the after-sales service supply chain, the second goal was to identify improvement opportunities for Philips Healthcare. This section covers a detailed description of the problem that was experienced within the boundaries of PH. Sub-section 3.3.1 shows an analysis of the problem, which finally results in a problem statement. Then, in sub-section 3.3.2 the research question as stated in the introduction will be adapted for the case of Philips Healthcare.
3.3.1 Problem analysis
Initially, a set of orientation interviews were conducted to identify the problems within PH on knowledge exchange with its supply base for service-parts and repair. The main finding of these interviews was that the existing knowledge exchange processes with suppliers in the after-sales period are not organized in a proper way. That is, it is not only the transfer of supplier information to the right person within PH that is important, but it is also important for PH to determine who will do the analysis of supplier information and who creates valuable knowledge out of it. Besides, it was found there are many different topics on which knowledge could be exchanged. Based on these findings, the question rose what information from the suppliers actually is requested by stakeholders within PH. Therefore, another round of interviews was conducted. As an input for this second round of interviews, an Ishikawa diagram was prepared and used during the conversations to stimulate discussion. In total, 14 people were interviewed who were related to the Plus Model for the business units iXR and MR. A detailed summary of these interviews is shown in Appendix 3. The final Ishikawa diagram (see Appendix 4), that was an output of these interviews, showed how the quality of the after-sales service supply chain is influenced. Based on this Ishikawa diagram several topics were extracted for which knowledge exchange in the after-sales service supply chain is required. These topics include the lead times for spare-parts, defects on arrival, repair feedback, serviceability of spare-parts, technology roadmaps and business continuity after a disaster occurs. They are explained below.

Lead-times for repairs are set to be 35 days on average, whilst the actual lead-times are 120 days on average. When this could be reduced in cooperation with suppliers, a lot of stock can be reduced in the SPS warehouses. Defect on Arrival (Defoa) is the percentage of spare-parts that arrives at the customer site but fail. This may have logistical (such as bad packaging) as well as quality (e.g. poor repairs) causes. In 2011 2.4%\(^6\) of all spare-parts were reported Defoa, meaning that these parts were already broken before even used. Knowledge exchange on Defoa can create insight in how a supplier may take preventive actions to avoid them and may decrease downtimes in the field, since otherwise the customer has to wait for delivery of a new part. With the exchange of repair feedback PH and suppliers can cooperatively improve processes in both the supplier and the PH organization. For improvements in the serviceability of spare-parts in the field information from suppliers is required because they have the most know-how available to identify improvement opportunities. Insight in technology roadmaps of suppliers may impact the decision to start a redesign or last time buy project. This is especially important for suppliers which are active in industries where the lifecycle of the products is much shorter than that of the PH systems (e.g. computer industry). Securing the business continuity with a supplier after a disaster occurred is very important for a company like PH since it may affect their deliveries to the field if spare-parts are not delivered on time.

The above analysis identifies that there are different ways to improve the after-sales service supply chain of PH (and thus the customer service level) by exchanging knowledge with the supply base for service-parts and repair. However, there seem to be no good organizational processes in place to execute this knowledge exchange. Therefore, the following Problem Statement has been defined:

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**Philips Healthcare is currently not able to proactively obtain information from suppliers in the after-sales service supply chain, and transform that information into useful knowledge for its internal and external stakeholders.**

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\(^6\) Philips: DEFOA Program Update (12/20/2011)
3.3.2 Research question
During the orientation interviews, it was found that PH needs to develop better structures for knowledge exchange with its after-sales service suppliers. Several topics were detected on which supplier information can be helpful. For these topics, several arguments were identified that indicate how collaboration with suppliers can achieve better results. However, there is no process in place at this moment to do this in a structured way. Therefore the research question of this study was defined as:

What should Philips Healthcare change in its current supplier management processes to proactively obtain information from its after-sales service suppliers and transform this information into useful knowledge for its internal and external stakeholders?

For answering this question properly, the conceptual model as presented in chapter 2 was used. This conceptual model can be separated into three building blocks; drivers of inter-firm knowledge exchange, knowledge exchange activities and knowledge application. Therefore, a set of sub-questions were defined which helped to structure the conducted research. These sub-questions are:

1) How do the drivers of inter-firm knowledge exchange influence the knowledge exchange processes between Philips Healthcare and its suppliers in the after-sales service supply chain?
2) How are the knowledge exchange activities between Philips Healthcare and its after-sales service suppliers currently organized and how can this be improved?
3) How should Philips Healthcare organize its knowledge application processes, so that it results into useful knowledge for both the after-sales service suppliers and the stakeholders within Philips Healthcare?

3.4 Research design
In order to answer the research questions, a sound research design had to be developed. Because of the many different stakeholders, related variables (see Ishikawa diagram), and the requirement to analyze the data within its context rather than independently (Yin, 2003), a case-based research strategy was selected. In this section, the actions required to solve the problem of Philips Healthcare are described. In sub-section 3.4.1, the developed case study design is presented which shows how the research question and the related sub-questions were answered. Sub-section 3.4.2 shows the way in which data has been collected and sub-section 3.4.3 shows how the analysis was organized. Finally, sub-section 3.4.4 shows how the validity and reliability of the study was assured.

3.4.1 Case study design
Case studies exist in different formats. Yin (2003) identifies four different categories; case studies that have single or multiple designs and are either embedded or holistic. For this study, a single case study with embedded units was found to be most applicable. According to Yin (2003), an embedded case study is advantageous over a holistic case study if logical sub units can be defined. As stated in the problem analysis (sub-section 3.3.1), different topics can be identified for which knowledge exchange with suppliers may be beneficial for stakeholders of PH. Therefore, a case study was performed with several of these topics as the logical sub units. Studying multiple cases would require a study at multiple focal firms. Although this would increase the rigor of the study, in the setting of this master thesis, that would be too time consuming. Because of the restricted time availability, it was decided to limit the number of sub units to two topics for which information is required from suppliers.

The first sub unit is about obtaining repair feedback from suppliers. The goal of obtaining this is to get feedback from a repair supplier on its findings in the repair process that is executed for PH. Based on this information actions can be determined to reduce defects in components or improve processes at
both the buyer and the supplier. The second sub unit is about management of spare-part availability after a disaster has occurred. In such situations quick and intensive contact between buyer and supplier is required to secure delivery. Recently, some of these disasters actually impacted the supply chain of PH. These include the earthquake in Japan (resulting in a tsunami and nuclear disaster) and the flooding in the Northern, Northeastern and Central regions of Thailand. In both cases, there are currently no standard processes available at PH.

These two cases were selected because of the current attention they receive within the organization (i.e. several people are involved on these topics). Besides, the two types of information exchange are dissimilar in their underlying processes and impact. Repair feedback is an example of knowledge exchange that can be organized in a structural manner and that is used for improvements in the reverse (repair) supply chain, having no direct impact on the end-customer of PH. Disaster management, on the other end, is only executed if a certain disaster has occurred and therefore much more ad-hoc organized. Moreover, insufficient disaster management may have a direct impact on the end-customer of PH since a lack of spare-parts implies longer downtimes of the systems in the field. These dissimilarities make it possible to generalize the findings because a wider range of issues can be covered.

3.4.2 Data collection and analysis
According to Yin (2003) several principles should be followed by collecting data for a case study. First, multiple sources of evidence have to be used to make the outcomes more accurate and convincing. Second, a case study database has to be created to allow secondary analysis by other researchers. Third, a chain of evidence should be maintained which allows other researchers to trace the steps taken during the case study.

For the data collection in this case study, a combination of interviews and document analysis was used (Van Aken et al., 2007). In Figure 16 the different sub-questions are shown in relation to the data sources that were used to study them within the context of PH. Below the different types of data collection will be explained. Moreover, for each of the research questions the approach will be discussed.

Given the research topic, it made sense to look at the topic from both the buyer and the supplier perspective. Therefore, interviews were held at some suppliers who were involved in the studied cases. The rationale for the selection of these suppliers can be found in Appendix 5. Besides, their related SAMs were interviewed from the side of PH. Experts from PH were defined per studied case. Besides representatives from purchasing, who are the link from PH to the suppliers, these experts were for repair feedback: SQA, as they set requirements towards suppliers; IS-OPS, which are experienced with providing repair feedback; SPS, which have detailed insight in the reverse supply chain; and the different BU’s, which have different stakeholders that may
use repair information. For disaster management the experts were: SPS, as they forecast the spare-part demand; IS-OOPS, as they are also facing availability issues when disasters happen; and the BU, which have to identify the (potentially) infected parts of their system. A complete list of all interviewees can be found in Appendix 6. For the document and data analysis, a variety of documentation was available on both repair information and availability information (including reviews of past events; procedures of related topics; SAP information etc). A complete list of used documentation can be found in Table 3. Sub-question 1 was answered by interviewing representatives from suppliers as well as their related SAMs of PH. During these interviews the several aspects of the developed conceptual model were reviewed, and it was discussed how these characteristics can be applied to the situation of PH. Moreover, during the interviews, some questionnaires were used to enrich the research with some quantitative support. By doing so, it was possible to better understand the conceptual model in practice. Finally, also documentation of related suppliers, both internal (e.g. contracts), and external (e.g. websites) was consulted to gain better insights of the situation. Sub-questions 2 and 3 were answered based on the interviews with suppliers, SAMs and experts from PH. It was asked how currently the exchange of knowledge for the two types of information is organized and how the roles and responsibilities are determined. Based on this, it was asked to describe whether the current processes have to be improved and how this should be done. Moreover, several related documents and data sets were analyzed.

Table 3: Studied documents

<table>
<thead>
<tr>
<th>Document name</th>
<th>Type of document</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPS GRS template suppliers</td>
<td>Template</td>
<td>Unknown</td>
</tr>
<tr>
<td>IS EOL Policy</td>
<td>Policy document</td>
<td>Unknown</td>
</tr>
<tr>
<td>Quality agreement</td>
<td>Appendix to contract</td>
<td>2011</td>
</tr>
<tr>
<td>Business Interruption Action Determination</td>
<td>Excel file</td>
<td>May 2011</td>
</tr>
<tr>
<td>Business Interruption Identification Sheet</td>
<td>Excel file</td>
<td>June 2011</td>
</tr>
<tr>
<td>Business review template</td>
<td>Presentation template</td>
<td>August 2011</td>
</tr>
<tr>
<td>business continuity plan_Roles and responsibilities</td>
<td>Process description</td>
<td>October 2011</td>
</tr>
<tr>
<td>HC Update Thailand Flooding Impact</td>
<td>Presentation</td>
<td>November 2011</td>
</tr>
<tr>
<td>PH UPA (Umbrella Purchasing Agreement)</td>
<td>Contract</td>
<td>December 2011</td>
</tr>
<tr>
<td>Repair feedback (example)</td>
<td>Excel file</td>
<td>April 2012</td>
</tr>
<tr>
<td>Repair History and Closed Loop Feedback</td>
<td>Project design</td>
<td>April 2012</td>
</tr>
<tr>
<td>Roll out of the NEW SUPPLIER CHANGE REQUEST MANAGEMENT (SCRM) Process</td>
<td>E-mail</td>
<td>April 2012</td>
</tr>
<tr>
<td>Suppliers Repair Data collection status</td>
<td>Excel file</td>
<td>April 2012</td>
</tr>
</tbody>
</table>

Analysis of the collected data was structured as follows. First, all interviews were worked out in transcripts. For the expert interviewees, these transcripts were sent back to them to allow the informants to comment on it. These transcripts were then reviewed to find data patterns within and across the different research questions. Documents, if applicable, were used to confirm the findings from the interviews. Based on this, a detailed case description was developed which will be presented in chapter 4. This case description was used as input to the analysis section as shown in chapter 5. In this analysis section, the case-study findings were tested towards the conceptual model.

To discuss the provisional results of the interviews and document research, a mid-term presentation was held with stakeholders of the project. These stakeholders include the project supervisors, members of the service purchasing team and additional people from PH. Besides the provisional results, this session was also used to determine the boundaries for the redesign as presented in chapter 6. That is, the combination of both the findings in literature and in the case-study resulted in a range of solutions that can help Philips Healthcare to solve its business problem. Depending on the available time, and
input from the project stakeholders, a decision was be made on the focus and extensiveness of this change plan.

3.4.3 Assurance of validity and reliability

The lack of rigor in case studies is often seen as problematic, especially if no attention is given to factors that can enhance this rigor. Four criteria are commonly used to assess the rigor of a research: internal validity, construct validity, external validity and relevance (Gibbert et al., 2008). Each of these criteria is discussed in Table 4, including the relevant activities used in this study to enhance them.

Table 4: Test for validity and reliability (Sources: Gibbert et al. (2008) and Yin (2003))

<table>
<thead>
<tr>
<th>Type of validity</th>
<th>Methods of addressing this in the case studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal validity:</td>
<td>• Development of a conceptual model</td>
</tr>
<tr>
<td></td>
<td>• Empirically testing of this conceptual model within the case company Philips Healthcare (Pattern matching)</td>
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<td></td>
<td>“The causal relationships between variables and results. Here the issue is whether the researcher provides</td>
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<tr>
<td></td>
<td>a plausible causal argument, logical reasoning that is powerful and compelling enough to defend the research</td>
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<tr>
<td></td>
<td>conclusions”</td>
</tr>
<tr>
<td>Construct validity:</td>
<td>• Triangulation by using interview and document data</td>
</tr>
<tr>
<td></td>
<td>• Triangulation by using multiple informants from different departments and different firms</td>
</tr>
<tr>
<td></td>
<td>• Expert informants received versions of the interview report to allow them to comment on it</td>
</tr>
<tr>
<td></td>
<td>• A mid-term presentation was held to discuss the analysis face with the key project stakeholders</td>
</tr>
<tr>
<td></td>
<td>• Supervisors of both TU/e and Philips Healthcare were consulted for input during the whole research</td>
</tr>
<tr>
<td></td>
<td>“The extent to which a study investigates what it claims to investigate, that is, to the extent to which a</td>
</tr>
<tr>
<td></td>
<td>procedure leads to an accurate observation of reality”</td>
</tr>
<tr>
<td>External validity:</td>
<td>• A clear rational for selecting the cases was in place for both selecting the topics (i.e. availability and</td>
</tr>
<tr>
<td></td>
<td>repair information) and the suppliers within these topics.</td>
</tr>
<tr>
<td></td>
<td>• Theory building on integrating service-part &amp; repair suppliers and the after-sales service supply chain</td>
</tr>
<tr>
<td>Reliability:</td>
<td>• Development of detailed interview protocols (including questionnaire questions)</td>
</tr>
<tr>
<td></td>
<td>• Methodology section in which the case study protocol was explained</td>
</tr>
<tr>
<td></td>
<td>“The intuitive belief that theories must be shown to account for phenomena not only in the setting in which the</td>
</tr>
<tr>
<td></td>
<td>studies, but also in other settings”</td>
</tr>
<tr>
<td></td>
<td>• Detailed results and outcomes were structurally displayed</td>
</tr>
<tr>
<td></td>
<td>“The absence of random error, enabling subsequent researchers to arrive at the same insights if they conduct the</td>
</tr>
<tr>
<td></td>
<td>study along the same steps again”</td>
</tr>
</tbody>
</table>

3.5 Reflection

In this chapter the research plan has been described. The conceptual model as developed in chapter 2 was empirically tested by executing a case study at Philips Healthcare. In order to do this properly within the context of a master thesis project, it was decided to focus on two topics in which knowledge exchange with the supply base is required: repair feedback and disaster management. These two topics were studied at both PH and its suppliers using interviews and document analysis. The collected data was then used to answer the research question and its related sub-questions. Finally, this research plan showed an overview of activities that were executed to assure the quality of the case study.
4  Empirical exploration

In this chapter the current state of knowledge exchange between PH and its suppliers is explored. Especially, attention is given to the difficulties that characterize the after-sales service phase. Input for this empirical exploration are the interviews conducted, both during the orientation phase of this research as well as the case study interviews conducted with Supplier Account Managers (SAMs), suppliers and internal stakeholders of PH (see Appendix 7 for the interview protocols). Moreover, several documents were analyzed including contracts, procedures and available templates for knowledge exchange. In section 4.1, the after-sales service organization of PH and the relation it has with its supply base are explained. Section 4.2 gives a detailed description of repair information exchange. In section 4.3 the same is done for the knowledge exchange when a disaster has occurred. Finally, in section 4.4 there will be a reflection on this chapter.

4.1 Knowledge Exchange in the After-Sales Service Organization

When customers of PH acquire a medical system, they can also buy a service contract, which includes agreements on maintenance and repair such that unexpected downtimes for the medical system are kept as short as possible. For PH, selling such a service contract is an important part of the value creation because relatively high margins can be attained with it and customers demand for high quality. During the orientation interviews, a respondent stated that systems are sometimes sold at cost price, leaving the service contract as the only profit maker for PH.

In order to execute these contracts, the services should be available through the complete lifecycle of a specific system. The typical lifecycle of a system from the business group IS lasts for about 15 years, as shown in Figure 17. Thus, after a product is delivered to the field and a service contract is sold, PH has the obligation to provide service for a 10 to 15 year period. In this complete period, customers have to be served as quickly as possible after a system goes down. This implies that the suppliers of PH should support the production of spare-parts for the complete service period. Since most spare-parts are produced by suppliers of PH, it requires a lot of interaction between PH and its supply base to be able to guarantee delivery for such a long period. This does not only involve the delivery of new spare-parts, but also influences suppliers for repair activities.

As shown in Figure 18, several stakeholders are involved in the delivery of after-sales services to the customer. These stakeholders are needed to provide both services (e.g. Field Service Engineers) and physical goods (e.g. spare-parts) to the customer. Spare-parts are sourced via different channels. About 20% of the service-parts are directly sourced from a vendor (a). 80% is gained from IS-OPS, the

![Figure 17: Demand for service parts for IS in relation to the installed base](image)
production facility of IS (b). If parts are needed, they are individually packed by IS-OPS and shipped to the warehouses of the service-part supply chain organization (SPS) (c). To be able to achieve the agreed service levels, service-parts have to be kept on stock in multiple places throughout the supply chain. There are three regional distribution centers (RDC), located in Singapore for Asian Pacific, Louisville for the Americas and Roermond for the EMEA region. From the RDCs, parts are shipped to the local distribution centers (LDC) in the Key Markets (d). Key Markets are organized on a country (or multiple smaller countries) level and are responsible for the sales and operational service delivery. When a medical device fails in the field, a Field Service Engineer (FSE) is sent for investigation (f). When a possible failure is found, the FSE orders parts which are picked up at the LDC, a Forward Stocking Location (FSL) or a drop-off point (e); this system differs per country and area. Failing parts are sent back by the FSE to one of the three defect warehouses which are regionally organized, located for Asian Pacific in Singapore, for the Americas in Fort Mills and in Tatabanya (Hungary) for EMEA (g). There, parts are decontaminated if needed and, if repairable, sent to the corresponding repair supplier. This can be either IS-OPS (h) or an external repair vendor (i). For all BU’s within IS, 47% of the spent on repairs is executed by external suppliers, 53% by IS-OPS. Some parts which are sent to IS-OPS are found to be un-repairable in-house. These parts are then sent to an external repair vendor (j). In total, 90% of the repairs are executed outside PH. Business processes, such as purchase order management and other formalities, are outsourced to Accenture and are executed in India. The outsourcing of such business processes is also known as Business Process Outsourcing (BPO). When parts are repaired, they are sent back to the RDC’s where all good parts are stored (k,l). Within the RDC’s no separation is made between new parts and repaired parts. Moreover, parts are not stored on a first-in-first-out principle, leaving all parts with an equal probability to be used in the field. Besides the streams of new and repaired service-parts, PH is currently running a pilot project to buy old medical devices back from the market (m). Part of the FRUs can be re-used in the service-part supply chain (n).

After-sales service delivery has received little attention for a long time at PH. As indicated by a respondent from the BU: “We are purely a production company and therefore we think that service delivery is nothing more than some production (of spare-parts) and some maintenance in the field”. This was also recognized by other internal PH employees as well as some suppliers. One supplier stated that

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7 Accenture/Philips GCS: Supply Workshop Outputs (11/23/2011)
“service is still undervalued. The most effort goes to the sale of new systems.” Although there is some shift towards service, the main culture is still focused on innovation of new products instead of performing service. One of the service purchasers claimed that this is quite strange realizing that millions of euros are spent by PH at those suppliers every year.

For the purchasing department, service always was a part of the operational purchasing activities and therefore did not receive much strategic attention. Purchase agreements with suppliers were developed by the supplier account managers, accountable for production. According to a supplier quality engineer, there was only some involvement of the service organization in this process. This is striking because major differences in the relationship with suppliers are identified at PH between the period that a specific product-line is produced and the period that exclusively service is delivered to that product-line. In the production period, suppliers deliver both to the production facility and to the service organization of PH. These suppliers are therefore called ‘BOM/Service suppliers’. BOM stands for Bill of Material and is used at PH to indicate the actual production of the product. When the production period ends and suppliers no longer deliver to production, these suppliers become ‘Service only’ suppliers. Demand for parts will be low in the service-only period relative to the production period, which makes it less interesting for suppliers of those parts to continue delivery. Moreover, one of the SAMs indicated that the decreased interest of suppliers is enlarged by the fact that demand forecast of spare-parts is very difficult which requires flexibility from the supplier to adapt its production schedule.

Although contracts force suppliers to keep delivering, in practice their supply to PH will not have priority. It is very difficult during the service period to enforce a supplier to act according the terms of the contract. As stated by some respondents, the only possibility for Philips is to shift to another supplier. In many cases however, this leads to very high switching costs because of the loss of undocumented knowledge that is often available at the supplier. Several suppliers and supplier account managers have indicated this as a lock-in for Philips at the supplier. A SAM stated: “Even if we are the design holder, I am not sure how well all documentation has been maintained over the years. Many spare-parts have been changed throughout the lifecycle. Despite the fact that there is a formal change process, I have the idea that, through experience, certain working practices has been occurred which is not formally documented.”

In recent years changes have been implemented to improve the quality of the after-sales period. First, the Service Purchasing team was started to create a dedicated intermediary between the after-sales service organization of PH and the suppliers for service-parts & repair. During the orientation interviews it was indicated that reasons to start the Service Purchasing team include visibility creation for service within PH and to level the high costs of service-parts and repair relative to the purchase of materials for operations. Second, the Plus Model (see Figure 19) was formed to create better alignment between the different functions within PH. In this multifunctional team, the different departments discuss and implement process improvements for service delivery. Third, within IS-OPS service-parts & repair has become a dedicated department. Before, service was an integrated part of the factory, but has now been separated to put more attention on service. The production manager of this repair center indicated that the focus is now much more on costs and added value. “An example of this is autopsy of parts, which allows exact determination of the cause of a failure.”

![Figure 19: Plus Model](image-url)
Although the above described changes are helping PH towards a better recognition of service in the organization, they do not provide insight in the activities that are executed by the suppliers. Currently Philips receives too little information from its suppliers and therefore lacks the ability to fully coordinate the lifecycle for service-parts & repair. Several PH employees therefore suggested that improvements in the service period should not only focus on better internal processes, but also on better interaction with the supply base.

The interaction with the supply base is however still rather limited. Service-parts & repair suppliers are managed mainly inside-out. That is, information is collected from the different stakeholders and shared with the supplier in a so called ‘Business Review Meeting’ (BRM). Suppliers do not provide much information about their performance or interesting findings to PH. One service purchaser stated that, when requested for, suppliers generally do share some information, but there is no standardized procedure for suppliers to share information in a structural manner. A supplier quality engineer of PH added to this that the structures within purchasing are not clear. “Although service purchasing is responsible for the service-parts and repairs, most suppliers are classified as BOM/Service suppliers and therefore managed by the SAMs for production.” This makes it hard for Service Purchasing to timely detect and respond to changes in the supply base that are relevant for after-sales service delivery.

In chapter 3 several topics were identified for which input from suppliers is required. This study will focus on the topics repair feedback and disaster management. Therefore, in the next two sections, it is set out what types of information are required from suppliers for these topics and how this information could be processed within PH to become valuable for the internal and external stakeholders.

4.2 Repair Feedback

In this section it is explored how exchange of repair feedback is currently organized. First the importance of repair feedback for a company like PH is investigated in sub-section 4.2.1. In sub-section 4.2.2 it is shown how repair information can help to improve several aspects within PH. Finally, in sub-section 4.2.3 the current organization of the exchange of repair information within PH is discussed and the problems that arise are presented.

4.2.1 Importance of repair feedback

By communicating about repairs, suppliers can create visibility in what the exact cause of a failure is, how it has been repaired and in what time-frame these repairs have been executed. A medical device manufacturer (e.g. Philips Healthcare) is responsible for the systems in the field and the maintenance involved during the lifecycle. Suppliers that deliver products to PH during the lifecycle of a system can be distinguished into five categories. As displayed in Table 5, these suppliers can deliver a combination of design, production and repair. Category 2 and 4 suppliers do not execute any repair activities for PH and are therefore not taken into account for the investigation on repair feedback. The other categories can be distinguished in suppliers that also execute designing and production, suppliers that execute production, and suppliers that are dedicated to execute repair activities. For the latter two supplier types (category 3 and 5 of Table 5) PH provides a so called Device Master Record (DMR). This is the technical specification of a part and serves as an instruction for the supplier of what should be delivered. The DMR is updated when changes are made in the design of the part. The suppliers are responsible to repair according to the newest requirements. Since this work is done outside PH’s visibility, it would be helpful for PH if the suppliers provide feedback.
on their repair activities to maintain transparency of the product quality. For suppliers that also do the
design of the products (category 1 of Table 5) PH only delivers general product requirements to the
suppliers. The impact or repair feedback will therefore be different for PH. As stated by a reliability
manager of PH, “when we design a part and another party produces it, it can be very useful to receive
repair data. (...) However, if someone else does the design, the repair data will be interesting for that
party to learn from it and implement improvements. PH is then only interested to see it is done in a
structured manner.” The next sub-section will show where repair feedback could potentially be used for.

4.2.2 Potential applications for repair feedback

During the interviews with suppliers and people within PH, several options for using repair feedback
were discussed. Figure 20 shows the list of potential applications and each of the items is discussed in
some detail. Since the purpose of the interviews was not to get a detailed overview of repair feedback application, the
list cannot be seen as a comprehensive one.

As stated by an employee of R&D, FRUs are
determined in cooperation with the
suppliers of the components that are
included in it. A supplier can be helpful in
FRU determination by providing repair
feedback on the failure rates of certain
components. This feedback helps PH to
identify which components have high failure
rates and should thus be identified as FRU
and which parts with low failure rates could be combined into FRUs. The R&D employee added to this
that components for which no historic failure rates are available, have to be monitored intensively
during the early stages of the life-cycle.

Reliability of systems is very important for PH. As stated by a reliability manager of PH, customers do not
accept too much failure in their systems; especially in the market of medical devices where safety issues
and very strict regulations are in place. From a PH perspective, failure of systems increases the cost of
maintenance and repair. Several interviewees indicated that repair information can help to analyze the
root-cause of a certain failure. This can be used as input for redesigning to increase the reliability of a
part. However, the systems of PH are functioning in complex environments in which there is a lot of
interaction with other devices and users. Therefore, it is not enough to investigate the broken part
without its context. To be able to do a good root-cause analysis also input is required from the FSE. With
this input, the complaint in the field can be used to determine a failure. According to an employee of the
PH internal repair center (SP&R), this is currently the case for only 30% of the returning goods. This
means that 70% of the feedback of the FSE is not useful for the repair supplier.

Besides the reliability in the field, an employee of PH R&D stated that the analysis done to improve the
reliability of products in the field could also be used during the NPI-phase. Historic information and root-
cause analyses of certain parts can be used to improve the design of future systems. However, the PH
R&D employee stated that “R&D should not only focus on historic data for new product development,
but should also look for new technologies that are reliable enough for application in medical devices.”
Since many suppliers are involved in other industries as well, they could be helpful by benchmarking failure rates of new technologies in other industries.

A supplier quality engineer of PH stated that the moment a supplier conducts analysis and/or repair activities on a certain part, these findings should be reported. Normally, this documentation process is secured by the quality system of a supplier. Unfortunately, such a system is not functioning well at every supplier. For PH this might be a problem, because they have to assure quality of spare-parts in the field. A recent investigation of the service purchasing team has shown that suppliers reduce the tracking of repair activities when parts are aged and volumes are low. This is typically the case in the service period. The supplier quality engineer stated that should therefore explain the importance of the repair information to suppliers; that this information is needed to secure quality throughout the supply chain.

Maintenance of systems in the field mainly involves the replacement of defect FRUs by new ones and sending back the defect FRUs for repair. According to a service manager, it regularly occurs that it is unclear for a FSE what FRU exactly causes a failure in the system. It is therefore not uncommon that several parts are replaced at the same time. This rigorous approach is convenient for the customer because the system is repaired. For PH however, it means that several FRUs are replaced that are not broken. Several interviewees stated that improved diagnostics of a system in the field might reduce these unnecessary replacements. Suppliers can be helpful with this since they have know-how about how repair or testing in the field may be improved.

The process of executing repairs can be improved by historic repair information. A supplier stated that this information can help to act more efficiently on the analysis of the incoming repairable parts, by focusing more on components that fail often. This will have a positive effect on the time in which a repair can be executed (because analysis can be done in a more structured manner) as well as the quality of that repair (because there will be a higher probability that the right cause will be found and repaired).

4.2.3 Current organization of repair feedback

It was identified that there is a need within PH to obtain repair feedback from suppliers for several reasons. However, a supplier quality engineer stated that exchange of repair feedback is currently not organized at PH. Although there are some interactions with suppliers on repair, these interactions are not structural of nature but only take place on an ad-hoc base. Figure 21 shows how these interactions currently take place as identified by the interviewees. Below, the activities will be described.

SAMs are responsible for the interaction with the suppliers. They request repair reports from the involved suppliers based on the requirements of SQA. Reports that are returned are found to be very divergent in terms of data quality. As a supplier quality engineer stated: “some suppliers are able, often supported by a good IT-system, to produce extensive reports. Others however are not able to transform the different data points into valuable information.” The reason...
for the divergence in feedback is, according to the supplier quality engineer, because of unclear questions that were asked by PH in the past. Although this might be the case, the analysis of the Quality Agreement\(^8\), which is part of the contract with a supplier, showed that there does exists a list of standard items about repair that suppliers should report back to PH. These Quality Agreements are updated regularly and it is therefore possible that Quality Agreements used for current suppliers do not include such a list. However, it was found that this list was not known by SQA. This indicates updates on quality agreements are not properly communicated internally. The SQA requirements are compared with the lists from the Quality Agreement in Table 6, with the items that request for the same information listed on the same row.

The feedback obtained from the pilot project was used for some analysis by SQA. However, after this analysis, no further action was taken on it. The respondents involved in this pilot-project agreed that there is no process in place at PH to give the right follow-up to the obtained information. A supplier quality engineer stated that findings from analysis that is related to products have to be reported back to the BU, since the BU is responsible for the system and all its components. This is currently not done within the PH organization. Only in case the BU indicates certain issues itself (based on internal information), the supplier is monitored more closely. An employee of the BU-iXR stated that in those cases, together with the supplier, reviews are done. The goal of these joint activities is to find out whether the part is produced according to the design or that there is another cause of the high product failure. This is not done with all suppliers. Instead, the BU tries to do this ‘risk-based’. That is, only suppliers which are of potential risk, such as new suppliers or suppliers with whom PH recently had issues with. Also, when issues are directly reported by the supplier, there is a formal procedure in place. The supplier sends a standard ‘supplier change request assessment’ (SCRA) form to a dedicated e-mail address. This form will then be added to the Philips Purchase Part Approval (PPA) process. After the PPA has been given, the supplier is able to execute the change. However, as stated by a SAM, for a change request done by a PH employee there is no formal process in place.

### 4.3 Knowledge Exchange for Disaster Management

This section describes how PH responds to and interacts with its supply base in case a disaster happens. Special attention is given to the employed activities during the recent crises in Japan and Thailand. First,

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\(^8\) Philips: Quality Agreement template (March 2011)
the importance of communicating with the supply base when a disaster occurs is explained in sub-
section 4.3.1. This is followed by a discussion of how disaster management is organized within PH in sub-
section 4.3.2.

4.3.1 Importance of disaster management
Disasters are not part of daily business and their key characteristic is that they occur unexpectedly,
leaving no time to get prepared for it. The main problem that arises when a disaster hits a certain area is
that the suppliers in that area are not able to deliver the requested demand in an acceptable time-
frame. This may be the case because a supplier may lack production capacity because of damage to its
production facilities or may lack raw materials or human resources. The moment a disaster occurs some
decisions have to be made quickly. According to a purchasing manager of PH, “the first days after a crisis
are crucial, if you cannot provide an overview of the affected parts in the first few days, the parts will
probably not be available anymore.”

In order to respond as fast as possible, intensive communication is required to secure supply. This
communication should take place both with the supply base as well as within the PH organization.
Communication within PH is important because of differing interests between the departments. In case
of a disaster different departments may be impacted and therefore need to secure their own supply.
According to a purchasing manager, internal communication between these departments is required to
reach out to the supply base together to create a certain buying power. It is very important to be closely
connected with suppliers to have knowledge on issues like availability, lead-times and price. This
knowledge can be used to make decisions in case of problems.

Several respondents stated that in case of shortage at the supplier, its customers will be generally
handled on a ‘first come first serve’ base. If PH is too late or the supplier is not able to fulfill the demand
for any other reason, PH has several alternatives, an employee of SPS indicated. PH might re-route the
production to another facility of the same supplier, source from another supplier, or go to the broker
market. A disadvantage of brokering is that the prices are much higher and that the quality of such
products is not always guaranteed. Moving to another supplier may take a long time because of formal
procedures this change has to go through. Therefore, the preferred option is to secure the continuity at
the current supplier in another facility.

4.3.2 Organization of disaster management
When the news of a disaster has reached the organization, it was indicated by several respondents that
the following steps should be taken by PH:
- Investigation of the disaster size in terms of impacted geographic area, industries and suppliers;
- Getting in contacted with the impacted suppliers and make clear what they still can provide;
- Making a decision to either place orders, source for alternatives or reallocate stocks.

In Figure 22, the above steps that are summarized in a process chart. Below, this process chart will be
explained in more detail based on the recent experiences with the crises in Japan and Thailand.

Depending on the geographic location and the type and number of suppliers that are located in that
area, the impact on the delivery of goods is high or low. To investigate the size of the disaster, a local
responsible person was contacted to get a first overview of the impact of the crisis on the areas
(industries) in which PH is involved. Based on this information, an assessment was made of the problems
that PH may face and which parts are impacted.
Since the purchasing department is the contact of PH to the supply base, they were indicated to be responsible to find out how PH is affected for both IS-OPS and SPS. Therefore, within purchasing someone was made responsible for the overall management of the disaster. This purchasing manager stated that some suppliers proactively sent a trigger to their customers where the disaster is announced. Moreover, some suppliers also indicated which parts were affected and what the consequences were for availability. Other suppliers did not provide such announcements. For those suppliers, the purchasing department had to find out itself whether parts of that particular supplier were affected. As stated by several respondents, this had not only to be done for the 1st tier supplier, but also for suppliers further upstream in the supply chain.

Defining the impact of a disaster on part-level is a difficult task. This is especially the case for the 2nd (and higher) tier suppliers. For 1st tier suppliers it is relatively easy, because from these parts the country of origin is known within the BU’s. As stated by a service purchaser, the main problem was that the country of origin often was the country where the most value is added to the part. This did not necessarily mean that all components in that part were produced in that country, making it very difficult to get insight for all the components on the Bill of Materials whether they were impacted by the disaster or not. All suppliers that had any chance to be impacted were therefore contacted to ask for potential problems in their supply chain, both for their own facilities as well as for their complete supply base. According to an employee of SPS, this was a very resource-intensive operation because each supplier was contacted personally.

When the impact of the disaster has become clear, PH had to make sure that the influence on its supply streams would be limited. Therefore IS-OPS and SPS had to investigate their own demand. When the demand was made clear by IS-OPS and SPS individually, the operational buyers actually placed the POs at the involved supplier. Sometimes, POs could not be placed because the demand was not clear exactly. However, the supplier needed security to do certain investments. In those cases PH could have decided to take liability for those investments in order to secure future deliveries. One of the suppliers stated that giving these liabilities took very long at PH during the Thailand crisis. The supplier was therefore forced to take extra risks himself.

Determining demand was more difficult for SPS than for IS-OPS. According to a purchasing manager, for IS-OPS the demand was determined based on the forecasted sales from Supply & Operational Planning (S&OP), a sub department of IS-OPS, and an investigation of current stock levels from the operational buyers. This was assessed for each BU individually. For SPS however, this was not enough. An employee of SPS gave an example of this. IS-OPS bought HDDs as single units, but SPS could only buy HDDs as a
component of a computer system. This meant that the 1st tier HDD supplier for IS-OPS is a 2nd tier supplier for SPS and thus SPS had to do extra investigation for some parts.

There might be cases in which the supplier has to make choices to which customer they will deliver. PH normally orders high mix, low volume goods and is therefore, especially for large companies, of less importance in case of a crisis. In such cases, the affected suppliers are more willing to produce bulk products for which little changes in the production process are required. The reason that this was not the case during the crises in Japan and Thailand is, according to several respondents, that PH has put a lot of effort in communicating with the supply base in a regular heartbeat and with very specific information, so that the supply base was able to focus on producing goods. This work also included getting insight in the 2nd (and higher) tier suppliers. A purchasing manager stated that, although the responsibilities of these suppliers are with the 1st tier supplier, when they were not able to manage them, PH would also have a problem. This was very much appreciated by the supply base. As one supplier stated, “PH used its connections to create leverage towards our suppliers (...). This has finally resulted that we could deliver everything to PH.” In case there are issues on availability, an employee of SPS indicated the following decision rules were used to determine the allocation of parts to the internal organization. First, the actual demand for service was secured; second, the actual demand for IS-OPS was secured; third, buffer-stocks for service were refilled; and finally, the buffer-stocks for IS-OPS were refilled.

4.4 Reflection

In this chapter, detailed descriptions were given of the general exchange of knowledge between PH and its supply base and on the specific types of exchange of repair feedback and exchange during disaster management. Specific attention was given to the processes that are important for the after-sales service organization of PH. Several problems were identified for repair feedback and disaster management within the PH organization. In chapter 5, the process will be investigated again, using the conceptual model that was presented in chapter 2. This will be done to find out whether the identified problems can be explained by the framework. It will be investigated what factors of this conceptual model play a role for repair feedback and disaster management at PH and, based on this, what improvement areas can be defined.
5 Analysis

In this chapter, analysis will be executed on the two cases that are studied; repair feedback and disaster management. The conceptual model that was presented in chapter 2 is used to analyze the different events that were presented in chapter 4. In Figure 23: Framework to link the conceptual model to the studied cases a framework is presented that will be used to link the cases to the conceptual model. For each block it is indicated where in this chapter it will be discussed in detail. Based on the analysis and diagnosis, section 5.4 determines the priority for improvement in the processes of PH. Finally, in section 5.5, a reflection on this chapter is presented.

5.1 Drivers of inter-firm knowledge exchange

This section provides an analysis of how the drivers of knowledge exchange, which are clustered in information, supplier, buyer and inter-firm relationship characteristics, affect knowledge exchange between PH and its supply base. This is done separately for the two cases that are studied. Input for this section was gained through interviews with representatives from suppliers and their related SAMs. Both the suppliers and SAMs were asked to score the different drivers that were defined during the literature review in chapter 2. The complete scoring table can be found in Appendix 8. For each characteristic, the different drivers were averaged which resulted in a single score per characteristic. Moreover, a distinction has been made between scores of suppliers and SAMs. Besides Respondents were also asked to motivate their scoring for each driver. These motivations are used in the discussion on the drivers as presented below. In sub-section 5.1.1, the drivers will be discussed for repair feedback. In sub-section 5.1.2 this will be done for disaster management.

5.1.1 Drivers for repair feedback

This sub-section describes what the drivers for the information-, supplier-, buyer-, and inter-firm relationship characteristics look like in the case of exchanging repair feedback and how they are influenced by the variables of the after-sales service supply chain. In Figure 24, the scoring for the different characteristics is displayed, separately for suppliers and SAMs.

Information characteristics for repair feedback

The five drivers presented in chapter 2, based on which information characteristics can be determined are accuracy, ambiguity, relevancy, tacitness and timeliness. The accuracy of the exchanged repair feedback is currently limited for PH. Although different per supplier, the overall finding is that suppliers are not investigating repair information in a structural manner. A lot of fields in the reporting tools used...
by these suppliers are ‘open text fields’ in which it is difficult to exactly define the message (e.g. the failure that was found). These ‘open text fields’ create ambiguity because they lead to deviations and contradictions when different repair engineers fill out different descriptions. The relevance of the exchanged information is experienced higher by the SAMs than by the suppliers. It is assumed that the main reason for this is that PH has not defined in detail what is expected from repair suppliers. Suppliers do not know why repair information should be exchanged. Hence, their perception of relevance is lower. It is agreed by both suppliers and SAMs that repair feedback is explicit information and thus low in terms of tacitness. This indicates that the transfer of repair feedback should be relatively easy. However, by reducing the number of open text fields, the explicitness can even be improved. Feedback from suppliers is currently not delivered on regular intervals. Even if agreements on the feedback intensity are made, suppliers often deviate from this schedule. This can be explained by the fact that no clear and standardized structures for exchange on repair feedback are in place.

Supplier characteristics for repair feedback
In chapter 2 supplier characteristics have been defined based on top-management involvement, absorptive capacity, IT-commitment, organizational size and willingness to share. Most suppliers indicated that the involvement of top-management is high for the account of PH. For operational processes (such as repair activities) they are however not involved in detail. Although most suppliers are not yet delivering good quality repair feedback to PH, most of them indicated they are capable to do it. They often already provide other customers with repair feedback or have IT-systems in place that may facilitate it. One supplier stated that it requires quite some resources to get the right processes in place, but if PH demands it, they are willing to invest in it. However, as another supplier stated, PH should make very clear what it is willing to do with that information before such investments will be made. The organizational size of the supplier was found to be no restriction for the delivery of repair feedback among the interviewed suppliers and SAMs. Most suppliers have fixed contact persons for the PH account which makes communication relatively easy. Finally, the willingness to share repair feedback is high at the supply base. According to a supplier, the difficulty is to appoint resources to it, because it is not clear what PH exactly wants to receive.

Buyer characteristics for repair feedback
In chapter 2 buyer characteristics have been defined on the same drivers as supplier characteristics. Moreover network centrality was added as a driver for buyers. The buyer will be considered to be PH. The involvement of top-management of PH is considered by both suppliers and SAMs to be low. According to a supplier, every 4-5 months the management of PH changes its focal points. This influences the absorptive capacity because it hard to successfully introduce a certain way of working. Moreover, short term management attention does not allow for structural improvements (in IT infrastructure). Another problem that makes it difficult to create standardization in working processes are the unclear roles and responsibilities of the different people at PH. Departments work with different
processes and people quickly change roles within PH. Therefore, it can be concluded that the
organizational size of PH negatively influences the exchange of repair feedback. A SAM stated that due
to this complexity, real improvements in the information exchange are not possible. This is closely
related to the willingness of PH to process repair feedback. Several suppliers indicated that they see the
willingness of SAMs to improve the communication with the supply base. However, the SAMs are not
able to create enough support within the organization to actually transform the obtained information
into something useful. The network centrality of PH is not found to be very important in the exchange of
repair feedback since repair feedback is something that is created in the repair process of the supplier
and does not involve its upstream supply chain.

Inter-firm relationship characteristics for repair feedback
In chapter 2, the inter-firm relationship characteristics were determined based on five drivers which are
competitive pressure, power relations, relationship intensity, trust and early supplier involvement.
Putting competitive pressure on the relationship with its suppliers becomes more important for PH. This
is mainly focused on price and not on performance issues (e.g. provision of repair feedback). It was
indicated by both suppliers and buyers that PH has the most power in the relationships. However, there
were some differences between the period of production and the service period. In service, the power
position shifts somewhat towards the suppliers since PH becomes more dependent on their products.
This shift is important for the exchange of repair feedback because the supplier may use it as a change
for negotiating on other topics. All suppliers indicated that the intensity of the relationship is high with
weekly or even daily contacts on different topics and with different people of PH. Employees of
suppliers and PH maintain personal relationships. This enhances informal interaction, which makes
communication channels unclear and scattered. Someone from the BU explained that within different
departments several projects with their contact persons at the suppliers can be started that may involve
the same topic (e.g. repair feedback). Although this indicates that the relational trust is high, it
undermines the formal structures that should be in place between PH and the supply base. Early
supplier involvement has influence on how repair feedback should be used. It was suggested by several
interviewees that suppliers who are design holders of a repairable part should use repair feedback
within their own organizations to improve products and processes instead of exchanging it to PH.

Impact of variables for after-sales service on repair feedback
Some of the variables that were defined in chapter 2 to have impact on inter-firm knowledge exchange
in the after-sales period were found to have impact on the exchange of repair feedback. The variety of
information in the supply chain does not play an important role in the exchange of repair feedback.
Although different types of repair feedback can be determined, this is all focused on a single activity
and has not to deal with other activities in the supply chain. As an employee of SQA stated, suppliers
want to do as little as possible on repair in the service period. On the other end, PH is focusing more
and more on improving processes on repair and repair feedback. This indicates that the buyer’s and
supplier’s goals differ on this topic. The amount of turnover that is spent by PH at the supplier and the
incentives for future business both influence the willingness of the supplier to provide repair feedback.
One of the SAMs stated that a supplier is currently trying to use this power by not responding to
requests for involvement in projects before any new business is awarded to that supplier. Direct sales of
the supplier to the end-customer (user) does not occur in the supply chain for imaging systems without
the approval of PH. According to an employee of the BU, this is because PH (or at least a certified field
engineer) has to guarantee the quality of the system before it can be used by the hospital. It is therefore
difficult for a supplier to directly deliver to the hospital. Obsolescence of spare-parts also has influence
on the feedback from repair suppliers. It was found by an employee of SQA that for older products,
suppliers are less willing to monitor their repair activities because they do not see added value of doing. That is, in the perception of the interviewed suppliers improvements on older products will not pay off. However, there may be other reasons of monitoring repair information, such as for quality and regulatory issues.

5.1.2 Drivers for disaster management
This sub-section describes how the drivers for the information-, supplier-, buyer-, and inter-firm relationship characteristics are embedded in the knowledge exchange for disaster management and how they are influenced by the variables of after-sales service. Since in the former sub-section the drivers were already discussed in detail for repair feedback, this sub-section will only elaborate on findings that differentiate from the findings for repair feedback. In Figure 25, the scoring for the different characteristics is displayed, separately for suppliers and SAMs.

Information characteristics for disaster management
The accuracy of the information was found to be very high during disaster management. Different communication channels were used which also reduced ambiguity. During disasters data exchange was experienced to be relevant. However, PH sometimes wanted to know too much information from the suppliers. For example, the demand from PH to give status updates on parts that were not affected by a disaster was experienced as unnecessary work by the supplier. Both tacit (e.g. size and impact of the disaster) and explicit (e.g. availability and lead-times) information was exchanged. Therefore, a combination of data files and (T-con or face-to-face) meetings was used. Supplies and SAMs agreed that during crises there is frequent interaction of, at least, several times per week.

Supplier characteristics for disaster management
As stated for repair feedback, PH is an important customer for many suppliers. Therefore, supplier’s top-management is involved when problems occur. Sufficient resources were dedicated by suppliers to facilitate the interaction with PH because the urgency was very clear for the suppliers. The commitment to IT was found to be irrelevant during disaster management because information exchange took place mainly through e-mail and meetings. Like for repair feedback, the organizational size of suppliers did not influence the exchange since fixed contact persons were assigned to PH which made communication relatively easy. The willingness of the suppliers to share information was very high. Compared to repair feedback, the goal of the exchange was very clear.

Buyer characteristics for disaster management
Different than for repair feedback, during disasters there is big pressure from all management levels of PH to secure supply. On Resources were assigned in the complete organization to ensure good disaster management. Several templates were created by PH employees to enhance communication on part-level. The size of the PH organization is advantageous during disaster management because it can help to gain attention from the suppliers. During disaster management PH seems to be able to effectively
cooperate with its suppliers. As one supplier notices communication with PH is very open and clear during a crisis. That is, the willingness of PH to share seems to be much higher in situations where business is seriously in danger. Also, if there were problems further upstream in the supply chain, PH tried to communicate directly with those suppliers if the 1st tier supplier could not get something done.

**Inter-firm relationship characteristics for disaster management**

Competitive pressure during disaster management forces a supplier to respond according to the requirements of PH. In general, PH has the most power in the relationship and is thus able to put enough pressure on suppliers. With large suppliers however, this may be different since these suppliers are only willing to perform bulk-production during disasters to optimize their output levels. Since PH often requires customized products, delivery from those suppliers may be at risk. An intense relationship and trust are favorable in disaster management because that will improve the extra effort that will be put in securing supply. It was indicated by a SAM that for shorter relationships, it was more difficult for PH to have the supplier act according the PH’s requirements. For the cases in which the supplier holds the design rights, PH had difficulties to reallocate business to other suppliers.

**Impact of variables for after-sales service on disaster management**

Some of the variables that were defined in chapter 2 to have impact on inter-firm knowledge exchange in the after-sales period were also found to have impact on the knowledge exchange for disaster management. The variety of information during disaster management is high. Information from different sources should be available (e.g. suppliers, key markets, governments, etc) in order to manage not only operational issues (availability, lead-time, and price), but also issues about the impact of the disaster (size, impacted industries, duration, etc.). During a crisis, a supplier is trying to survive, while PH wants to continue business. This difference in goals is an extra difficulty for service because it is about small numbers of parts which is often not interesting for a supplier to put effort on. This also shows that the amount of turnover is important in disaster management to gain attention from the supplier. Moreover, incentives of future business are also an important factor in such cases. The link between the supplier and the end-customer of PH does not play a role in disaster management. As stated for repair feedback, this is not an issue within the IS business. The main problem that is found for service compared to production in disaster management is the obsolescence of spare-parts. In such situations, suppliers focus on bulk-production while the parts used in service are often low in volume, which makes it difficult to get these parts delivered.

5.2 **Knowledge exchange activities and knowledge application**

This section analyzes how the exchange activities between the suppliers and PH are currently performed and how this knowledge should be applied by internal and external stakeholders. In literature, several aspects are defined on how the different activities involved in knowledge exchange can be discussed. After successfully obtaining information, a firm should transform this information into knowledge that can be used to create value. After this knowledge synthesis has taken place, processes and tools should be defined that can be used to map the knowledge and make it possible to apply it in the organization. Based on these processes and tools, attention should be given to the application of the knowledge. These activities will be discussed in detail below. In sub-section 5.2.1, these will be discussed for repair feedback and in sub-section 5.2.2 disaster management is discussed.

5.2.1 **Knowledge exchange and application for repair feedback**

This sub-section describes how the activities for knowledge exchange and the application of knowledge in the organization of PH are present for repair feedback.
Obtaining information for repair feedback
The way how information is obtained depends on the characteristics of the exchanged information. Besides the type of information and the way it is communicated, also the agreements that are made on the transfer of information between the buyer and supplier are important. In chapter 4, it was shown that many different types of information on repair can be requested from suppliers. However, in section 5.1 it was found that only information that is really needed should be exchanged. Although pilot projects have been started to obtain repair feedback from suppliers, there seems to be no specific goals on what that information should be used for. Many fluctuations in quality were found between different suppliers. One supplier stated that they have the infrastructure to produce very extensive reports. However, since PH does not specifically ask for it, this supplier will not put effort in it to collect all the required data. Some other suppliers have stated that repair information is collected by them for all steps in their repair process. This information is not delivered to PH because it was not asked by them. Besides the lack of requirement setting by PH, structurally obtaining information from suppliers is also hindered by the way how the actual transfer activities take place with these suppliers. In general, structural exchange of data files does not take place. A SAM stated that “most information is based on face-to-face meetings.” Based on these meetings actions are defined and each party has to execute these actions individually. Moreover it was found that the agreements on information transfer differ from supplier to supplier; each SAM seems to have its own process for communication.

Knowledge synthesis with repair feedback
During knowledge synthesis a firm should transform the obtained information into knowledge that can be used to create value. In this transformation both buyer and supplier should be involved. Therefore, it should be made clear who is responsible for the synthesis of information. It was stated that for obtained repair information, a quality check has to be performed first to find out whether the report is filled in consistently. That is, the most important factor for analysis is that the information used is reliable. Analysis can be done by PH, the supplier or a combination of them. For analysis within PH the main problem, as stated by several interviewees, is that the different departments of PH do not structurally communicate with each other. This creates difficulties in creating a follow-up of the exchanged knowledge. When analysis is executed in cooperation between PH and the suppliers, interaction should take place through the SAM. During the interviews it was found that regularly meetings take place between SAMs and supplier representatives. These meetings were indicated as a good method to have joint discussions on the interpretations of repair feedback analysis. When the supplier is doing the analysis, it should report back to PH what the results and taken actions are. It was indicated by several people of PH that the analysis of repair feedback by suppliers is the most appropriate way of working. However, this is currently difficult to organize because of the lack of available processes and explicit goals at PH of what to do with the repair feedback. The possibility of analysis by the supplier also depends on the type of supplier. It is more likely that suppliers that own the design rights do their own analysis (as opposed to dedicated repair suppliers), because they are also responsible for the follow-up.

Knowledge processes/tools for repair feedback
Processes and tools should make sure that knowledge is presented in a clear, concise and user-friendly format so that everybody who needs the knowledge is able to understand and use it. For the exchange of repair feedback, there is found to be a lack of fixed structures. Moreover, there is no focus on what exactly should be done with the repair feedback from suppliers. These two aspects make it hard to determine the roles and responsibilities for analysis on the obtained information. Besides, it is difficult to determine how the created knowledge should be presented to the internal and external stakeholders. Several respondents stated that in order to improve this, the purpose and requirements of
repair feedback should be defined. Thereafter, it should be determined in detail how the required information should be exchanged and how the analysis and reporting should take place. Some respondents indicated that analysis on repair feedback could increasingly be simplified by implementing a standardized system for repair reporting. For each specific cause of failure and action taken to solve that failure, a unique code can be determined. This reduces the ambiguity of the information and improves the opportunities for analysis.

**Knowledge application for repair feedback**

Successful application of knowledge requires input from different sources, a focus on long-term (or structural) purposes, sufficient resources, reward systems for using the knowledge and timely availability of required information. Within PH, no example of successful application of repair feedback has been found. From some suppliers, information was obtained and analyzed in pilot projects. Sometimes interesting results from these analyses were discussed with the suppliers. However, after the analysis and discussion, a plan has to be made to actually introduce changes and create improvements. During the interviews, it seemed that this last step was not taken into account by the PH employees. The interviewees agreed that, to successfully apply repair feedback, there should be a regular input from the suppliers to secure the long term focus. Moreover, it was agreed it is very important to determine what the outcome of the exchange activities have to be. However, there was no joint vision on how to transform findings of repair feedback into structural improvement or change plans. It was shown in chapter 4 that there are several potential applications of repair feedback, but there is no consensus on what is the most important application. This should first be made clear because otherwise it will be difficult to attain the required resources to execute successful repair feedback.

5.2.2 Knowledge exchange and application for disaster management

This sub-section describes how the activities for knowledge exchange and the application of knowledge in the organization of PH are present for disaster management. Since in the former sub-section these activities were already discussed in detail for repair feedback, this subsection will only elaborate on findings that differentiate from the findings for repair feedback.

**Obtaining information in disaster management**

Compared to repair feedback, obtaining information is organized more structurally for disaster management. According to the respondents, during a crisis insight should be created in the size and impact of the crisis, and the price, availability, and lead-times of the products. This makes that the goal of communication is clear for all parties and specific questions can be formulated. Some suppliers may take initiative and obtain information from their supply base and communicate potential issues to PH. PH communicates several times per week with its suppliers in the first period after the crisis. In such meetings the status of all the affected parts is discussed. A main problem that was found on obtaining information was an internal PH problem, since it was found that several internal databases (especially BoM-data) were not up-to-date. This was the main cause of the difficulty to get insight in the impacted parts and the required demand for these parts, as stated in chapter 4.

**Knowledge synthesis in disaster management**

Knowledge synthesis for disaster management requires continuous interactions between PH and the supply base. It was found that it is very important for PH to constantly be updated by suppliers to be able to respond quickly when a situation changes. Based on this input, PH can internally discuss on the steps that has to be taken. This should then be communicated back to the suppliers (in terms of POs, liabilities, etc.). During the recent crises in Japan and Thailand, both suppliers and PH stated that PH
managed this very well. A supplier stated that “it is a matter of supply and demand. If you are clear in your demand or pay enough, then you will get the parts.”

Knowledge processes/tools for disaster management
Within SPS there is a plan to manage the business continuity in case of interruptions in the supply chain for the outgoing flow (from PH to the field). For the incoming side (from supplier to PH) this is not in place. However, during the recent crises, special templates were created by PH, to standardize the communication over the supply base. These can be used in future disasters as well. Moreover, it was indicated that a more extensive plan (i.e. the SPS plan for outgoing flows) could be beneficial as well. At this moment, this may not be necessary since there is enough know-how available within PH However, if the next disaster takes place in 10, or even 20 years, this know-how might be gone because employees change roles or even leave the company.

Knowledge application in disaster management
The application of knowledge during a crisis is typically done directly after the information has been received. However, during a crisis there are many learning moments. Therefore it was indicated that, after the crisis, these lessons learned have to be analyzed and the main findings have to be reported. As stated by an employee of SPS, responsibilities should be defined at certain function levels and not at the level of particular persons. This will ensure that, in case of future disasters, the right people can be allocated to manage the disaster. It might be helpful to also involve suppliers in the evaluation since they are not only providers of knowledge, but also the users of knowledge during a crisis.

5.3 Diagnosis
In this section, a diagnosis will be presented based on the analysis of section 5.1 and 5.2. For each of the studied information types, the main findings are shown based on which improvement areas will be identified. For repair feedback this is done in sub-section 5.3.1; disaster management is discussed in sub-section 5.3.2.

5.3.1 Diagnosis on repair feedback
This sub-section presents a diagnosis on the main aspects for repair feedback and the potential areas for improvement. For repair feedback, five factors were identified during the analysis:

- Large variety in repair feedback from suppliers;
- No clear requirements set by Philips Healthcare;
- No focus on application of repair knowledge;
- No consensus within Philips Healthcare on communication method;
- No follow up after exchange.

First, there is a large variety in the quality of repair feedback from suppliers. In the pilot projects that were executed, some feedback reports were found to be of relatively high quality and suitable to perform analysis on. However, other suppliers provided unstructured reports with many ‘open text fields’. From the supply side it was stated that the unclear requirement setting of PH causes the lower quality of their repair feedback. From the PH perspective however, it is believed that suppliers are not able to deliver the right information to PH. Even if PH clearly sets-out what is going wrong, suppliers are not able to improve their way of working. This is an interesting finding since both suppliers and PH indicate that the main difficulty for successful knowledge exchange lies at the other’s organization. Although it is difficult to find out which party is right, these different opinions make clear that there is a
lack of understanding of each other’s processes and capabilities. By improving interaction between suppliers and PH on this topic, this may be improved.

Second, as stated already for the first factor, many suppliers experience that there are no clear requirements set by PH on the expected repair feedback. Suppliers perceive reporting on repair feedback as an extra effort for which additional resources should be assigned. If no explanation is given by PH on the requirements and applicability of the repair feedback, they are not eager to do this investment. From the perspective of PH however, a supplier should, according to its own quality procedures, work on continuous improvements. Suppliers should keep track of repair data and use this data as an input for internal improvements and/or change request at PH. The interviewed suppliers were not aware of this expectation of PH. Therefore, communication to the supply base should be improved in which exact goals and requirements are made clear.

Third, to be able to define the goals of repair feedback, PH has to determine what repair feedback will be used for. There is currently no focus on the application of repair feedback. Although in chapter 4 several possible applications are stated, a precise description of what requirements repair feedback should satisfy and what input is required for this from suppliers could not be provided by the respondents. This makes it difficult to reach out to the supply-base and ask for information, because it is not clear for suppliers what information should exactly be provided. Moreover, suppliers are not willing to assign resources without a clear business case. Improvements can be realized by determining the exact applications for which repair feedback can deliver the most added-value to PH or its suppliers.

Fourth, within PH there is no consensus on the way in which they should communicate with the supply base. There is currently no standard process in place for the exchange of repair feedback. Instead, SAMs often have own agreements with suppliers on how repair feedback should be provided. This makes it difficult to perform standardized analysis or make comparisons between different suppliers. Another related problem is the high turnover in job positions at PH. Because of this low continuity, it is difficult to create long-term relationships and standardization in communication. Improvements may be realized by standardizing processes for communication with suppliers. For example, a section may be added to the purchasing agreement in which the communication process is described in more detail. To be successful with such standardization however, first the other factors, as described above, should be improved.

Fifth, there is no follow up within PH after the exchange of repair feedback. If analysis is executed on repair feedback, the results most often do not lead to corrective or preventive actions. This can be partly explained by the fact that it is difficult to execute analyses if the objective is not clear. However, another important reason for the lack of follow up is the absence of attention on repair feedback in the organization of PH, especially within the BU’s there is currently no attention for repair feedback. Since the BU’s are the product owners, they should decide on changes the design of products. Repair feedback from suppliers is currently not used for design changes. Before improvements can be made on this topic, a cultural shift should take place towards becoming a more service oriented company.

5.3.2 Diagnosis on disaster management
This sub-section presents a diagnosis on the main aspects for disaster management and the potential areas for improvement. For disaster management, four factors were identified during the analysis:

- No alignment over departments;
- Difficulties for service compared to operations;
- Openness and frequent communication with supply base;
- Lessons learned from recent disasters.
First, there is no alignment between the parts used in SPS and IS-OPS. IS-OPS is able to order all parts that are on the BoM-list individually, which makes it relatively easy for them to find out whether these parts are impacted by a certain crisis. SPS however, can only order FRUs from suppliers, which are often combinations of different parts from the BoM-list. When SPS has to determine the impacted parts of a crisis, each FRU should be investigated on the included parts before the BoM-list can be checked to indicate the origin of the part. This is an extra step that should be taken. During the recent crises, it was found that the databases, in which the FRU- and BoM-lists are stored, were not up to date. An important improvement action should therefore be to get (and keep) these lists up to date.

Second, during crisis situations there are specific difficulties for SPS (compared to IS-OPS) that have to be dealt with. These difficulties include demand prediction and control of obsolete spare-parts. Predicting spare-part demand for a longer period is difficult for SPS since it is not known beforehand when a part will fail in the field. Some indication can be given based on historic data, but this is not very precise and not available for all parts (e.g. new service-parts). Because it is hard to investigate which FRU’s are exactly affected (as shown above), it takes a long time before predictions can be made. The obsolescence of spare-parts is found to be another problem for SPS during disaster management. Suppliers have the tendency to focus on bulk production and not on low volume, aged parts. In case a part cannot be delivered by the supplier, it currently takes a long time to take action (either shift to another supplier or broker or do redesign on the part) because of the formal procedures that have to be completed. This might be accelerated by creating an escalation process that can be used in crisis situations. With such an escalation process, the times of the formal procedures should be reduced.

Third, during disaster management there seems to be openness and frequent communication with suppliers after disasters have occurred. Both at PH and at the supply base, high priority is given to execute proper disaster management. Although some suppliers stated that PH sometimes wants to be too much ‘in control’, the frequent interaction is in general appreciated in crisis situations. Moreover, it is appreciated by the 1st tier suppliers that PH uses its size and power to put pressure upstream in the supply chain to secure deliveries. Within PH it was found that during the crises in Japan and Thailand not always full attention was given to the problems of service. The main reason for this is that the exact demand for service is hard to identify. An improvement for future crises could therefore be to have more focus on service, since service is of increasing importance for PH.

Fourth, at this moment there is a lot of knowledge within PH on disaster management, gained during recent experiences. This knowledge is still in the heads of the current PH employees. Because of the high staff turnover within PH, it might well be that these people have left their current roles when a next disaster occurs. Therefore, securing the information in a calamity plan would be preferable. After the eruption of the Eyjafjallajökull-volcano in Iceland, a so called business continuity plan (BCP) was developed for outgoing parts of SPS (from SPS to the field). This plan can be used as a starting point in defining a BCP for incoming parts of SPS (from suppliers to SPS).

5.4 Priority determination
Based on the analysis and diagnosis sections, five improvement areas can be identified, that play a role in both repair feedback and disaster management. These main improvement areas can help PH to improve its overall performance on knowledge exchange with the supply base. They include:

- Ad-hoc organization of external communication;
- Company culture is too much focused on innovation instead of after-sales service;
- Low internal transparency;
• Unclear processes (both internal as external);  
• Unclear utility of knowledge exchange within Philips Healthcare.

Improving these five areas seems to be essential for PH to create successful knowledge exchange with its supply base. However, because of time limitations in this study, a redesign can only be developed for a sub-set of these areas. Therefore, it is identified below which of the main improvement areas should receive priority and therefore should be included in the redesign.

It was indicated that the improvement areas should be executed in a subsequent order. This helps by setting their priority. According to the findings in the case studies, suppliers are willing to cooperate in knowledge exchange, as long as PH asks specific questions. These questions should therefore be defined, before interaction with the supply base can be set up. This is therefore the most important issue to solve for PH. The problem is that it is currently not clear within the organization of PH what information is required, what is exactly exchanged and who is responsible for that. Internal transparency should therefore be improved, since it creates difficulties for people who are in contact with suppliers (generally SAM’s). They do not exactly know what they should ask those suppliers. At the same time, people from different parts of the organization start projects for which information from suppliers is required. This creates a scattered set of questions to the supply base. Therefore, external communication should be improved then. These unclear processes result in the feeling at an individual employee level that they have to know everything to be in control. That is, it is not clear where knowledge is available so people start to collect all kinds of information themselves. Thus, the processes for knowledge exchange should be secured, so that everybody knows the roles and responsibilities. The overall reason that this is difficult to change is that within PH there is a strong focus on innovation instead of after-sales service delivery. On the long run, this culture should shift towards a more service oriented organization. Figure 26 shows the improvement areas in their prioritized order.

Based on the prioritized list of main improvement areas, the most important areas for redesign had to be identified. This was done through a discussion with 10 people including the project supervisors from both PH and the university, members of the service purchasing team and additional stakeholders of the project from other departments within PH. During this discussion, it was stated that the focus for redesign should be on the first three areas. That is, it was argued that detailed process improvement and culture change require too much time to fit in the scope of this study. Moreover, it was believed by the participants of the discussion that, in order to change these areas, higher-level management should be in the lead.

When the focus of the redesign was made clear, a discussion was held on what parts of the studied cases should be focused for redesign. For disaster management it was found that there are already some good processes that were developed during recent disasters (see chapter 4). Within PH, the difficulties of managing disasters are known. After the crises that occurred in recent years, SPS already
created a high level business continuity plan (BCP) for the outgoing flows (from SPS to the key markets). Therefore, there is still a lot of know-how within PH on both disaster management and the BCP creation which will make the creation of a BCP for incoming flows (from supplier to SPS) not problematic. Therefore, no priority will be given to this in the redesign phase of this study. However, some issues should be stated that PH should take into account when creating a BCP for incoming flows.

Attention should be given to the difficulty of predicting demand for service-parts. Moreover, it should be secured that FRU- and BoM-lists are up to date and there are escalation processes for obsolete parts. Some parts of the BCP for incoming flows can be linked to the BCP for outgoing flows. Especially in the first phase of the BCP, in which the impact of the disaster is identified, activities can be executed collaboratively. The subsequent phases should not be executed jointly because different actions are required for incoming and outgoing flows. Instead, the BCP for incoming and the BCP for outgoing flows should run in parallel. An overall ‘disaster management’ board should make sure that the two are linked with each other on critical points. For example, information on availability at suppliers may be important for the planning of outgoing product flows. In Appendix 9 a high level overview of the BCP for outgoing flows is presented. This may be used as a first step in determining the process for incoming flows.

During the discussion session it was decided that the focus of the redesign will be on the creation of a change plan for repair feedback. In the analysis and diagnosis sections it was shown that the current processes for this type of information exchange do not seem to be successful. The main point made in section 5.3 was that the goal of exchanging repair feedback is not clear for suppliers. This was caused by the internal problem that PH has with a detailed identification for what application the repair feedback will be used. Therefore, in the next chapter a redesign will be presented in which these aspects are taken into account.

5.5 Reflection

In this chapter, the case study of PH was analyzed by using the conceptual model that was defined in chapter 2. Based on this analysis, the main improvement areas were identified and priority was set to the most important improvement areas. In

Table 7, an overview is given of the most important findings of this chapter. Moreover, the opportunities for improvements are given, it is stated to what part of the conceptual model and main improvement area it is related.

<table>
<thead>
<tr>
<th>Finding</th>
<th>Improvement opportunity</th>
<th>Place in the conceptual framework</th>
<th>Main improvement area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large variety in quality of repair feedback from suppliers</td>
<td>Create more interaction between suppliers and PH to decrease the lack of understanding of each other</td>
<td>Drivers – ‘information characteristics’</td>
<td>External communication</td>
</tr>
<tr>
<td>Obsolete spare parts cannot be delivered by supplier</td>
<td>Create an escalation process that can be used in crisis situations</td>
<td>Drivers – ‘Supplier characteristics’</td>
<td>Unclear processes</td>
</tr>
<tr>
<td>No clear requirements set by PH</td>
<td>Determine and start communicating the exact goals of knowledge exchange on repair feedback to the supply base</td>
<td>Drivers – ‘buyer characteristics’</td>
<td>Utility of knowledge exchange</td>
</tr>
<tr>
<td>Share lessons learned from recent disasters within PH and with suppliers</td>
<td>Develop a business continuity plan for incoming parts to SPS</td>
<td>Drivers – ‘Inter-firm relationship characteristics’</td>
<td>Unclear processes</td>
</tr>
<tr>
<td>No consensus within Philips Healthcare on communication</td>
<td>Define standardized processes for communication</td>
<td>Exchange activities – ‘obtaining information’</td>
<td>Internal transparency</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
<td>Exchange activities</td>
<td>Impact</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Openness and frequent communication with supply base</td>
<td>More focus on service in the project teams</td>
<td>‘Obtaining information’</td>
<td>External communication</td>
</tr>
<tr>
<td>No follow up after exchange</td>
<td>Cultural shift towards a more service oriented company</td>
<td>‘knowledge synthesis’</td>
<td>Utility of knowledge exchange</td>
</tr>
<tr>
<td>Difficulties in predicting demand</td>
<td>Generate an indication based on historic data</td>
<td>‘Knowledge synthesis’</td>
<td>Unclear processes</td>
</tr>
<tr>
<td>Bill of Material lists are not up to date</td>
<td>Get master data up to date</td>
<td>‘Knowledge processes/tools’</td>
<td>Internal transparency</td>
</tr>
<tr>
<td>No focus on application of repair knowledge</td>
<td>Determine the exact applications for which repair feedback can deliver the most added-value.</td>
<td>Knowledge application</td>
<td>Organizational culture</td>
</tr>
</tbody>
</table>
6 Redesign

This chapter will present a redesign that describes how the current situation of PH can be shifted towards a higher level. In section 6.1 a proposal for redesign of the current processes will be presented. Then, in section 6.2, a pilot study that was executed within PH is presented. In this pilot study, parts of the designed process were executed to evaluate the practical applicability of it. Section 6.3 presents an advice to PH on the execution of the designed process. Finally, section 6.4 gives a reflection on this chapter.

6.1 Process design

The redesign will be based on the redesign model presented by Van Aken (2007). In this model (shown in Figure 27), first, specifications have to be developed. The redesign has to present a solution for the current problems at PH regarding repair feedback. Since repair is a typical after-sales activity, the design should fit into the after-sales service organization of PH. Moreover the first three steps of the main improvement areas that were discussed in section 5.4 have to be covered. In sum, the specifications for the redesign are:

- Focus on repair feedback;
- Taking into account the current after-sales service organization at PH;
- Helps to clarify the utility of repair feedback;
- Improves internal transparency;
- Improves (standardization of) external communication.

The utility of knowledge exchange is identified as the most important issue to solve before the other aspects can be improved. Because interviews at different departments showed that it is not clarified what the utility of repair feedback is, first an environment has to be created in which people with different backgrounds (SPS, IS-OPS, Purchasing (SQA) and different BU’s) are involved. Together, such a ‘repair feedback team’ of PH can discuss for what applications repair feedback can be used.

After the utility of repair feedback has been defined, the internal roles and responsibilities can be defined to increase the internal transparency. Since the purchasing department is the link to the supply base, they should be involved in the communication with the suppliers. They should do this based on the requirements set by SQA (which is part of the purchasing department). These requirements are set by SQA based on the discussions in the cross-functional team. The cross-functional team is a good platform for this, since there is knowledge from the complete organization.

When the internal roles and responsibilities are clarified, the focus can be shifted to the organization of communication with the supply base. As described in chapter 4, at this moment each SAM individually asks suppliers to provide PH with information. However, to make it possible to compare the repair feedback of different suppliers, this should become more standardized. In order to achieve such a standardized process, first the requirements should be made clear by the cross functional team. Moreover, it should be made clear what the capabilities are of suppliers to report on repair activities.
Therefore, representatives from suppliers should also be involved in the cross-functional team to identify the capabilities of repair reporting.

After the specifications are set, a model is designed based on creative thinking (synthesis). In Figure 28 a process chart is presented, based on the specifications discussed above. This process chart is an updated version of the current process chart for repair feedback as described in chapter 4. The adaptations are shown in the color green. This process explicitly takes the requirements of the BU’s, IS-OPS and SPS into account. As successfully shown in the case of disaster management, different functions should be combined in order to avoid fragmentation of questions to the supply base. Therefore, the different departments are united in a ‘repair feedback team’ instead of separate entities.

The direct change requests from suppliers to PH are still organized as a direct interaction between the suppliers and the BU’s. For repair feedback however, the SQA is involved to combine the different requirements for knowledge exchange. This is adopted from the process for disaster management. That is, for disaster management, it was found that determining a specific function which is responsible for combining the demands of the different departments is beneficial. The SAM remains responsible for the interaction with the supplier.

6.2 Pilot study

A pilot study was set up to evaluate the design in practice (see Figure 27). The goal of this pilot study was to find out whether the creation of a cross-functional team could improve the determination of repair feedback requirements including its potential applications within PH. Because this should be made clear before a detailed external communication can be designed, no attention was given to this topic. A workshop was organized, for which people from different involved departments of PH (SPS, IS-OPS, Purchasing and different BU’s) as well as several suppliers, were invited to identify their capabilities of repair reporting. Finally, a cross-functional group of 6 people was formed including representatives of internal departments and one participant from a supplier. Together several steps were taken to determine the requirements for repair feedback from suppliers. In Appendix 10, a detailed process design is given. In sub-section 6.2.1, the results of the workshop are presented. Sub-section 6.2.2 then discusses the findings and takeaways.

6.2.1 Workshop results

As indicated in the process design, first the potential applications of repair feedback were determined. A brainstorm session was held which resulted in a total of 13 different clusters with possible repair feedback applications. These clusters are displayed in the left column of Table 8. In Appendix 11 a complete overview of the brainstorm session and clustering is given. After the clusters were set, the priority of each cluster was determined. Every participant was asked to distribute 10 points over the most important applications (max. 6 points per application) and to shortly describe to the other
participants why this is the most important application for him/her. It was decided to leave the cluster ‘Defoa’ (Defect on Arrival) out of the priority determination. This cluster was indicated by one of the participants to be a special case of repair feedback because it mainly requires information from the Field Service Engineer. It should therefore be handled as a separate topic. Table 8 gives an overview of the scorings. The clusters ‘components’ and ‘trending’ were indicated as most important by the participants. Each of the participants agreed that these two are the most important issues because they are the main sources of information required to execute (most of) the other clusters. These two were therefore defined in some more detail:

- Component analysis stands for the detailed investigation of which components caused the failure of the part. It analyses in detail which component is/are broken within a part.
- Trending analysis focuses on failure trends. It looks for increase/decrease of failures, commonalities between failures etc.

For each of the two selected applications for knowledge feedback, action plans were defined. The participants were split-up in 2 teams. Each of these teams worked on a single application. For this, the issues of the conceptual framework were taken into account. The results of this step – the action plans – can be found in Appendix 12. These results only give a first step in developing a more structural way of organizing repair feedback. Different sessions like this are required to find out in greater detail who has to be responsible for certain issues. There are however some interesting findings from this workshop that can be taken as a lesson for the future. These will be discussed in the next sub-section.

### 6.2.2 Findings and takeaways

A main finding of this repair feedback workshop is that the first step of determining the utility of repair feedback should be the separation between continuous improvement and issue solving. Issue solving may be handled as a crisis situation, in which communication channels are organized on a fast and ad-hoc basis. For continuous improvement however, knowledge exchange should be organized in a much more structural way. In this workshop, the focus was on the exchange of repair feedback for continuous improvement. Several points were indicated as important takeaways/conclusions of this workshop.

- At this moment there is too much a one way flow of information and knowledge; PH asks a lot, but does not provide any feedback to the supplier.
• Component and trend analysis seem to be the basis on which much information can be retrieved. Although this should be verified with other people within Philips, these two seem to be the basic pillars on which repair feedback can be organized.

• The brainstorm and clustering session showed that there are a lot of different applications for repair feedback. Most of them require the same types of information.

• Discussion across departmental and organizational boundaries gave some interesting insights in each others’ work and views on potential applications of repair feedback. It was found that different departments within Philips struggle with the same issues.

• Obtaining repair feedback from suppliers is found to be much more difficult than just transferring some data. It seems that for each supplier individual agreements should be made.

• Sometimes so much data is received on which so much analysis can be done, that it is not known anymore what should be done, what the priorities are and who should do the analysis.

• Now, lots of analysis within the BU is based on field data, but repair data can also be interesting; especially when these two can be combined. Therefore alignment should be created.

In sum, because of the cross functional set up of the workshop different views were found that others had not thought of yet. Interaction between the different functions is needed to clarify the requirements towards the supply base. It can be concluded that component and trend analysis should be considered as the main applications for repair feedback. However, different sessions like this are required to investigate in greater detail which functions have to be responsible for certain issues.

### 6.3 Execution plan

The pilot study has shown that the designed process is potentially a good way to organize repair process at PH. However, still a lot of work has to be done and decisions have to be made before it is functioning properly. This section provides PH with a plan to execute the process design in practice. Before the designed process for repair feedback can be used, several actions have to be taken. These actions are:

• Determine exact application for repair feedback;
• Specify requirements and questions to suppliers;
• Increase internal transparency by specifying accountabilities on a functional level;
• Harmonize communication with the supply base for all SAMs.

### Table 9: Roles and responsibilities

<table>
<thead>
<tr>
<th>Function/Department</th>
<th>Role</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Repair feedback team’</td>
<td>Decision making unit</td>
<td>- Defines the most important applications of repair feedback;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Sets the required information from repair suppliers.</td>
</tr>
<tr>
<td>Service purchasing (SQA)</td>
<td>Process owner</td>
<td>- Defines requirements to suppliers based on input from members of the ‘repair feedback team’.</td>
</tr>
<tr>
<td>SAM</td>
<td>Interface to supplier</td>
<td>- Communicates with supplier based on a standardized process.</td>
</tr>
<tr>
<td>SPS</td>
<td>Infrastructure provider</td>
<td>- Provides a database and tool in which repair feedback of different suppliers can be stored and analyzed.</td>
</tr>
<tr>
<td>IS-OPS (repair)</td>
<td>Repair- and supportive activities</td>
<td>- Repair supplier for SPS and thus collects repair data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Executes autopsy to verify repair tools and processes of suppliers.</td>
</tr>
<tr>
<td>BU’s</td>
<td>Product owner</td>
<td>- Uses repair feedback based on the requirements set in the ‘repair feedback team’. Potentially functions like R&amp;D, NPI, reliability, and service innovation are involved;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Runs change activities in cooperation with suppliers.</td>
</tr>
<tr>
<td>Supplier</td>
<td>Provider of repair reports</td>
<td>- Collects repair data based on the requirements set by the ‘repair feedback team’ and provides it to PH;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Participates in change activities that follow from repair feedback</td>
</tr>
</tbody>
</table>
Because it was found during the analysis that different internal stakeholders are not aligned, it is advised to make use of a cross-functional ‘repair feedback team’ that is responsible for executing the actions stated above. Such a ‘repair feedback team’ can be formed around current cross-functional initiatives, such as the Product Quality Teams. Representatives of the service purchasing team should be defined as the process owner for the organization since this function is responsible for linking the requirements of PH to the capabilities of a supplier. Moreover, within the service purchasing team, there are currently pilot projects with suppliers on repair feedback (by SQA), which has created some insights in how to manage this. In Table 9, the roles and responsibilities of the other members of the ‘repair feedback team’ are determined.

6.4 Reflection
In this chapter, a redesign has been presented for the execution of repair feedback at PH. It was found during a discussion session that disaster management is already organized quite well. Some recommendations were given on how PH could secure the current experience on disaster management for future crises. However, main focus is given to the change of the current procedures for the exchange of repair feedback with suppliers. First a process has been designed in which the supply base and different departments of PH are linked to each other to increase the transparency of repair feedback activities. Part of this designed process was then executed in a pilot study to determine the applicability in practice. During the pilot study interesting results were obtained. However, several steps have to be taken before the process can be fully applied. Therefore, the roles and responsibilities were defined to execute these steps.
7 Conclusions and Recommendations

In this chapter the conclusions and recommendations of this study are set out. Conclusions are drawn in section 7.1. This will be done based on the research questions. The managerial implications are shown in section 7.2. In section 7.3 the contribution to theory is presented. Finally the limitations (section 7.4) and suggestions for future research (section 7.5) are discussed.

7.1 Conclusions

Knowledge exchange between firms in the after-sales service supply chain is an important determinant of successful after-sales service delivery for OEMs. Within after sales-service several aspects influence the behavior of and relationships between firms. Since the characteristics of buyers and suppliers and their relationships are important determinants for the success of knowledge exchange; in the case study the following research question has been researched:

What should an OEM change in its current supplier management processes to proactively obtain information from its after-sales service suppliers and transform this information into useful knowledge for its internal and external stakeholders?

With the following sub-questions:

1) How do the drivers of inter-firm knowledge exchange influence the knowledge exchange processes between Philips Healthcare and its suppliers in the after-sales service supply chain?
2) How are the knowledge exchange activities between Philips Healthcare and its after-sales service suppliers currently organized and how can this be improved?
3) How should Philips Healthcare organize its knowledge application processes, so that it results into useful knowledge for both the after-sales service suppliers and the stakeholders within Philips Healthcare?

Before answering the questions mentioned above, first the conclusions regarding literature are drawn in sub-section 7.1.1. Then the conclusions with regard to each of these sub-questions are described in sub-sections 7.1.2 – 7.1.4. Finally in sub-section 7.1.5, the research question will be answered.

7.1.1 Conclusions regarding literature

After sales service is of growing importance for OEMs because after-sales services are considered a more stable source of income than products, service offerings positively influence both first-time and repeat buying decisions, services show a higher profit margin compared to product offerings and, by providing services, a company can get a better understanding of the customer’s needs compared to its competitors (Cohen et al., 2006). Since this study has been executed in the context of the healthcare sector, special attention has been given to the market environment in this sector. The healthcare sector is traditionally organized in a non-competitive way. However, due to rising costs there is a trend towards a more commercial healthcare sector that act at lower costs (Porter & Teisberg, 2006). This has implications for suppliers to the healthcare sector since they have to guarantee higher uptimes of their systems in the field and higher and more reliable throughput times of their medical devices. Therefore, the implication for the OEM is to minimize the downtime by offering an after-sales service supply chain that is able to quickly respond to failures in the field (Peterson et al., 2005).

The after-sales service supply chain differs from normal manufacturing and service supply chains in several ways. First, the after-sales service supply chain combines both manufacturing and service supply chains to deliver a combination of products (e.g. spare-parts) and services (e.g. repair services and in-
field maintenance) to the customer. Second, the demand forecast for after-sales is unpredictable since it cannot be forecasted when a system will fail and which part of that system fails. Thirdly, the after-sales service supply chain includes reverse logistics operations (Johnson & Mena, 2008). This means that the supply chain is not a one-way process, but in fact includes a stream backwards to ensure activities such as repair, refurbishment and recycling (Thierry et al., 1995). It was found that information sharing with suppliers is an important input for OEMs to create well-organized supply chains. However, the information flows upstream in the after-sales service supply chain did not receive much attention yet. Many scholars only focus on successful information transfer, without taking into account the creation and application of knowledge within the supply chain (e.g. Fawcett et al., 2007; Easterby-Smith et al., 2008). This study has tried to develop a conceptual model in which information from different actors can be taken to a higher level by performing both knowledge exchange activities and knowledge application.

The activities required for the exchange of knowledge can be seen as a three step process (Graham et al., 2006). The first step involves the actual transfer of information from the supplier to the buyer. This can happen in many different ways, and depends mainly on the degree of tacitness of the transferred information. The second step is to combine the different information resources towards a synthesis. This should be a result of either activities employed within the OEM, activities that are employed in collaboration between buyer and supplier, or activities employed at the supplier. The third step is then to formalize this synthesized knowledge into processes and tools that can be used by the members of the supply chain. The actual implementation of these processes and tools is defined as knowledge application. During knowledge application the developed processes and tools are adapted to the local/organizational setting and then implemented (Song et al., 2005). It is important to precisely monitor this process to make sure that the new working method is indeed an improvement. This is best done by setting preliminary goals that have to be met through the knowledge exchange and application activities.

Factors that influence successful knowledge exchange include: information characteristics, inter-firm relationships, and buyer and supplier characteristics. Each of these factors involves underlying characteristics that help to identify and measure the influence of these factors. Six specific variables were defined that indicate the differences between knowledge exchange in production supply chains and after-sales service supply chains. These variables include the variety of resources, the (lack of) mutuality of goals, the amount of turnover spent by the buyer, the incentives for future business, the link between the supplier and the end-customer, and obsolescence of spare-parts.

7.1.2 Conclusions regarding the characteristics of inter-firm knowledge exchange
In this section, an answer will be provided on sub-question 1:

*How do the drivers of inter-firm knowledge exchange influence the knowledge exchange processes between Philips Healthcare and its suppliers in the after-sales service supply chain?*

The characteristics of inter-firm knowledge exchange were identified based on a review of the literature. The drivers behind these characteristics can help to interpret the success and difficulties of knowledge exchange. It was found that, in after-sales service supply chains, information on different topics can be exchanged, including Defects on Arrival (Defoa’s), repair feedback, service improvements, technology roadmaps and information during disaster management. Each topic has its own characteristics and should therefore be managed in different ways. However, non-codified knowledge (i.e. open-text field) significantly reduces the quality of information in terms of accuracy and ambiguity and should therefore be avoided. Besides, creating more regular intervals of information transfer is important for the
perception of relevance and timeliness of information. This, in turn, may increase the willingness to share information at both the supplier and the buyer.

The characteristics of suppliers are different for each company. Each supplier is organized differently and has different focus points. Although this makes it hard to generalize the findings on supplier characteristics, some similarities on how suppliers responded on the account of PH were found. For most suppliers PH is a large customer and thus multiple resources are allocated to that account. The size of the account of PH at a supplier thus impacts supplier behavior. The size of the supplier’s organization was found to be no restriction for knowledge exchange. In literature, it was stated that larger companies are better capable of utilizing their resources for successful knowledge exchange. However, in the case study, the opposite was found. Within PH knowledge exchange was limited due to the organizational size. That is, information is often ‘invisible’ for the people in the organization. This was the result of the many different departments that all have their own working methods, which makes responsibilities unclear. Moreover, departments were unaligned and processes for knowledge creation were lacking. This makes it difficult to follow up on the information that was provided by the supply base.

The informal contacts between PH and suppliers increases the exchange of knowledge in ad-hoc situations (such as in crisis situations) but makes the exchange of structural information more difficult. In normal situations, PH has the most power in the relationship with its supply base. Therefore, suppliers are willing to invest in the relationship with PH. However, within the after-sales service period, it was found that these investments are declining.

Most variables that were found to influence the behavior of buyers and suppliers in the after-sales service supply chain are found to be present for PH. The presence, in the after-sales service supply chain, of variety of resources, mutuality of goals, amount of turnover spent by the buyer, incentives for future business and obsolescence of spare-parts make it difficult for PH to effectively organize knowledge exchange with its after-sales service suppliers. The moderating effect of the direct link between the supplier and the end-customer does not play a role in the case of Philips Healthcare.

7.1.3 Conclusions regarding the inter-firm knowledge exchange activities
In this section, an answer will be provided on sub-question 2:

How are the knowledge exchange activities between Philips Healthcare and its after-sales service suppliers currently organized and how can this be improved?

It was found to be important that only information that is really required should be obtained from suppliers. That is, there is a tendency within PH to ask as much information as possible from the supply base without knowing where to use it for. This results in high pressure on suppliers to provide all these types of information, without focusing on the core requirements. Besides the extensive set of questions asked to suppliers, the way in which the actual communication with suppliers is organized, differs per supplier.

There is no standardized way of communicating which creates a scattered collection of communication channels without someone having the complete overview. A lot of communication between PH and its suppliers mainly takes place through face-to-face meetings, T-cons or e-mail. This means that there is no much exchange based on structured formats. However, in the case of disaster management it was found
that the use of standard templates can be successful. With templates, everybody is forced to work with the same method.

To be able to do good analysis, it is important that the information is reliable. Therefore, information from suppliers should be verified before the actual analysis can be executed. This may require a lot of resources. It depends on the goal of the knowledge exchange whether PH or the supplier should do this. Within PH, there is a strong opinion to leave analysis as much as possible to the supply base. However, at this moment suppliers do not see the added value of doing this. Main reason for this is that they do not receive detailed requirements from PH to do the analysis. In case of disasters, this is different, because in such cases PH provides suppliers with as detailed information as possible. It is an important learning for cases of structural knowledge exchange that PH should be more precise in the questions towards the supply base.

Suppliers are willing to help PH in a lot of different areas. Moreover they are often capable in doing so. This is different from the perception within PH where it is generally assumed that suppliers are not capable to deliver qualitative information based on the requirements of PH. This was especially found in the investigation of repair feedback.

In sum, fixed structures are not in place for knowledge exchange between PH and the supply base. This begins with the communication to suppliers, which is scattered and not structured. Moreover, within PH there is often no exact focus on the goal of knowledge exchange activities. An exception of this occurs in case of disasters, when people within different departments have the right objectives in mind. Therefore, it can be concluded that knowledge exchange with suppliers should be organized in a structured way in order to gain valuable results. Three steps were found in literature that should be gone through in order to create valuable knowledge based on input from suppliers. For each of these three steps, it is important that suppliers remain involved in the execution. That is, the outcomes of the knowledge exchange activities may be input for new activities or actions that should be executed in the supply chain. This can be to either improve products and processes at PH or at the supplier.

7.1.4 Conclusions regarding knowledge application
In this section, an answer will be provided on sub-question 3:

How should Philips Healthcare organize its knowledge application processes, so that it results into useful knowledge for both the after-sales service suppliers and the stakeholders within Philips Healthcare?

In recent years, the attention to after-sales service has grown within PH. The Plus Model and a dedicated service-parts & repair department within IS-OPS were set up to create better alignment between the different functions within PH. Moreover, the establishment of the Service Purchasing team created an intermediary between the after-sales service organization of PH and the suppliers for service-parts & repair. The results that are currently visible are an increasing focus on specific after-sales issues. First, there is a strong focus within the organization on Defoa reduction, second, a facility was set up for refurbished systems and, third, direct buy initiatives were started to cut out costs for after-sales service.

A growing need for knowledge to perform these improvement initiatives was identified. This knowledge can be created by collecting information both within PH as well as at the partners in the after-sales service supply chain. In both cases it is important to make clear what will be done with the information before collecting it, to avoid the collection of irrelevant information. Especially towards suppliers, it is important to be precise in this, since they have to assign extra resources to the gathering of information.
Therefore, the application of the knowledge should be defined first. Knowledge application has often been neglected in literature as a part of the knowledge exchange process. Also in the case of PH knowledge application does not receive much attention. Although many different people within PH state that knowledge from the supply base is vital for the (after-sales) organization of PH, it was much more difficult for these people to exactly define how that information should be applied.

Several steps should be taken to come to the desired explicitness. Once the goals for the application are set, the actual application should still be performed. This should be managed closely by PH. In order to successfully apply knowledge within PH, there should be regular input from the suppliers to create some sense of relevance at both the supplier and buyer. In order to achieve this, PH should be very specific in asking questions. As found in disaster management, this was done successfully. The information that was exchanged was all related on cost, availability and lead-times. This made it possible for the supplier to be very precise in answering.

7.1.5 Inter-firm knowledge exchange in the after-sales service supply chain for OEMs

In this section, the answers to the sub-questions will be combined to provide an answer to the research question of this study:

*What should an OEM change in its current supplier management processes to proactively obtain information from its after-sales service suppliers and transform this information into useful knowledge for its internal and external stakeholders?*

There are many topics within after-sales service supply chains that require the exchange of knowledge to allow successful management. In the executed case study it was indicated that service-parts and repair suppliers may contribute by providing knowledge on several topics. Each of these topics has their own characteristics and therefore need individual investigation to identify the required processes for inter-firm knowledge exchange. There should be a clear focus on how and where the knowledge of the supplier will be applied. For suppliers, this is found to be very important, because it gives them insights in where the information they share is used for. Therefore, after the application has been determined, clear requirements should be communicated to the supply base. By asking very concrete questions, suppliers are better able to collect the needed information. Since a supplier should assign resources to the collection and sharing of information, the OEM should understand that suppliers request for such unambiguous definitions. Based on this it can be made clear who will do the analysis on the obtained information. This can be done either by the supplier, by the OEM (buyer) or in collaboration.

Since the reliability of the exchanged information is considered to be one of the most important determinants of successful knowledge exchange, the OEM should create standardized structures for communication. That is, all people that get in contact with the supply base should do this in the same way. Especially when critical data is exchanged that will be used for analysis and/or comparison with other data sets. The quality of communication with the supply base can be further increased by creating a single point of contact for the suppliers. By doing so, responsibilities are clear transparency is improved as the owner of certain information is known. Besides a single point of contact, it should also be made clear that knowledge is exchanged regularly. By defining fixed time intervals between which information is provided by the supplier, the perception of relevance and timeliness of information will be improved. This, in turn, may increase the willingness to share information at both the supplier and the buyer.
7.2 Managerial implications
Based on the above conclusions, several implications can be defined for both managers within PH as well as managers of other OEM firms that deal with similar issues. The implications are based on the main improvement areas that were defined for PH. First, utility of knowledge exchange should be made clear before actual knowledge exchange takes place. This is discussed in sub-section 6.2.1. In sub-section 6.2.2 implications are shown on the improvement of internal transparency that is required for successful inter-firm knowledge exchange. Finally, in sub-section 6.2.3, the implications for the improvement of external communication are presented.

7.2.1 Define the utility of knowledge exchange
It was found at PH that it is difficult to exactly define the needs that have to be achieved with knowledge exchange. A good example was found in the case of repair feedback where many different ways to use repair feedback were identified by the different respondents, but none of them was able to describe the process in detail. To better define the utility of knowledge exchange, several recommendations can be given.

- Determine the exact applications for which repair feedback can deliver the most added-value. Defining the utility of knowledge exchange starts to investigate where this knowledge can be used for. If this is agreed by different actors in the organization, it will be much easier to organize the knowledge exchange and application activities.
- Execute component and trending analysis for repair feedback. These two types of analysis were found to be the underlying knowledge sources for many applications of repair knowledge. With these analyses you know for example which components are broken (component analysis) and how often this happens (trending analysis).
- Improve the focus on after-sales service within the organization. This will result in a better visibility of problems in after-sales service delivery which will lead to allocation of more resources to start improvement projects such as knowledge exchange with suppliers.

7.2.2 Improve internal transparency
Internal transparency is an important requirement for successful inter-firm knowledge exchange. A striking example of the confusion that can arise when internal responsibilities are not clear was found at PH. Interviews with both suppliers and purchasers showed that there are meetings with each other regularly. In these meetings, problems are discussed and business is evaluated. Employees of PH who do not have direct contact with suppliers had a different opinion about this. One of them stated that “currently there is no communication based on a fixed structure, only sometimes ad-hoc on part level”. This is an interesting finding because it shows that there is a lack of transparency within PH. Although there are regular meetings with (key) suppliers, the results of these meetings are not spread throughout the organization. To improve the internal transparency, several recommendations can be given to managers.

- Use cross-functional discussion sessions to find out the main problems and motives of other functional areas. One of the main takeaways of the workshop organized for repair feedback was that people from different departments were not aware of the activities employed in other departments.
- Define exact roles and responsibilities for the knowledge exchange activities. Before asking suppliers to exchange information, it should be made clear who is responsible for what part of the exchange activities. The cross-functional discussions can be used to determine this.
• When a disaster has occurred, the experiences of that disaster should be secured in a business continuity plan. Such a business continuity plan can secure the lessons for disasters that may happen in the future.

7.2.3 Organize external communication in a structured manner
In order to create valuable knowledge that can be compared for different suppliers, it is important that communication with the supply base is organized in a structured manner. At PH however, the communication with the supply base is scattered and too much ad-hoc based. Different departments start their own projects with suppliers without discussing this with the internal stakeholders. This was found in disaster management where different departments started to secure their demand for their own products. For repair feedback a supplier stated that he is involved in many different projects related to service-parts and repair, all with different departments. To better structure the external communication, managers should take into account the following recommendations.

• Standardize the way in which purchasing managers communicate with suppliers on critical information. When each purchasing manager receives different types of information, it is very difficult to perform unambiguous analysis on that information.
• Create more discussion between suppliers and the focal firm to determine the requirements of knowledge exchange. At PH, there was a large variety in the quality of information from different suppliers. When requirements are set more precise, suppliers better know what to exchange.
• Study the possibilities of standardized coding for repair activities. It was found during the case study that many repair suppliers use ‘open text fields’ to report repair feedback. This hinders the analysis of the data and reduces the quality of information in terms of accuracy and ambiguity. The use of standardized coding reduces this significantly.

7.3 Contribution to theory
The literature review that was executed in this study has identified a gap in literature with regard to inter-firm knowledge exchange in the after-sales service supply chain. The studies of Moberg et al. (2002), Hult et al. (2004), Fawcett et al. (2007), and Myers & Cheung (2008) all discussed the knowledge exchange between organizations in a supply chain. However, they have not paid attention to the explicit situation of after-sales service. This study has tried to contribute to this gap in literature by developing a conceptual model that investigates the drivers for inter-firm knowledge exchange and extended it with by taking into account variables for after-sales service. These variables have been identified by examining existing literature. Since this literature was fragmented and not focused on the purpose of this study, the variables have been tested in a case study. Besides, this conceptual model contributed to the existing literature by taking into account not only the knowledge exchange activities, but also including the application of knowledge in the supply chain. Knowledge application is the capability of an organization to use the knowledge generated during the exchange activities. Knowledge application is not very much addressed in literature yet, since most studies focus on the degree of information and knowledge exchange, either in terms of ‘how much’, ‘at which speed’ or ‘how effective’. Only a few papers discuss how the determinants of knowledge exchange can enhance knowledge creation (Meier, 2011). By adding application to the conceptual model, the effort that has been put in inter-firm knowledge exchange activities can actually be used to create value in the supply chain.

7.4 Limitations
Despite the merits of this study, there also are some limitations. First, little attention is given to the information exchange from the OEM towards the supply base. For PH, an important topic in this area is
the feedback from the field service engineer towards the repair supplier. This feedback may help the supplier in determining the failure cause of a part. However, the quality of the feedback from the FSE is often lacking, which makes it impossible for the supplier to use it. Second, because no extensive body of literature on after-sales service supply chains is available, the developed conceptual model has been built up from different other research streams in supply chain management. Therefore, the theoretical completeness and practical relevance of this conceptual model cannot be proven. Third, this study seeks to identify how OEMs should organize their processes for inter-firm knowledge exchange in the after-sales service supply chain. However, since this case-study was executed within a single OEM, the generalization towards other companies should be made with some prudence. Fourth, the case study conducted in this research, only tested the conceptual model for two topics; repair feedback and disaster management. For the other topics that were identified during the orientation phase of this study, different requirements might be found. Finally, the suppliers that were interviewed for the cases were selected with strong involvement of representatives of PH. It might be that this has created a bias toward suppliers that have a good relationship with PH.

7.5 Suggestions for future research
Based on this study, there are several directions for further research. First, the developed conceptual model requires further testing in the field to determine its theoretical completeness and practical relevance. Although the current case study has shown its applicability, more studies should be executed to prove its robustness in different situations. Second, since the main focus of this study was on knowledge exchange from the supplier to the buyer, it would be interesting to test the applicability of the framework on knowledge exchange from the buyer to the supplier. Third, the proposed factors in the conceptual model are originating from different research streams. It might therefore be interesting to also test the framework for other types of supply chains. Fourth, besides for different types of supply chains, the framework could also be tested for other types of interactions, such as that between the OEM and the end-user. Fifth, further research might be focused more on the application of knowledge that takes place after processes have been standardized. Thus, there might be for example studies on how buyers and suppliers behave over time when the exchange of knowledge is structured and embedded within their organizations. For this it would be interesting to see what action should be taken to maintain the knowledge exchange activities and what factors influence change in these activities over time. Sixth, an interesting finding of this research is that power shifts during the after-sales period towards the supplier. It might be interesting to study in detail how the OEM should manage this. Finally, it was found in literature that the larger an organization the better it is capable to exchange knowledge with other organizations. However, in the case study it was found that a large organization (PH) had many difficulties compared to smaller organizations (several suppliers) because of the lack of transparency in the organization. It is interesting to find out how this difference occurs.
Bibliography


# Appendix 1 – Factors Influencing the Conceptual Framework

<table>
<thead>
<tr>
<th>Authors (year)</th>
<th>Knowledge/information characteristics</th>
<th>Buyer/supplier characteristics</th>
<th>Inter-firm relationships</th>
<th>Exchange activities</th>
<th>Knowledge application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyer &amp; Singh (1998)</td>
<td>- Absorptive capacity - Network position</td>
<td>- Absorptive capacity - Ability to recognize knowledge value - Ability to assimilate and use knowledge retention capabilities - Intra-organizational Transfer Capability - Motivation to teach (donor) and learn</td>
<td>- Relationship length - Volume/intensity of exchange - Complementarity of donor firm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easterby-Smith et al. (2008)</td>
<td>- Tacitness - Ambiguity - Complexity</td>
<td>- Absorptive capacity - Ability to recognize knowledge value - Ability to assimilate and use knowledge retention capabilities - Intra-organizational Transfer Capability - Motivation to teach (donor) and learn</td>
<td>- Power relations - Trust and risk - Social ties</td>
<td>- Structure and mechanisms of the relationship</td>
<td></td>
</tr>
<tr>
<td>Fawcett et al. (2007)</td>
<td>- Strategic and operational knowledge - Tacit knowledge</td>
<td>- Willingness (tempered by competitive disadvantages) such as info leakages - Technical connectivity</td>
<td></td>
<td>- Face-to-face meetings - IT-systems</td>
<td></td>
</tr>
<tr>
<td>Moberg et al. (2002)</td>
<td>- Accuracy - Timeliness - Proper formatting - Operational information - Strategic information</td>
<td>- Information technology commitment - Organizational size - SCM commitment</td>
<td>- Trust</td>
<td>- IT-systems</td>
<td></td>
</tr>
<tr>
<td>Modi &amp; Mabert (2007)</td>
<td>- Top-management involvement</td>
<td>- Top-management involvement</td>
<td>- Competitive pressure - Evaluation and certification - Future business incentives - Long-term relationship - Trust - Degree to which the donor can satisfy the requirements of the recipient. - % of turnover of donor fulfilled by the buyer</td>
<td>- Collaborative communication - Direct contact</td>
<td>- Supplier performance improvement</td>
</tr>
</tbody>
</table>
| Myers & Cheung (2008)            | - Risk of copying/sharing with competitors  
- External knowledge might undermine flexibility of decisions | - Information sharing  
- Joint sense making  
- Knowledge integration | - Agility to react to changes  
- Adaption to market structures and environmental conditions  
- Alignment of supply chain members |
|---------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Nonaka (1994)                   | - Truthfulness  
- Volume  
- Transferability of the meaning | - Creative chaos  
- Redundancy of information  
- Requisite variety | - Cross functional teams  
- Face-to-face communication  
- Creative dialogues  
- Share images | - Cost reduction  
- Improved profit margin  
- Higher contribution to the firm’s development  
- Consistence with the organization’s vision |
| Simatupang et al. (2002)        | - Tacitness  
- Relevancy  
- Accurate  
- Timely | - Mutual trust  
- Common implicit perspective | - IT-systems  
- Personal communication  
- Codified communication  
- Joint training | - Customer service  
- Inventory velocity  
- Responsiveness  
- Product quality  
- Product availability  
- Lead-times  
- Cash conversion  
- Logistic cost  
- Net asset returns  
- Total inventory days of supply |
IS Purchasing Organization

IS Purchasing Manager

- Finance
- Human Resources

- Assistant

- GTC Purchasing Manager
- MRI Purchasing Manager
- IXR Purchasing Manager
- DXR Purchasing Manager
- CT/NM Purchasing Manager
- US Purchasing Manager

- Commodity Cluster
  - Mechantronics & IS Specific

- Supplier Quality Assurance
- Supply Program Office
- Value Sourcing & Productivity

- Suzhou Purchasing Manager
- Brazil Purchasing Manager
- India Purchasing Manager

- G55 Purchasing
- SPS Purchasing

- PNMS Purchasing Manager
Service Purchasing

Purchasing Europe
- Service Purchaser (XR, BST)
- Service Purchaser (MR, BST)
- Service Purchaser (GTC, PPP, HBG)
- Service Purchaser (BBN)
- Student (BST)

Purchasing North America
- Service Purchaser (CT, CLE)
- Service Support (CLE)
- Supply Talent Assignment (CLE)

Commodities & Programs
- Commodity Mgr. (Repair, CLE)
- Commodity Mgr. (Packaging, BST)
- Program Purchaser (BST)

Supplier Quality
- Supplier Quality (BST)
- Supplier Quality (CLE)
- TBH Supplier Quality (BST)
- TBH Supplier Quality (CLE)
### Appendix 3 – Orientation Interviews

<table>
<thead>
<tr>
<th>Department respondent</th>
<th>Duration</th>
<th>Discussed topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>BU-IQR</td>
<td>2hr</td>
<td>An important factor for customers is the ‘Elapsed time to Repair’ (ETTR). Within the BU, there is therefore a serviceability strategy to make service better and cheaper. This strategy includes service innovation (towards the FSE) and service marketing. However, these do not include any contact with the supplier. PH indicated the lead-times for repair to be on average 35 days. However this is currently around an average of 120 days. When reducing this in cooperation with the suppliers, this means that a lot less stock is required in the SPS warehouses and a higher turnover of spare-parts can be realized.</td>
</tr>
<tr>
<td>BU-MR</td>
<td>1hr</td>
<td>The procedure at the FSE should be improved, to reduce mistakes on for example NFF in autopsy. That is, the FSE is now simply replacing some units which might be broken. However, they may be not broken at all. This is, because the FSE has not the tooling to test or replace certain particular components of a spare-part. This increases the flow of NFF-products. Although there currently is a program in place in which dedicated engineers of PH are trying to improve the service delivery (Program for Released Products (PFRP)), suppliers should be involved because they are the real product specialist of many spare-parts. Within PH there is a tendency to specify everything by themselves, while suppliers are often much better in it.</td>
</tr>
<tr>
<td>BU-MR</td>
<td>2hr 15min</td>
<td>It is currently not exactly known which components are in the different systems. This is hard to identify since IS-OPS buy modules which are then labeled as service parts. This makes it very complicated when a supplier announces the phase-out of a particular product (e.g. hard disk drives), because within PH nobody knows exactly to which systems this phase-out is related. When the right system is identified, there are two options to take which is a last time buy at the supplier, which can be either held on stock at PH or at the supplier (depending on negotiations) or a redesign of the system in such a way that a new type of the product fits into the system. This is called backwards-compatible design.</td>
</tr>
<tr>
<td>BU-MR</td>
<td>50min</td>
<td>For Quality Defoa suppliers do not manage the problems in their products enough. However, it also happens that suppliers come up with improvement suggestions, but PH denies them because of struggles in the own organization. To reduce the number of quality Defoas, new processes should be in place. For this, suppliers could help by communicating information about the parts so that the handling of these parts by PH can be improved. For example, issues like shelf life and product changes are helpful. Another problem is that communication often takes place in informal and unstructured ways. Although this is satisfactory for the individual employee, for PH this means a fragmented information pool and suppliers who do not know who is responsible within PH for certain issues.</td>
</tr>
<tr>
<td>IS-OPS</td>
<td>1hr</td>
<td>The operational buyers have difficulties to monitor the suppliers because there is too little information about for example throughput-times, Defoa and repair yield (scrap). This makes it impossible for IS-OPS to make a route-cause analysis of the failure of a part. For aged parts IS-OPS looks together with the supplier for solutions. This is very difficult because it is often in the end of the life-cycle (after support is guaranteed (best effort period)). SPS requires most from IS-OPS (and similar for external suppliers) information sharing about Defoa and delivery performance. Delivery performance consists of process monitoring and material scarcity.</td>
</tr>
<tr>
<td>IS-OPS</td>
<td>50min</td>
<td>Repair is currently the most discussed topic within PH. Moreover it is a more complex field than new-buy purchasing, because in new-buy purchasing is mainly about cost issues. Instead, repair has many issues to cope with: How important is their repair for the supplier financially? How large is the repair department within the total supplier’s firm? Is there a dedicated repair process at the supplier, or is it just done as ‘extra’? What is mentioned about repair in the contracts with suppliers (warranty, explicit section about repair)? Besides, especially the reduction of repair lead-times can be an interesting topic. It is currently hard to predict how long a repair will take before the part is available again.</td>
</tr>
<tr>
<td>Purchasing</td>
<td>30 min</td>
<td>The link between supplier and FSE is currently missing, because several logistical chains are in between them. Because this communication is weak and the origin of a part cannot be traced, the supplier is not able to find out the causes of a failure. Also without part traceability, the communication between supplier and FSE can be improved. Therefore, information from the supplier can be used to better instruct the FSE, so that they are able to replace certain parts on side. Moreover, information from the supplier can give insight in, so called, epidemic failures, which are failures of a complete production batch. For this warranty claims can be sent to the supplier. However, there is currently no procedure for warranty. If you want to change that, the FSE (or the blue-room) should be able to identify the production/repair date of a part. The supplier should also be able to do this, but this is not asked to them currently.</td>
</tr>
<tr>
<td>Service Purchasing</td>
<td>1hr</td>
<td>Service has been delivered for a long time but often against high costs and low efficiency. Because of higher demand for service, this has to change. Machines are sometimes sold at cost-price making service as the only profit maker. By involving suppliers to become more efficient</td>
</tr>
</tbody>
</table>
and reduce costs, it is most important that knowledge of the suppliers about quality is consolidated in a central system where everybody can access to. This should improve the transparency of which parts origin from which supplier. Moreover, it should lead to a quality measurement towards the suppliers, based on which improvements can be initiated. It also has to flow to other departments of PH)

| Service Purchasing | 1hr 15min | Currently, PH does not have insight in what exactly is repaired by the suppliers on the component level. That is quite strange if you realize that yearly millions of Euros are spent by PH on repair. At this moment, suppliers are free to take that money without giving feedback. At this moment, we are busy to ask for raw data from the suppliers and do the analysis ourselves. However this should not be what we want. We are the customers of the repair-suppliers, so they should provide us with useful services and feedback instead of us controlling their work. Moreover we should expect from the supplier that he takes reasonable actions to prevent the component to fail again. Especially when the design of the parts is done by them. If it is a Philips design, we should be the one who has to do the analysis. However, since they are paid for the repair, they should provide us with useful feedback. |
| Service Purchasing | 1hr 15min | If PH asks for information to the supplier, it will almost always get it. However, PH often does not specify properly what they expect from the supplier. Therefore, the information problem is not so big; the problem is what PH does with this information. Information has to be organized around different categories. Two are specified: 1) development has to be alert on life-cycle issues and 2) Defoa feedback has to be more extensive because much Defoas are reported as No Failure Found by the repair suppliers. Other items that are not organized properly (mainly due to lack of internal processes) are: cost-reductions, warranty-issues and part-traceability (no unique part numbers). |
| Service Purchasing | 1hr 30min | Service purchasing has become important because someone indicated that service had very high costs relative to the purchase of materials for operations which is characterized by high volumes and thus high cost reductions. Service wants to know information about the supplier because problems at the supplier directly influence the service execution. Examples include: financial stability of the supplier; start-up costs of an order; reliability of the parts (or length of their life-cycle); profit margin of the supplier; exact manufacturing facility (does it take place at the supplier or has the supplier it outsourced as well?); repair history of a part; and serialization of parts. If the supplier does this, bad production batches can be identified. |
| Service Purchasing | 40 min | Information about business planning and product portfolio is required to increase the service level of PH. A large improvement opportunity can be gained by reducing the amounts of repair. This can be gained by improving the possibilities for good diagnostics in the field and better control over repair suppliers. It may lead to reduction of transportation, fewer unnecessary field replacements and reduced external repairs. |
| SPS | 30 min | Within PH, there is a need for order confirmation and lead-time information on an operational level. On a more tactical level, information about defects is required; this includes information about what is defect and how often and the corrective action of the supplier. Finally strategic information needed is about knowledge sharing on design issues with PH R&D. Operational information is the most important. It is about the order, lead-time and pro-active reporting on defects and repair. Ideally, it should all be included in the contracts, but this is not the case yet. However, we don’t do everything right. For example, we explicitly mark the difference between Defoa items and normal repair streams. However, we then don’t tell the supplier how they should handle these to streams differently. |
| SPS | 40 min | Inventory and Defoa are very important. The ideal inventory level is a optimum between flexibility and spent. A higher inventory level (high spent) means a very flexible and responsive organization hence, low down times in the field. Too much Defoa has a high impact on customer satisfaction. At one side, the on-time delivery is optimized (up to 98% for CCP) it makes no sense however if a large amount of these parts seem to be defect on their arrival. Currently, the processes at PH do not provide ways to handle Defoa properly. |
Appendix 4 – Ishikawa Diagram

Supply Chain Operations
- Extra service parts through system harvesting
- No FIFO flow at warehouse
- Spare parts from suppliers
  - PLC of parts is smaller than PLC of system
  - In same stream as repair parts
- Logistics
  - Poor packaging
  - Poor transportation
- Lead times
  - CCP: 98% on time
  - Non-CCP: 95% on time
- No view on 2nd tier suppliers
- Compliance at suppliers not regularly controlled
- 60-70% internal
- 30-40% external suppliers
- BMC = in all countries 95% on time
- Lost parts
- Supplier quality
  - Supplier quality tests different
  - PPA not available for all service parts
- Diagnosis/Autopsy
  - Wrong investigations by FSE, blue room or supplier
- Working Processes
- Unpredictable repair cycle times
- Now: Management of escalations
- Difficulties in forecasting demand

Quality
- Focus on BOM parts in Purchasing
  - Focus on BOM parts in Purchasing
  - Low urgency for suppliers
  - Downtime is unpredictable
  - Constraints in service supply chain
- Weak position for negotiation
  - Small # of parts
  - High dependency
  - No periodical updates
- Poor supplier contracts on Service
  - No process on warranty claims
  - No process on warranty claims
  - No process on warranty claims
  - Business Review Meetings
- Supplier Cooperation
  - Contact with only small part of supply base (about 10%)
  - No contact between supplier and FSE on root-causes

Information Availability
- No tracking of # of failure
- No individual part serialization
- No due about age of part
- Old and new parts not distinguished
- No connection between different systems
- Connection problem between different systems
- Different supplier information systems
  - PPS/BOM/Service not always combined
  - Master Data System

Quality of After-Sales Service SC
Appendix 5 – Supplier Selection

The selection criteria were defined in cooperation with the project supervisors of PH in order to select relevant suppliers. The two cases that were studied differ from each other in several ways. For each case, a selection of suppliers had to be found that are experienced in the topic of the respective case. The argument for this was that experienced suppliers are better able to give a valuable opinion on the case topic. When selecting suppliers randomly, it would have been difficult to get detailed insights. Besides this selection criterion, also a more practical criterion was applied to the supplier selection process. It was decided for both cases that it would be beneficial to have face-to-face interviews with the supplier representatives. Therefore, only suppliers within an acceptable travel distance from Best were selected. Thus, foreign suppliers without a branch in the Netherlands were excluded from the list of potential suppliers. As a result of these criteria, it was needed to carefully select relevant suppliers which could be visited and interviewed.

For repair feedback, supplier selection was based on a subset of suppliers that were already providing repair feedback to PH. A list of 19 suppliers was available\(^9\), that were providing reports with repair data to PH. Therefore, from these suppliers it was expected that they have some experience in exchanging repair feedback with PH. Four of these suppliers were located close enough to travel to. For one of these suppliers however, PH suggested that it was not the right moment to interview them, because of the high workload at that supplier for PH activities. The other three suppliers were then contacted and willing to cooperate. They are summarized in the table below. The column with the current quality of repair feedback is the scoring as given by PH employees on the feedback that they received at that moment (April 2012).

**Final selection of suppliers for repair feedback**

<table>
<thead>
<tr>
<th>Name</th>
<th>Country of origin</th>
<th>Current quality of repair feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier J</td>
<td>United States (located in BE)</td>
<td>‘Unacceptable’</td>
</tr>
<tr>
<td>Supplier N</td>
<td>The Netherlands</td>
<td>‘Partially Acceptable’</td>
</tr>
<tr>
<td>Supplier P</td>
<td>United States (located in NL)</td>
<td>‘Unacceptable’</td>
</tr>
</tbody>
</table>

Both the Japan Earthquake and the flooding in Thailand were defined as candidates because of their recent occurrence, which means that there are a lot of people who have knowledge about it, both internally as well as at the supply base. The impact of the Japan Earthquake was found to be much larger in terms of impacted commodities and suppliers. Moreover, this disaster also impacted the supply chain for outgoing parts, since the warehouses in Japan. This complexity made it difficult to get a good overview of the impact by investigating some suppliers. The flooding in Thailand however, was much more focused, since this disaster was restricted to the supply chain for incoming parts (supplier to PH) and only a single type of industry was impacted; hard disk drives (HDD). Therefore, the flooding in Thailand was chosen to select suppliers on. During the research it was found out that ‘supplier J’ that was interviewed for repair feedback, also was impacted by the Japan Earthquake. Therefore, it was decided to also interview this supplier for disaster management. All suppliers for disaster management are displayed in the table below.

**Final selection of suppliers for disaster management**

<table>
<thead>
<tr>
<th>Name</th>
<th>Country of origin</th>
<th>Affected by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier D</td>
<td>Ireland (located in NL)</td>
<td>Thailand flooding</td>
</tr>
<tr>
<td>Supplier H</td>
<td>United States (located in NL)</td>
<td>Thailand flooding</td>
</tr>
<tr>
<td>Supplier J</td>
<td>United States (located in NL)</td>
<td>Japan Earthquake</td>
</tr>
<tr>
<td>Supplier PD</td>
<td>The Netherlands</td>
<td>Thailand flooding</td>
</tr>
</tbody>
</table>

---

\(^9\) Excel file: Suppliers Repair Data collection status (April 2012)
## Appendix 6 – List of Interviewees

<table>
<thead>
<tr>
<th>Department/company</th>
<th>Interviewee function</th>
<th>Department/company</th>
<th>Interviewee function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experts</strong></td>
<td></td>
<td><strong>Experts</strong></td>
<td></td>
</tr>
<tr>
<td>BU (IXR)</td>
<td>Reliability manager</td>
<td>SPS</td>
<td>Supply chain planning &amp; procurement manager</td>
</tr>
<tr>
<td>BU (MR)</td>
<td>Lifecycle manager</td>
<td>SPS</td>
<td>Sr. modality performance manager</td>
</tr>
<tr>
<td>IS-OPS - repair</td>
<td>Unit manager repair</td>
<td>SPS</td>
<td>Customer demand manager</td>
</tr>
<tr>
<td>SPS</td>
<td>Sr. business project manager</td>
<td>Service Purchasing</td>
<td>Strategic purchaser</td>
</tr>
<tr>
<td>IS-OPS - repair</td>
<td>Unit manager repair</td>
<td>Purchasing</td>
<td>Purchasing director</td>
</tr>
<tr>
<td>SPS</td>
<td>Sr. business project manager</td>
<td>Purchasing</td>
<td>Commodity manager</td>
</tr>
<tr>
<td>SQA</td>
<td>Strategic supplier quality engineer</td>
<td>SAMs</td>
<td></td>
</tr>
<tr>
<td>SQA (service)</td>
<td>Supplier quality manager</td>
<td>SAMs</td>
<td></td>
</tr>
<tr>
<td><strong>SAMs</strong></td>
<td></td>
<td><strong>SAMs</strong></td>
<td></td>
</tr>
<tr>
<td>Service Purchasing</td>
<td>SAM supplier N</td>
<td>Purchasing</td>
<td>SAM supplier H</td>
</tr>
<tr>
<td>Service Purchasing</td>
<td>SAM supplier P</td>
<td>Purchasing</td>
<td>SAM supplier D</td>
</tr>
<tr>
<td>Service Purchasing</td>
<td>SAM supplier J</td>
<td>Purchasing</td>
<td>SAM supplier PD</td>
</tr>
<tr>
<td><strong>Suppliers</strong></td>
<td></td>
<td><strong>Suppliers</strong></td>
<td></td>
</tr>
<tr>
<td>Supplier N</td>
<td>Customer Support Manager</td>
<td>Supplier H</td>
<td>Global account manager</td>
</tr>
<tr>
<td>Supplier P</td>
<td>Program Manager</td>
<td>Supplier D</td>
<td>Global program manager</td>
</tr>
<tr>
<td>Supplier J</td>
<td>Global material manager</td>
<td>Supplier PD</td>
<td>Product coordinator</td>
</tr>
</tbody>
</table>
Appendix 7 – Interview Protocols

Interview protocol for:
- Suppliers
- Supplier Account Managers

General questions
- What type of products does Supplier X deliver to Philips Healthcare?
- Are these products designed by Philips or by Supplier X?
- Could you please explain the relationship between Supplier X and Philips Healthcare?
- Are there any problems in the relationship between Supplier X and Philips Healthcare?
- Is Philips Healthcare, according to you, an important customer for Supplier X?
- How will this be in the future? (short and long term)
- Are there for Philips Healthcare alternative suppliers available who make similar products as Supplier X?
- Could you explain the difficulties for Philips when they want to shift to another supplier? (focus on Service Parts and Repair)
- What information is exchanged between Supplier X and Philips Healthcare?

Case specific: Repair feedback
- What arrangements have been made in the field of repair information exchange?
- Do you see the necessity of sharing this information?
- How does the knowledge transfer take place on repair feedback?
- To whom of Philips/Supplier X is this information provided?
- How can this information exchange on repair with Supplier X be improved?
- How is the exchange on repair feedback organized with other customers?

Case specific: Disaster management
- Are there, in normal situations, sometimes issues with Supplier X about the availability of parts?
- Does Supplier X have a standard protocol to manage interruptions in the supply chain? How does it look like?
- How did the earthquake and tsunami in Japan hit Supplier X? How was this with the Thailand flooding?
- How did the knowledge transfer take place during each of these crises?
- To whom of Philips/Supplier X is this information provided?
- What could be improved in the knowledge exchange during these disasters?
- How did the knowledge exchange during these disasters go with other customers? (suppliers only)

Questionnaire questions

<table>
<thead>
<tr>
<th>Information characteristics: About the communication between Philips Healthcare and Supplier X</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy of the exchanged information</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Ambiguity of the exchanged information</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Relevancy of the exchanged information</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Explicitness of the exchanged information</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Timely availability of the exchanged information?</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
### Supplier X characteristics: About the communication between Philips Healthcare and Supplier X

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Laag</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willingness to exchange the information on availability with Philips</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Capability to exchange the information on availability with Philips</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Impact and size of the organization</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Involvement of top-management</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>IT-infrastructure</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

### Philips Healthcare characteristics: About the communication between Philips Healthcare and Supplier X

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Laag</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willingness to exchange the information on demand forecasts with Supplier X</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Capability to exchange the information on demand forecasts with Supplier X</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Impact and size of the organization</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Involvement of top-management</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Position in the supply network (power level)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>IT-infrastructure</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

### Relationship characteristics: About the communication between Philips Healthcare and Supplier X

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Laag</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity of the relationship?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Trust in each other?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Competitive preassure from outside?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Who is the most powerful in the relationship Supplier X?

How would you grade the relationship with Supplier X?
Interview protocol for:
- Experts within Philips Healthcare

General questions
- Could you please elaborate on your tasks and responsibilities within Philips Healthcare?
- What information is exchanged between suppliers and Philips Healthcare?
- Why is sharing of information so important?
- What are the consequences of the lack of information sharing?
- What are the (potential) internal Philips problems that may cause this?
- What are the (potential) problems at the supply side that may cause this?
- How is the communication with suppliers organized?
- Is this the same for all situations?

Case specific: Repair feedback
- What type or repair information can be used within Philips Healthcare? And your department?
- Why is it important for Philips Healthcare/your department to obtain feedback on repairs?
- Do you see the necessity of sharing this information?
- How should information transfer take place on repair feedback?
- How should the information be processed after it is obtained?
- Who of Philips/supplier should be involved in this ‘knowledge processing’?
- Could you please explain, in detail, how the process for knowledge exchange in such situations looks like?
- How can the information exchange on repair feedback with suppliers be improved?

Case specific: Disaster management
- Are there, in normal situations, sometimes issues with suppliers about the availability of parts?
- How did the earthquake and tsunami in Japan hit Philips Healthcare? And your department?
- Could you please explain what had to be done after a disaster like Thailand and Japan?
- What information was exchanged by the supplier to Philips Healthcare?
- How was this information processed after it was obtained by Philips Healthcare?
- What information was exchanged by Philips Healthcare to the supplier?
- How was this information processed after it was obtained by the supplier?
- Who of Philips/supplier was involved in this ‘knowledge processing’?
- Could you please explain, in detail, how the process for knowledge exchange in such situations looks like?
- Are there differences between different countries/industries/suppliers? What are these differences?
- What could be improved in the knowledge exchange during these disasters?
### Appendix 8 – Scoring table: Drivers of knowledge exchange activities

#### Repair feedback

<table>
<thead>
<tr>
<th>Information Characteristics (1-5)</th>
<th>SAM J</th>
<th>Sup. J</th>
<th>SAM N</th>
<th>Sup. N</th>
<th>SAM P</th>
<th>Sup. P</th>
<th>Average SAMs</th>
<th>Average Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>5</td>
<td>3.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Ambiguity (=unambiguousness)</td>
<td>-</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>4</td>
<td>2.0</td>
<td>3.7</td>
</tr>
<tr>
<td>Relevancy</td>
<td>-</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>-</td>
<td>4</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Tacitness (=explicitness)</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>-</td>
<td>4</td>
<td>3.0</td>
<td>4.3</td>
</tr>
<tr>
<td>Timeliness</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>-</td>
<td>5</td>
<td>3.0</td>
<td>4.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2.80</td>
<td>3.20</td>
<td>4.40</td>
<td></td>
<td></td>
<td></td>
<td><strong>3.1</strong></td>
<td><strong>4.1</strong></td>
</tr>
</tbody>
</table>

| Supplier Characteristics (1-5)    |       |        |       |        |       |        | **3.5**      | **4.4**           |
| Willingness to share              | 4     | 5      | 4     | 4      | 4      | 4      | 4.0          | 4.3               |
| Absorptive capacity               | 5     | 5      | 3     | 5      | 3      | 5      | 3.7          | 4.3               |
| Organizational size               |       |        |       |        |       |        | **3.5**      | **4.4**           |
| Top-management involvement        | 4     | 5      | 5     | 5      | 3      | 5      | 4.0          | 5.0               |
| IT-commitment                     | -     | -      | 2     | 3      | 3      | 5      | 2.5          | 4.0               |
| **Total**                         | 3.50  | 3.75   | 3.25  | 4.75   |        |        | **3.5**      | **4.4**           |

| Buyer Characteristics (1-5)       |       |        |       |        |       |        | **3.0**      | **3.5**           |
| Willingness to share              | 4     | 5      | 4     | 4      | 3      | 3      | 3.7          | 4.0               |
| Absorptive capacity               | 4     | 5      | 2     | 2      | 1      | 2      | 2.3          | 3.0               |
| Top-management involvement        | 4     | 5      | 4     | 3      | 1      | 2      | 3.0          | 3.3               |
| Position in the supply network (power level) | -   | 5     | 2     | 4      | 4      | 4      | 3.0          | 4.3               |
| IT-commitment                     | 3     | -      | 3     | 3      | 1      | -      | 2.3          | 3.0               |
| **Total**                         | 3.00  | 3.20   | 2.00  | 2.75   |        |        | **2.9**      | **3.5**           |

| Relationship Characteristics (1-5) |       |        |       |        |       |        | **4.33**     | **4.0**           |
| Intensity of the relationship     | 4     | 5      | 5     | 5      | 2      | 3      | 3.7          | 4.3               |
| Trust in each other               | 4     | 5      | 4     | 4      | 4      | 4      | 4.0          | 4.3               |
| Competitive pressure from outside | 5     | 4      | 4     | 3      | 4      | 4      | 4.3          | 3.7               |
| **Total**                         | **4.33** | **4.00** | **3.33** | **3.67** |        |        | **4.0**      | **4.1**           |

<table>
<thead>
<tr>
<th>Overal grade of the relationship (1-10)</th>
<th>7.5</th>
<th>8</th>
<th>7</th>
<th>7</th>
<th>7.5</th>
<th>7</th>
<th>7.3</th>
<th>7.3</th>
</tr>
</thead>
</table>
## Disaster management

<table>
<thead>
<tr>
<th>Information characteristics (1-5)</th>
<th>SAM D</th>
<th>Sup. D</th>
<th>SAM H</th>
<th>Sup. H</th>
<th>SAM PD</th>
<th>Sup. PD</th>
<th>Average SAMs</th>
<th>Average Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy of the exchanged information</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4.00</td>
<td>4.50</td>
<td></td>
</tr>
<tr>
<td>Ambiguity of the exchanged information</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4.00</td>
<td>4.25</td>
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<tr>
<td>Relevancy of the exchanged information</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4.00</td>
<td>4.50</td>
<td></td>
</tr>
<tr>
<td>Explicitly of the exchanged information</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>3.75</td>
<td>4.00</td>
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</tr>
<tr>
<td>Timely availability of the exchanged information?</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4.00</td>
<td>4.25</td>
<td></td>
</tr>
<tr>
<td>Overall grade of the relationship (1-10)</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>6.5</td>
<td>7.63</td>
<td>7.63</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Supplier characteristics (1-5)</th>
<th>SAM H</th>
<th>Sup. H</th>
<th>SAM PD</th>
<th>Sup. PD</th>
<th>Average SAMs</th>
<th>Average Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willingness to share</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4.00</td>
<td>5.00</td>
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<tr>
<td>Absorptive capacity</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>3.50</td>
<td>4.75</td>
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<tr>
<td>Organizational size</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>3.50</td>
<td>4.25</td>
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<tr>
<td>IT-commitment</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>2.33</td>
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<td>Overall grade of the relationship (1-10)</td>
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<table>
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<th>SAM H</th>
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<th>SAM PD</th>
<th>Sup. PD</th>
<th>Average SAMs</th>
<th>Average Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willingness to share</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3.75</td>
<td>5.00</td>
</tr>
<tr>
<td>Absorptive capacity</td>
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<td>3</td>
<td>4</td>
<td>4</td>
<td>3.00</td>
<td>4.00</td>
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<tr>
<td>Top-management involvement</td>
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<td>3</td>
<td>4</td>
<td>4</td>
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<td>4.25</td>
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<tr>
<td>Position in the supply network (power level)</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>1.67</td>
<td>4.00</td>
</tr>
<tr>
<td>IT-commitment</td>
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<td>3</td>
<td>2</td>
<td>-</td>
<td>2.25</td>
<td>3.00</td>
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<tr>
<td>Overall grade of the relationship (1-10)</td>
<td>3.13</td>
<td>4.05</td>
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</table>

<table>
<thead>
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<th>Inter-firm relationship characteristics (1-5)</th>
<th>SAM H</th>
<th>Sup. H</th>
<th>SAM PD</th>
<th>Sup. PD</th>
<th>Average SAMs</th>
<th>Average Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity of the relationship</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>3.25</td>
<td>4.75</td>
</tr>
<tr>
<td>Trust in each other</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>3.25</td>
<td>4.25</td>
</tr>
<tr>
<td>Competitive pressure from outside</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4.00</td>
<td>3.75</td>
</tr>
<tr>
<td>Overall grade of the relationship (1-10)</td>
<td>3.50</td>
<td>4.25</td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>
Appendix 9 – Business Continuity Plan for Outgoing Parts (Overview)

Left out for confidentiality purposes
Appendix 10 - Solution Design

Specifications
- Focus on repair feedback
- Focus on limited set of products to make the discussion as specific as possible
- Limited amount of participants to keep it manageable
- Involve people from different departments to cover the complete internal organization
- Involve suppliers to create insights in their requirements and capabilities
- Discussion based on the conceptual model on inter-firm knowledge exchange
- Taking into account the after-sales situation (BOM/service VS service only products)
- People preferably have to sit together in one room to facilitate discussion

Workshop design
Participants from:
- Service Purchasing, PH (2x)
- SPS, PH
- BU-MR, PH
- BU-iXR, PH
- IS-OPS repair, PH
- Global Quality Manager, Supplier X

Introduction/presentation (20 min)
- Short introduction of participants (5 min)
- Introduction to research, conceptual model and empirical findings (10 min)
- Explanation of workshop design and time schedule (5 min)

Brainstorm session (10 min)
In a brainstorm session each participant will be asked to individually describe possible applications (minimum 5) of repair feedback. Each of the applications has to be written down on a post-it..

Clustering and priority determination (40 min)
The post-its will be collected and put on a flip-over sheet. The first one sticks them on the sheet, the second tries to combine his/her ideas with that of the first. The third does the same etc. so that several clusters are created. After this is finished, the clusters have to be verified and cluster names should be defined. Every participant is now asked to distribute 10 points over the most important applications (max. 6 points per application) and to shortly describe to the team why this is the most important application for him/her. After every participant has done this, there will be a top-3 of applications. A final check will be done to find-out if the majority agrees.

Sample scoring matrix

<table>
<thead>
<tr>
<th>Application 1</th>
<th>Application 2</th>
<th>Application ...</th>
<th>Total:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name 1</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Name ...</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td></td>
<td>30</td>
</tr>
</tbody>
</table>
Determination of goals (10 min)
For the top-3 of applications (high level) SMART-goals (Specific, Measurable, Attainable, Relevant, Timely) have to be defined in order to make clear for everybody what is meant by the applications and how the success of the application can be measured afterwards.

Action plans (45 min)
For each of the top-3 applications of knowledge feedback, action plans are defined. The participants will be split-up in 3 teams (to be defined during the break) and each of these groups will work on a single application. This will be done based on the conceptual framework. Distinction can therefore be made in the following items:
- Required information (from suppliers?)
- Required internal stakeholders
- Required external stakeholders
- Communication methods
- Follow-up process steps
- Users

Important is to determine who has to do what to make the chosen application work and when has this to be finished. This can result in specific actions or preliminary actions (like starting a project-team). Moreover quick-wins should be defined.

Sample of application matrix

<table>
<thead>
<tr>
<th></th>
<th>Required information</th>
<th>Required internal stakeholders</th>
<th>Required external stakeholders</th>
<th>Communication methods</th>
<th>Follow-up process steps</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application 2</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Application 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Presentations and discussion (45 min)
Each team will be asked to present their solution to the group based on which feedback can be given and a discussion can be held on each of the 6 items.

Problem redesign
After the process has been set, the actual workshop should give insights in the solution to the analyzed problems. In order to make a qualitative design for the solution, a pilot workshop should be held. The outcomes of the workshop can be used as a proposal for the effective use of repair feedback.
## Appendix 11 – Outcomes Brainstorm Session from Workshop

<table>
<thead>
<tr>
<th>Usage/diagnosis</th>
<th>Design</th>
<th>NFF</th>
<th>Delta</th>
<th>Failure Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Identify wrong usage of products</td>
<td>• Identify design flaws in the system</td>
<td>• NFF yes/no</td>
<td>• Reduce Defoa (improve quality and reliability)</td>
<td>• Reduce F01 of defects</td>
</tr>
<tr>
<td></td>
<td>• Service repair vs. small new design with current technique</td>
<td>• Reduce NFFs</td>
<td>• II Defoa, defect also found at repair</td>
<td>• Reduce FR/RR</td>
</tr>
<tr>
<td></td>
<td>• Improve current and future design</td>
<td>• Reduce NFF</td>
<td>• Delta reduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Prevent NFF</td>
<td>• Reduce Defoa’s</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Delta number</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Optimization of logistical flow</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost/repair process</th>
<th>Number of return</th>
<th>Trends</th>
<th>Issue solving</th>
<th>Closed loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Improve M1K</td>
<td>• Limit quantity of repair returns</td>
<td>• Trending</td>
<td>• Initiate problem solving for issues</td>
<td>• SWG number (failure data from field)</td>
</tr>
<tr>
<td>• Reduce scrap at vendor</td>
<td>• Keep the service supply chain clean of zombies</td>
<td>• Failure production based on product build date -&gt; preventive repair</td>
<td></td>
<td>• Date of failure</td>
</tr>
<tr>
<td>• Help with continuous improvement</td>
<td>• Apply 3 strikes out rule (need serial number)</td>
<td>• Production date (aging of product/bad production badge)</td>
<td></td>
<td>• Error description customer</td>
</tr>
<tr>
<td>• Reduce cost</td>
<td>• Serial number (multiple returns/history)</td>
<td>• Report to auditing institutions</td>
<td></td>
<td>• Need link to field comments in order to improve field process</td>
</tr>
<tr>
<td>• Calculate repair yield (on material level)</td>
<td></td>
<td></td>
<td></td>
<td>• Separate defect code (what) vs repair code (how)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stock planning</th>
<th>Revision level management</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Make Weibulls per failure mode</td>
<td>• Reduction of “old” revision level on performance</td>
<td>• Identify weak FRU’s and start improvements</td>
</tr>
<tr>
<td>• Order enough stock on obsolescence (bad calls)</td>
<td>• Revision level in/out</td>
<td>• Components used in repair and prices to understand repair price</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Understand most common root cause &amp; prevent this failure (parco)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Detect components found</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Issue solving</th>
<th>Closed loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>• SWG number (failure data from field)</td>
<td>• Date of failure</td>
</tr>
<tr>
<td>• Error description customer</td>
<td>• Need link to field comments in order to improve field process</td>
</tr>
<tr>
<td>• Separate defect code (what) vs repair code (how)</td>
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</table>
## Appendix 12 – Action Plans from Workshop

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<tr>
<th>Required information</th>
<th>Components</th>
<th>Trending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- # of components used in repair (Pareto) requested when trending changes (goes up) or issue trigger</td>
<td>- Serial number</td>
</tr>
<tr>
<td></td>
<td>- Known weak components</td>
<td>- Production date</td>
</tr>
<tr>
<td></td>
<td>- 2nd/3rd tier supplier of component (changes)</td>
<td>- Installation date</td>
</tr>
<tr>
<td></td>
<td>- Revision level of FRU</td>
<td>- Failure date</td>
</tr>
<tr>
<td></td>
<td>- Introduction date of FRU</td>
<td>- Re-ship date</td>
</tr>
<tr>
<td></td>
<td>- Confirmed MTBF (PH data)</td>
<td>- Repair codes</td>
</tr>
<tr>
<td></td>
<td>- Reliability data (PH data)</td>
<td>- 12NC → FRU</td>
</tr>
<tr>
<td></td>
<td>- Use of the part (PH data)</td>
<td>- Components</td>
</tr>
<tr>
<td></td>
<td>- Level of repair (on component level, not on unit level)</td>
<td>- Internal reference number</td>
</tr>
<tr>
<td></td>
<td>- Intended use of the failing component (design/within spec)</td>
<td>- Outlier reported by vendor</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required internal stakeholders</th>
<th>Components</th>
<th>Trending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Maintenance/product quality teams (PQM-ers)</td>
<td>- PQM Managers (BU)</td>
</tr>
<tr>
<td></td>
<td>o Service innovation</td>
<td>- Customer Service Data analysts (BU)</td>
</tr>
<tr>
<td></td>
<td>o Operations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Purchasing (Cost)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o SPS (logistics)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Development</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Supplier quality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Customer service data analysits?</td>
<td></td>
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<tr>
<td></td>
<td>- Service purchasing?</td>
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</tr>
<tr>
<td></td>
<td>‘who is doing the analysis?’</td>
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<table>
<thead>
<tr>
<th>Required external stakeholders</th>
<th>Components</th>
<th>Trending</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>- Repair supplier</td>
<td>- Repair supplier</td>
</tr>
<tr>
<td></td>
<td>o Owner of design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Manufacturer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Repair only</td>
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</table>

<table>
<thead>
<tr>
<th>Communication methods</th>
<th>Components</th>
<th>Trending</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Reports</td>
<td>- Reports</td>
<td>- Constant, consistent data flow</td>
</tr>
<tr>
<td>- Regular T-cons/meetings between supplier and multi-disciplinary team</td>
<td>- Quarterly Business Review meeting</td>
<td>- SAMs</td>
</tr>
<tr>
<td>- Tailor made query from supplier (repair) database</td>
<td>o Managers appointed to service in repair vendors</td>
<td>- Data accessible by all within Philips</td>
</tr>
<tr>
<td>o Pre-defined data fields</td>
<td>- Predefined 4-blockers with Pareto’s</td>
<td>- Good definition</td>
</tr>
<tr>
<td>o Possible or not? Depends per supplier</td>
<td>o Data elements</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Follow-up process steps</th>
<th>Components</th>
<th>Trending</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Deep dive on top component (analysis)</td>
<td>- Distinction between:</td>
<td>- Field trending</td>
</tr>
<tr>
<td>- Regular T-con/meeting → define improvement actions</td>
<td>- Repair trending</td>
<td></td>
</tr>
<tr>
<td>- Other clusters from brainstorm:</td>
<td>- Combination possible?</td>
<td></td>
</tr>
<tr>
<td>o Issue solving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Design improvement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Failure rate reduction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Users | - Joined action between Philips and supplier  
| |  o Organized per supplier  
| | Who is in the lead for:  
| | - Data analysis  
| | - Deep dive investigation & follow up  
| | - Improvement actions | - The required internal and external stakeholders  
| | o Cost reduction  
| | o End2end feedback |